AIR QUALITY IMPACT ASSESSMENT:
MUSWELLBROOK COAL COMPANY LIMITED NO. 1 OPEN CUT EXTENSION

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Prepared
for
HLA-Envirosciences
On behalf of
Muswellbrook Coal Company Limited

by

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1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for HLA-Envirosciences. It provides an assessment of the air quality impacts of the proposed mining of the No. 1 Open Cut Extension (''Extension'') which is proposed to be developed on the Muswellbrook Coal Company lease to the east of Muswellbrook in the Upper Hunter Valley. The Extension is proposed to be developed and operated in association with the current No. 2 Open Cut Mine. The assessment deals with a nine year period during which Run of Mine (ROM) coal from the Extension is planned to be produced at a rate of up to 1.25 Mtpa. Total production rates from the Extension and the No. 2 Open Cut will be unchanged at current maximum production levels of 1.8-2.0 Mtpa.

The project area is shown in **Figure 1**. **Figures 2** and **3** show the locations of air quality monitoring sites and the locations of the closest residences respectively.

The assessment is based on a conventional approach and uses a computer-based dispersion model, with local meteorological data and estimates of dust emissions, to predict the concentration and deposition rate of particulate matter from the proposed Extension. To assess impacts the predicted concentration and deposition levels are compared with air quality criteria that apply in New South Wales (NSW). Three periods have been analysed in detail covering the life of the project.

In summary the report provides information on the following:

- The way in which mining is to be undertaken focusing on describing those aspects that will assist in understanding how the mine will affect air quality
- The surrounding mines that are expected to operate during the life of the project
- The existing air quality conditions in the area around the proposed Extension
- Air quality goals that need to be met to protect the air quality environment
- Meteorological conditions in the area
- The methods used to estimate dust emissions and the way in which dust emissions from the Extension will disperse and fallout
- The expected dispersion and dust fallout patterns due to the mine and a comparison between the predicted dust concentration and fallout levels and the relevant air quality criteria
- The control methods to be used by the mine to reduce dust impacts

2. AIR QUALITY STANDARDS AND GOALS

2.1 Air quality management and goals in NSW

The NSW Environment Protection Authority (EPA) is responsible for the management of air quality in NSW. In practice this means that the EPA specify the operating conditions for activities likely to cause air pollution and advise government on policy issues and laws/regulations that need to be implemented to maintain air quality at acceptable levels. Thus EPA advice includes such things as what are appropriate goals/standards with which to assess air quality, the need for unleaded petrol and catalytic converters on motor vehicles, the emission limits with which industry must comply, and the particular controls and operating rules that should be implemented at industrial facilities such as coal mines.

In addition, the EPA has set out assessment procedures in a document titled ''Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW'' (**NSW EPA, 2001**). This document includes guidance for the use of models and also sets out relevant air quality criteria for PM_{10}, TSP, and dust deposition.

The criteria specified by the EPA are:

- The Australian National Environment Protection Council's (NEPC) National Environment Protection Measure (NEPM) and EPA criterion for 24-hour PM_{10}
- The NSW EPA's annual PM_{10} ''Action for Air long-term reporting goal'' (**NSW EPA, 1998**)
- The National Health and Medical Research Council's (NHMRC) annual average goal for Total Suspended Particulate matter (TSP)
- The NSW EPA's annual average dust deposition goal for insoluble solids

In addition it is useful to take note of the following international criteria:

- The US EPA's 24-hour PM_{10} Standard (revised July 1997)
- The US EPA's annual average PM_{10} Standard (revised July 1997).

Although the most significant emission from mining is particulate matter (dust) in various size ranges, it is recognized that mining also results in emissions of carbon monoxide (CO), nitrogen oxides (NO_x) and minor quantities of sulphur dioxide (SO_2) from diesel vehicle exhausts and blasting.

The sulfur content of Australian diesel is too low to cause sulphur dioxide goals to be exceeded even in mines that use large quantities of diesel. For this reason no detailed study is required to demonstrate that emissions of SO_2 from the mine will not significantly affect SO_2 concentrations. Similarly emissions of NO_x from mining operations in the Hunter Valley occur sufficiently far from lease boundaries so that air quality criteria are not exceeded and no detailed assessment is undertaken for NO_x.

2.2 Particulate matter from mining

The way in which particulate matter affects the environment is complex. It has the capacity to affect health and to cause nuisance effects.

To assist in interpreting the significance of predicted concentration and deposition levels some background discussion on the potential harmful effects is provided in the following sections.

Particulate matter can be categorised by size and/or by chemical composition. The potential harmful effects depend on both.

The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 µm from reaching the more sensitive parts of the respiratory system. Particles with aerodynamic diameters less than 10 µm are referred to as PM_{10}. Particles larger than 10 µm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals still make reference to measures of the total mass of all particles suspended in the air. This is referred to as Total Suspended Particulate matter (TSP). In practice particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 µm. TSP includes PM_{10}.

Also of concern are fine particles with aerodynamic diameters of 2.5 µm or less. These particles are referred to as $PM_{2.5}$. Just as PM_{10} particles are a sub-component of TSP, so $PM_{2.5}$ particles are a sub-component of PM_{10} and therefore a sub-component of TSP. $PM_{2.5}$ particles can penetrate body's defensive systems and reach the lower parts of the respiratory system. There is evidence that particles in this size range are more harmful than the coarser component of PM_{10} namely the 2.5 to 10 µm fraction (**Schwartz et al., 1996**).

Emissions from mining operations include particles that are derived primarily from the mechanical disturbance of dusty materials such as soils, overburden and coal. Mining emissions will also include particles from diesel exhausts in activities where diesel powered equipment is used. Thus mining generates particles in all the above size categories, namely $PM_{2.5}$, PM_{10} and TSP. However, the great majority of the particles from open cut mining operations are larger than 2.5 µm. This is in contrast to particles found in bushfire smoke, or in the atmosphere in urban areas, where many of the particles are the result of combustion processes. A study of the distribution of particle sizes near (10 to 200 m) mining dust sources was undertaken on behalf of the State Pollution Control Commission (SPCC - now EPA) in 1986. The average of approximately 120 samples showed that $PM_{2.5}$ comprised 4.7% of the TSP, and PM_{10} comprised 39.1% of the TSP in the samples (**SPCC, 1986**). Thus, although emissions of $PM_{2.5}$ do occur from open cut mines the percentage of the emissions in this size range is small and in practice the concentrations of $PM_{2.5}$ in the vicinity of open cut mines are low compared with internationally recognised goals. There are no standards or goals for $PM_{2.5}$ in Australia at this stage although a $PM_{2.5}$ goal is being developed. In the absence of Australian goals this report will make reference to the **US EPA (1997)** Standard, where applicable and no detailed assessment of $PM_{2.5}$ impact is provided in the report. Other studies (see **Holmes Air Sciences, 1998**) show that open cut mines have little difficulty in complying with the US EPA's Standards for $PM_{2.5}$ and consequently this should not been seen as an omission in the assessment.

2.3 Summary

Table 1 and **2** summarise the criteria relevant to this study. In applying these standards/goals for assessing impacts it should be recognised that there are areas in the vicinity of the mine, such as land owned by the proponent, land owned by other mining companies, or land owned by third parties, where the landowner may agree to accept exceedances of the standards/goals.

Further it should be recognised that air quality at any particular receptor is determined by emissions from many sources, which will contribute various proportions (depending on the location of the receptor in relation to the dust source and on dispersion conditions) to the overall pollutant burden in the air. This is particularly true in the case of particulate matter, where there are a large number of sources, including mining, agriculture, traffic, bushfires and local and remote wind erosion sources. These factors need to be taken into account when assessing impacts.

Table 1 lists three entries for 24-hour PM_{10} concentrations and two entries for annual average PM_{10} concentrations. The criteria referred to in assessing the project are shown in bold print. The others are either reporting standards or regional goals. Compliance with regional goals requires management and control of all sources and is thus beyond the scope of an individual project. Nevertheless individual projects, particularly large projects such as open cut coalmines, should be assessed for their influence on regional air quality and this has been done in this report.

Table 1. Health-based air quality standards/goals for particulate matter concentrations

POLLUTANT	STANDARD/GOAL	AGENCY
Total suspended particulate matter (TSP)	90 µg/m^3 (annual mean)	NHMRC
Particulate matter < 10 µm (PM_{10})	50 µg/m^3 (24-hour maximum) 30 µg/m^3 (annual mean)	NSW EPA criteria NSW EPA long-term reporting goal
Particulate matter < 2.5 µm ($PM_{2.5}$)	65 µg/m^3 (98th percentile of 24-hour averages over three years) 15 µg/m^3 (1-year average)	US EPA Standard US EPA Standard
Carbon monoxide (CO)	87 ppm (108 mg/m^3) (15-minute average) 25 ppm (31 mg/m^3) (1-hour average) 9 ppm (10 mg/m^3) (8-hour maximum)	WHO WHO NHMRC and NEPM reporting standard
Nitrogen dioxide (NO_2)	12 pphm (245 µg/m^3) (maximum 1-hour) 3 pphm (60 µg/m^3) (annual mean)	NEPM and NSW EPA reporting standard NEPM, NSW EPA reporting standard
Sulphur dioxide (SO_2)	25 pphm (700 µg/m^3) (10-minute average) 20 pphm (570 µg/m^3) (1-hour maximum) 8 pphm (225 µg/m^3) (24-hour average) 2 pphm (60 µg/m^3) (annual average)	NHMRC NEPM reporting standard NEPM reporting standard NHRMC and NEPM reporting standard

Table 2 shows the maximum acceptable increase in dust deposition over the existing dust levels. In assessing cumulative impacts, where all

dust sources are considered, the upper limit is taken to be 4 g/m²/month.

Table 2. NSW EPA amenity based criteria for dust fallout

Existing dust fallout level (g/m²/month)	Maximum acceptable increase over existing fallout levels (g/m²/month)	
	Residential	Other
2	**2**	**2**
3	1	2
4	0	1

The criteria for dust fallout levels in **Table 2** are set to protect against nuisance impacts.

3. DISPERSION METEOROLOGY

The computer-based dispersion model ISCST3 has been used in this study. This model requires data on wind speed, wind direction, atmospheric stability[1] class and mixed-layer height[2].

Data are available from a number of different sites including a meteorological station operated as part of the Mt. Arthur project (see **Figure 1**). These data are representative of the area being assessed and data covering the twelve month period 31 July 1999 to 25 July 2000 have been used for the current study. A total of 8,520 hours of data were available for the study. This corresponds to 97% of the data potentially available in a year. As discussed below, the distribution of winds for this year of data was consistent with long-term patterns observed in the Hunter Valley, with some local topographic effects. The data were therefore considered to be representative of dispersion conditions at the site.

The data provide hourly information on wind speed, wind direction, and other parameters required for dispersion modelling. **Figure 4** shows annual and seasonal wind roses prepared from the data.

The data show that over a year the prevailing winds are aligned along a northwest - southeast axis, which is common for much of the Hunter Valley. The northeast winds are the result of topographical effects caused by the valley that leads to McCulleys Gap to the northeast of Muswellbrook.

[1] In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme (as used in this study) 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 to the height above the ground through which ground-based emissions will eventually be dispersed once a plume has been thoroughly mixed. An elevated plume, initially above the mixed-layer height will remain isolated from the ground until such time as the mixed-layer height reaches the height of the plume. In general the mixed-layer height will increase during the day as the sun causes convection to deepen the turbulent layer of the atmosphere close to the ground. Mixed-layer height will also increase if the wind speed increases because higher wind speeds will increase turbulence as the wind blows over the rough ground.

Appendix A summarises the statistics of the meteorological data set, showing ''Joint wind speed-wind direction and stability class tables''.

4. EXISTING AIR QUALITY

Muswellbrook Coal Company operates a High Volume Air Sampler measuring 24-hour average concentrations of Total Suspended Particulate (TSP) matter and an air quality monitoring network comprising 20 dust deposition gauges, which measure monthly average dust fallout levels. The locations of the monitoring sites are shown in **Figure 1**.

4.1 Concentration

The TSP data are summarised in **Table 3**. The maximum 24-hour concentration measured to date has been 92.6 µg/m^3 (measured on 18 January 2002). The data include a period of intensive monitoring in January 2002 in which attempts were made to quantify the effects of blasting and it may be noted that the measurement of 92.6 µg/m^3 included the effects of blasting The measurements affected by blasting are shown enclosed in an ellipse in **Figure 2**. Some of these readings show elevated levels. The average of all data collected to date has been 46.6 µg/m^3. The average of the data excluding the blast monitoring results is 43.0 µg/m^3. The difference between the two is 8.4%. The later value is probably more representative of background levels, but conservatively, the value of 47 µg/m^3 has been adopted as the background for the purpose of assessment.

Currently there is no 24-hour criterion for 24-hour TSP concentrations. The 24-hour criteria for TSP have been replaced by criteria for PM_{10}. However, it may be useful to note that the former US EPA Primary Standard for TSP was 260 µg/m^3 and the Secondary Standard was 150 µg/m^3. The US EPA Primary Standards are set to protect the community against health effects and the Secondary Standards are set to protect the community against all other effects (including nuisance effects) with an adequate margin of safety. The available data set, while limited in the period which it covers, suggests that TSP levels in the area are likely to comply with these two standards.

Table 3. TSP Concentrations (24-hour average) at TSP1 (see Figure 2)

01-Aug-01	14.6
03-Aug-01	13.7
10-Aug-01	20.7
15-Aug-01	13.7
23-Aug-01	42.6
20-Sep-01	59
08-Oct-01	41
10-Oct-01	4.9
02-Nov-01	47
06-Nov-01	59.1
14-Nov-01	60.7
28-Nov-01	44.1
16-Jan-02	71.2
17-Jan-02	85.4

18-Jan-02	92.6
19-Jan-02	56
20-Jan-02	20.8
21-Jan-02	29.2
22-Jan-02	37
23-Jan-02	78.6
24-Jan-02	59.5
25-Jan-02	45.4
26-Jan-02	30.4
27-Jan-02	39.6
28-Jan-02	68.2
11-Feb-02	42.6
12-Feb-02	37.4
13-Feb-02	45.9
14-Feb-02	47.5
15-Feb-02	49.2
16-Feb-02	38.2
17-Feb-02	52.4
01-Mar-02	35.2
04-Mar-02	39.9
05-Mar-02	39.6
07-Mar-02	55.1
08-Mar-02	42
12-Mar-02	89.1
13-Mar-02	51.7
20-Mar-02	76.5
21-Mar-02	72.7
25-Mar-02	21.8
26-Mar-02	31.7
Average	**46.6 (43.0 excluding blasting results)**

As a general rule long-term average PM_{10} concentrations are 40% of the corresponding TSP concentration. This is true in areas where mining is the main source of particles. It may not be true in urban areas where combustion sources (motor vehicle emissions etc) are the dominant source and is not necessarily valid for short-term averages. In addition it may not be true when bushfire smoke is present. Based on the assumption that 40% of the TSP is PM_{10} the long-term PM_{10} concentration is estimated to be 18.6 $\mu g/m^3$, which is below the NSW EPA's annual reporting goal of 30 $\mu g/m^3$.

4.2 Deposition

Dust deposition has been measured at up to 15 sites since 1988. The number of sites has varied throughout this time as the mine has developed and different areas have needed to be monitored. The locations of the monitors are shown in (see **Figure 2**). The annual average dust deposition rates have varied from 8.8 g/m^2/month at Site 15 in 1989 to 0.5 g/m^2/month at Site 18 in 2000. The monthly data are shown in **Appendix B**.

Table 4. Summary of Annual Average Dust Deposition Data (Insoluble Solids) Collected by the Muswellbrook Coal Company Monitoring Program - g/m^2/month

	Site 2	Site 7	Site 10	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 22	Site 23	Site 24	Site 26	Site 27
1988	1.2	***1.2***	2.2	-	4.7	0.8	-	**-**	**-**	-	-	-	**-**	-	-

	Site 2	Site 7	Site 10	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 22	Site 23	Site 24	Site 26	Site 27
1989	1.4	***1.6***	1.4	-	8.8	1.5	-	-	-	-	-	-	-	-	-
1990	0.6	***0.8***	2.3	-	5.5	1.7	-	-	-	-	-	-	-	-	-
1991	1.7	***1.5***	5.2	-	1.7	2.4	-	-	-	-	-	-	-	-	-
1992	2.0	***1.8***	6.1	-	1.3	2.5	-	-	-	-	-	-	-	-	-
1993	2.8	***1.6***	3.4	-	1.3	2.7	-	-	-	-	-	-	-	-	-
1994	1.9	***1.0***	2.3	0.7	2.9	2.5	1.8	-	-	-	-	-	-	-	-
1995	1.9	***1.0***	2.2	0.9	2.1	1.3	1.2	***0.9***	***0.9***	1.2	-	-	-	-	-
1996	1.5	***1.0***	3.0	1.0	2.0	1.5	1.1	***1.0***	***1.2***	1.7	1.1	0.8	***2.3***	3.6	1.0
1997	2.5	***0.8***	3.1	1.1	3.1	2.8	2.2	***1.1***	***1.3***	1.2	1.0	1.6	***2.6***	2.1	1.0
1998	1.8	***0.9***	2.0	1.5	2.5	3.3	1.7	***0.8***	***5.6***[3]	1.2	1.1	1.6	***2.2***	0.7	1.3
1999	2.5	***1.1***	2.3	0.9	3.1	2.9	3.0	***0.9***	***1.2***	1.3	0.9	0.8	***1.4***	0.9	1.5
2000	1.9	***1.0***	1.7	1.1	2.1	1.7	1.4	***0.5***	***3.0***[4]	2.0	1.1	1.0	***1.0***	2.5	4.2
2001	1.1	***0.7***	1.7		3.7	1.5	1.5	***1.4***	***0.9***	1.4	1.4	0.8	***1.9***	2.3	1.5

Gauges 7, 24, 18 and 19 are close to residences (see **Figure 2**). With the exception of Gauge 19, which recorded an annual average dust deposition level of 5.6 g/m^2/month in 1998 these gauges have all recorded deposition levels below the NSW EPA's goal of 4 g/m^2/month. The elevated fallout level at Site 19 in 1998 was due to bird droppings in the gauge. Thus none of the sites close to residences have recorded elevated dust deposition levels. The data indicates that an increment in dust fallout of 2 g/m^2/month could be accommodated without a noticeable deterioration in air quality.
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[3] Affected by bird droppings for five month out of twelve.
[4] Affected by insects, and clay transported by birds and bird droppings

5. MINE PLAN AND ESTIMATED EMISSIONS

Mining for the No. 1 Open Cut Extension Project will be confined to the area shown in **Figure 1**. Mining commences in Year 1 at the western end and progresses toward the east. Overburden will be removed by free-dig or drilled and blasted. Approximately 50% will need to be blasted. Overburden will loaded to 190 t trucks and transported to emplacement areas in the western edge of the pit which will advance to the east. Coal will be loaded to 85 t trucks and hauled to the coal crusher and stockpile area located at the western end of the pit. After crushing and stockpiling it will be loaded to 25 t and 35 t trucks and transported over sealed public roads to the Ravensworth Coal Terminal. By Year 4 the pit will have advanced to the approximate centre of the area identified as the Project Area in **Figure 1**. At this stage the active mining area will be relocated to the eastern end of the marked area and will then progress in a westerly direction reaching the centre of the pit by Year 10. Mining will be undertaken in the same manner as before except that waste will be emplaced to the east as the pit advances to the west towards the centre of the pit.

In this second stage of mining the coal will be transported to the coal handling facilities located to the south of the central portion of the open cut (see **Figure 1**).

Table 5 summarises the volumes of material that are planned to be moved in each year in the life of the project.

Year 1 represents an interesting case because, although overburden production is small compared with later years, it is the period when mining will be closest to Muswellbrook.

Year 4 is of interest because overburden production is relatively high and mining is taking place in the central part of the open cut area.

Year 9 is the period when overburden production will be at its greatest.

Table 5. ROM Coal and Overburden produced by No. 1 Open Cut Extension Project

Year	ROM coal production Mt	Overburden production Mbcm	Inter-burden Mbcm	Partings kbcm	Total waste Mbcm
1	1.135	2.937	1.188	27.0	4.153
2	1.193	2.848	1.439	18.0	4.304
3	1.197	2.821	1.951	15.0	4.787
4	1.208	3.883	2.430	19.0	6.332
5	1.210	5.685	2.692	12.1	8.389
6	1.220	5.732	2.715	12.2	8.458
7	1.225	5.755	2.726	12.3	8.493
8	1.250	5.873	2.781	12.5	8.666
9	1.250	5.873	2.781	12.5	8.666
10	0.547	2.335	1.217	5.0	3.557

5.1 Preamble

The assessment covers three representative years during the life of the mine. The model requires estimates of particulate matter emission rates for each activity associated with the mining operation for each of the periods that are to be assessed, which in this case are Years 1, 4 and 9. The operations would include:

- Drilling overburden
- Blasting overburden
- Dozers on overburden (assisting, drills, excavators and shaping dumps)
- Loading overburden to trucks
- Hauling overburden to waste dumps
- Unloading overburden at waste dumps
- Shaping waste dumps
- Dozers on coal (ripping)
- Loading coal to trucks
- Hauling coal to dump hopper or ROM stockpile
- Unloading coal to dump hopper or ROM stockpile
- Re-handling coal at ROM stockpile
- Loading coal to product stockpiles
- Loading coal to trucks for transport off-site
- Grading roads and other areas

In addition there will be dust emissions due to wind erosion from exposed working areas (including pits and dumps) and also from stockpiles.

Emissions from all these sources have been determined in accordance with emission factors developed in the United States (**US EPA, 1985** and revisions) and in Australia (**NERDDC 1988**).

5.2 Approach to modelling

This section outlines the way in which the ISCST3 model has been used to model the dispersion of dust from the mine.

The generation of dust from sources such as wind erosion and loading operations, depends on meteorological conditions. This means that emissions must be provided to the model in a way that reflects the hour-by-hour changes in the emission rates, which occur as meteorological conditions change. This is different from the historical approach used in Hunter Valley coalmine EISs in which annual average emission rates were used. Time-varying emission rates have been used in the current study for wind erosion sources and for the loading and unloading of coal and overburden.

A further complication has arisen in dealing with short-term cumulative impacts. Many coal mines now operate real time dust control strategies in an attempt to mitigate short-term impacts. These control strategies are unlikely to have any significant effect on long-term dust concentration and dust deposition levels, but are expected to significantly reduce the impacts of short-term episodes. However the effect of these control measures is impossible to model.

To model these reliably would require detailed knowledge of the control strategies to be adopted by each mine for each set of meteorological conditions.

In view of the difficulty in accurately taking into account the effects of real time controls on short-term impacts they have not been modelled. Short-term impacts have been assessed by referring to the historical performance of mines in the area as revealed by the air quality monitoring data. This shows that short-term 24-hour goals have not been exceeded in the last five years., and since the No. 1 Open Cut Extension proposal represents a continuation of an exsiting activity albeit in a different location it is unlikely that short-term goals would be exceeded in the future.

5.3 Controls

The controls that are available for the mine can be summarised in three broad categories:

1. Engineering controls
2. Planning controls to increase the separation between dust emission sources on the mine and sensitive areas
3. Operational controls which vary mining activities when adverse meteorological conditions occur

Engineering controls involve measures such as shielding conveyors, selection of appropriate stockpile stacking and reclaim systems, maintaining dust loadings on trafficked areas at low levels by watering and using agglomerating agents, and installation of sprinkler systems on coal handling areas.

Planning controls include the maintenance of adequate buffer distances between dust sources and receptors and progressive rehabilitation of mined areas to minimize the area susceptible to wind erosion. They may involve the acquisition of impacted properties or limiting the extent of mining.

Operational controls involve curtailing dust-generating activities when wind speeds, or more significantly, wind directions would take dust from its source to a sensitive area. Watering of roads and stockpiles with water trucks can be considered in this category of controls.

The dust control measures that will be incorporated into the project and which have been taken into account in the modelling are listed below:

- Dust controls to be fitted on all drill rigs
- Watering of all trafficked areas, active work areas, coal handling areas, and other areas susceptible to wind erosion
- Minimising exposed land susceptible to wind erosion
- Progressive rehabilitation of areas disturbed by mining activities

For the current model runs allowance has been made for all these controls. The model assumes 75% control on haul roads due to dust suppression watering. The model runs do not take into account the effect of real-time control measures, which can have a significant effect on reducing short-term (24-hour) impacts on specific areas. Real-time controls are unlikely to significantly affect the long-term averages that form the basis of the assessment in this report.

5.4 Estimated emissions from No. 1 Open Cut Extension Project

Appendix C provides details as to how dust emissions from each dust producing activity were calculated. These have been calculated including the effect of dust controls and the assumptions that have been made in estimating these emissions. **Table 6** summarises the estimated TSP emission rates.

Table 6. Summary of estimated emissions (kg/y)

Activity/Source	Estimated Emissions		
	Year 1- kg/y	Year 4 - kg/y	Year 9 - kg/y
Drilling Overburden	1,452	2,214	5,135
Blasting Overburden	1,513	2,310	3,190
Loading Overburden	8,970	13,677	18,719
Hauling o/b	104,918	159,966	218,931
Dumping overburden	8,970	13,677	18,719
Dozers on o/b in pit	47,600	20,400	20,400
Dozers on o/b on dumps	27,200	27,200	27,200
Dozers on coal	185,700	185,700	185,700
Loading coal	124,850	132,880	124,850
Hauling coal	26,706	28,424	29,412
Unloading coal at hopper + re-handle coal hopper	68,100	72,480	75,000
Unload coal at hopper	13,500	12,080	12,500
Load coal to stockpile	5,400	4,832	5,000
Load coal to trucks for export off-site	124,850	132,880	124,850
Hauling coal off-site (first 4 km only	72,640	77,312	80,000
Grading roads and other areas	1,132	1,132	1,132
Wind erosion from pit and waste dumps	19,163	19,163	19,163
Wind erosion from and Main ROM and Product stockpiles	3,066	3,066	3,066
Total	**845,730**	**909,393**	**972,967**
ROM coal production - Mtpa	1.135	1.208	1.250
Ratio of TSP:ROM production in kg of TSP per tonne of ROM coal produced	0.75	0.75	0.78

5.5 Estimated emissions from other local mines

The approach used to assess cumulative impacts would typically involve estimating emissions from nearby mines by referring to the relevant EISs for the years that most closely correspond to the stages being modelled for the No. 1 Open Cut Extension Project.

Figure 1 shows the locations of each of the existing and potential mines. These include:

- Bengalla
- Mt. Arthur North (now part of Mt Arthur Coal)
- Drayton

- Dartbrook
- Mt. Pleasant (at some period in the future).

In the cumulative modelling work, each neighbouring mine has been treated as five volume sources located at the apparent points of major emissions as determined by inspection of the dust contours provided in the EISs.

Sources have been considered in three classes; wind erosion sources where emissions vary with the hourly average wind speed according to the cube of the wind speed, and loading and unloading operations where emissions vary as wind speed raised to the power 1.3. All other sources have been assumed to have emissions independent of wind speed.

For neighbouring mines the proportions of emissions in each of these categories has been assumed to be (**Holmes Air Sciences, 2000**):

- 0.732 for emissions independent of wind speed
- 0.135 for emissions that depend on wind speed (such as loading and unloading), and
- 0.133 for wind erosion source.

6. METHODOLOGY

The short-term industrial source complex model (ISC3-ST - Version 99155) has been used in this study. The model is an advanced Gaussian dispersion model approved by the US EPA for use in regulatory assessments undertaken within the United States. It is one of the most widely used regulatory models in the world. The model is accepted by the NSW EPA for assessing the dispersion of dust. A complete description of the model is provided in US EPA publications (**US EPA 1995A** and **1995B**). These two volumes provide user instructions (Volume 1) and a comprehensive technical description of the algorithms used in the model (Volume 2). For convenience, a very brief description of the model is provided below.

The model uses the Gaussian dispersion equation to simulate the dispersion of a plume from either point, area or volume sources. The model takes account of dry and wet deposition and includes algorithms to account for retention of dust within an open pit and includes mechanisms for determining the effect of terrain on plume dispersion. The model works on an hourly time step. This means that it requires a meteorological file that provides wind speed, wind direction and other dispersion parameters on an hourly basis. For each hour the dispersion of plumes is determined using the conventional Gaussian model assumptions. These model assumptions have some limitations and it is worth noting some of these at this point.

One of the most significant limitations of the Gaussian model is that it assumes that a steady state dispersion condition is reached instantaneously. That is, if one were to imagine that the plume is simulating for a particular hour, one would see each source of dust producing a plume that extends indefinitely in the downwind direction to the edge of the prediction grid. In reality, under very light wind conditions, this is an inappropriate assumption.

Consider for example a condition where the wind speed is 0.5 m/s. At the end of one hour any emission that occurred at the beginning of the hour will have travelled approximately 1.8 km from the source

(0.5 m/s x 3,600 s). Thus, under these light wind conditions, the dust will have travelled 1.8 km from the source, but the model assumes the dust will have travelled to the edge of the prediction grid that in this case may be up to 10 km from the source. In the next hour the meteorological conditions may remain the same or, more likely, the wind direction will change and the light wind condition may still persist. The model then assumes that a new equilibrium is established instantaneously and the plume travels in the new downwind direction at the new wind speed.

Because for surface sources the worst-case dispersion conditions are associated with light winds the model has the potential to significantly overstate impacts at long distances downwind from the source. Since this problem leads to an overstatement of impacts rather than an understatement of impacts, this does not create a significant problem for environmental impact assessment. However, it should be borne in mind that there is a potential to overstate impacts at more distant receptors.

The ISC model also has the capacity to take into account emissions that vary in time, or with meteorological conditions. This has proved particularly useful for simulating emissions on mining operations where wind speed is an important factor in determining the rate at which dust is generated.

For the current study the mine was represented by a series of 25 volume sources. Each volume source was a combination of all dust emissions from activities in the general area. Estimates of emissions for each volume were developed on an hourly time step. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of mining activity and the wind speed. It is important to do this in the ISC model to ensure that long-term average emission rates are not combined with worst-case dispersion conditions which are associated with light winds. Light winds in a mining area correspond with periods of low dust generation (because wind erosion and other wind dependent emissions rates will be low) and also correspond with periods of poor dispersion. If these measures are not taken then the model has the potential to significantly overstate impacts.

7. ASSESSMENT OF IMPACTS DUE TO DUST EMISSION

7.1 Preamble

This section provides an interpretation of the predicted contours of dust concentration and deposition levels. Simulations were undertaken for each of the three years 1, 4 and 9.

It should be noted that the proposed mining operation and the existing activities are linked. Under the revised timing of mining operations, in Year 1 the No 2 Open cut will still be operational and contributing to the air emissions that are currently measured and accounted for as the existing" background" dust concentration and deposition. The predicted emissions from No. 1 Open Cut will, in fact, be overstated as the revised timing of mining operations will mean that only a small proportion of the modelled coal and overburden tonnages actually removed. As the air emissions are not being remodelled to reflect this change, the model predictions should considered for assessment of impacts purposes to be a "worst case" scenario.

For the Year 4 and Year 9 scenarios, the No. 2 Open Cut will have ceased operations. The currently recorded background levels include a component that is attributable to the operations of the No. 2 Open Cut. This will no longer be the case in Year 4 nor for later years. It would therefore be expected that the total dust concentration estimated after taking into account background levels will be less than that stated by an amount equal to the contribution that the No. 2 Open Cut currently makes to existing dust levels.

For each of the cases considered, isopleth diagrams have been produced showing the following:

1. The predicted annual average PM_{10} concentration
2. The predicted annual average TSP concentration, and
3. The predicted annual average dust deposition.

The air quality criteria used for deciding which properties are likely to experience air quality impacts are:

- EPA 24-hour PM_{10} Standard of 50 $\mu g/m^3$ for PM_{10}
- EPA annual average PM_{10} long term reporting goal of 30 $\mu g/m^3$ for PM_{10}
- NHMRC annual average TSP goal of 90 $\mu g/m^3$
- NSW EPA annual average deposition goal of 2 g/m^2/month.

Although these criteria appear simple to apply, in practice there are difficulties. The reason for this is that, with the exception of the 2 g/m^2/month goal, each standard/goal is a cumulative standard/goal and requires knowledge of the contribution of all other dust sources that contribute to the background level of dust. If this were confined to the past or existing conditions then monitoring data could be used to quantify existing dust concentration and deposition levels, at least for receptors at which such data were available. However, the assessment needs to consider periods in the future.

The most significant sources of particulate matter in the future would be expected to be mining, agriculture and human activity in and natural sources. Emissions from local human activity, agriculture and natural sources would be expected to remain at a more or less constant level over the next ten years or so. Mining sources may change depending on a number of factors many of which would be difficult to predict. However, because of the prevailing meteorological conditions the principle existing sources of particulate matter, namely Bengalla, Drayton, Dartbrook and Bayswater Colliery (now part of Mt Arthur Coal) contribute very little to concentrations of particulate matter in the area affected by emissions from Muswellbrook Coal. Potential future mines namely Mt. Arthur North and Mt Pleasant are in a similar position in the sense that they would not be expected to significantly affect air quality in the area that will be affected by Muswellbrook Coal. Therefore it is reasonable to assume that current monitoring represents background conditions that are likely to apply for the life of the project.

Based on the monitoring data reviewed in **Section 4** the following background levels have been assumed for assessment purposes:

- Annual average PM_{10} - 18.6 $\mu g/m^3$

- Annual average TSP - 46.6 μg/m^3
- Annual average deposition - 1 g/m^2/month.

7.2 Year 1

7.2.1 Predicted annual average PM_{10} - No. 1 Open Cut Extension alone and cumulatively

Figure 5 shows the predicted annual average PM_{10} concentrations for the No. 1 Open Cut Extension Project in Year 1. It shows that Residence 14 is the most affected by emissions from No. 1 Open Cut Extension. It is predicted to experience an annual average PM_{10} concentration of less than approximately 4 μg/m^3 due to emissions from the No. 1 Open Cut Extension Project. This is a very small fraction of the 30 μg/m^3 EPA annual average long term goal. Assuming a background of 18.6 μg/m^3 the net result would be 22.6 μg/m^3. This is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.2.2 Predicted annual average TSP - No. 1 Open Cut Extension alone and cumulatively

Figure 6 shows the predicted annual average TSP concentrations for the No. 1 Open Cut Extension Project in Year 1. It shows that Residence 14 is the most affected by emissions from No. 1 Open Cut Extension. It is predicted to experience an annual average TSP concentration of less than approximately 7 μg/m^3 due to emissions. This is a very small fraction of the 90 μg/m^3 NHMRC annual average guideline value. Assuming a background of 46.6 μg/m^3 the net result would be 53.6 μg/m^3. Again this is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.2.3 Predicted annual average dust deposition (insoluble solids)

Figure 7 shows the predicted increase in annual average dust deposition is approximately 0.8 g/m^2/month. This is well below EPA's incremental goal of 2 g/m^2/month that applies in areas experiencing existing dust deposition levels of 2 g/m^2/month and below. Again this is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.3 Year 4

7.3.1 Predicted annual average PM_{10} - No. 1 Open Cut Extension alone and cumulatively

Figure 8 shows the predicted annual average PM_{10} concentrations for the No. 1 Open Cut Extension Project in Year 4. It shows that Residence 13 is the most affected. It is predicted to experience an annual average PM_{10} concentration of approximately 3 μg/m^3 due to emissions from No. 1 Open Cut Extension. This is a small fraction of the 30 μg/m^3 EPA annual average long term goal. Assuming a background of 18.6 μg/m^3 the net result would be 21.6 μg/m^3. This is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.3.2 Predicted annual average TSP - No. 1 Open Cut Extension alone and cumulatively

Figure 9 shows the predicted annual average TSP concentrations due to emissions from the No. 1 Open Cut Extension Project. Residence 13 is the most affected and is predicted to experience an increase in annual TSP concentrations of approximately 5 µg/m^3. This is a small fraction of the 90 µg/m^3 NHMRC annual average guideline value. Assuming an annual background TSP concentration of 46.6 µg/m^3 the net result would be 51.6 µg/m^3. This is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.3.3 Predicted annual average dust deposition (insoluble solids)

Figure 10 shows the predicted annual average dust deposition for the No. 1 Open Cut Extension Project in Year 4. It shows that Residence 13 is the most affected. It is predicted to experience an annual average dust deposition rate of approximately 0.5 g/m^2/month. This is below EPA's incremental goal of 2 g/m^2/month that applies in areas experiencing existing dust deposition levels of 2 g/m^2/month and below.

7.4 Year 9

7.4.1 Predicted annual average PM_{10} - No. 1 Open Cut Extension alone and cumulatively

Figure 11 shows the predicted annual average PM_{10} concentrations for the No. 1 Open Cut Extension Project in Year 9. It shows that Residence 13 is the most affected. It is predicted to experience an annual average PM_{10} concentration of approximately 3 µg/m^3 due to emissions from the No. 1 Open Cut Extension. This is a small fraction of the 30 µg/m^3 EPA annual average long term goal. Assuming a background of 18.6 µg/m^3 the net result would be 21.6 µg/m^3. This is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.4.2 Predicted annual average TSP - No. 1 Open Cut Extension alone and cumulatively

Figure 12 shows the predicted annual average TSP concentrations due to emissions from the No. 1 Open Cut Extension Project. Residence 13 is the most affected and is predicted to experience an increase in annual TSP concentrations of approximately 5 µg/m^3. This is a small fraction of the 90 µg/m^3 NHMRC annual average guideline value. Assuming an annual background TSP concentration of 46.6 µg/m^3 the net result would be 51.6 µg/m^3. This is a conservative estimate since some of the emission from the No. 1 Open Cut Extension replaces emissions from existing operations at the No. 2 Open Cut.

7.4.3 Predicted annual average dust deposition (insoluble solids)

Figure 13 shows the predicted annual average dust deposition for the No. 1 Open Cut Extension Project in Year 9. It shows that Residence 13 is the most affected. It is predicted to experience an annual average dust deposition rate of marginally above 0.5 g/m^2/month. This is below EPA's incremental goal of 2 g/m^2/month that applies in areas experiencing existing dust deposition levels of 2 g/m^2/month and below.

7.5 Emissions of CO, NO_2 and SO_2

Diesel fuels used in mobile equipment and explosives will result in the emission of CO, NO_2 and SO_2. However experience from both modelling and monitoring data in the Hunter Valley has shown, that the level of emission and the distance to the boundary of Hunter Valley mines are such that none of the air quality criteria listed in **Table 1** are likely to be exceeded by these emission.

8. MONITORING AND MITIGATION MEASURES

The modelling results are based on the assumption that the project will apply dust control measures similar to those applied at other mines in the Hunter Valley. The locations of the nearby residential areas of North Muswellbrook to the west and southwest are favourable given the prevailing winds in the area. Nevertheless there will be a need to ensure that dust emissions are kept to the minimum practicable level to ensure that the effects of dust emissions are kept at the minimum levels practicable. This section outlines procedures proposed for the management and control of dust emissions.

Proposed dust management and control procedures
The following procedures are proposed for the management of dust emissions from the mine. The aim of these procedures is to minimise the emission of uncontrolled dust. Dust can be generated from two primary sources, these being:

i) wind blown dust from exposed areas, and

ii) dust generated by mining activities.

Table 7 and **Table 8**, list the different sources of wind blown and mining generated dust respectively, and their recommended control procedures.

Table 7. Control procedures for wind blown dust

Source	**Control Procedures**
Areas disturbed by mining	Disturb only the minimum area necessary for mining. Reshape, topsoil and rehabilitate completed overburden emplacement areas as soon as practicable after the completion of overburden tipping.
Coal handling areas	Maintain coal-handling areas in a moist condition using water carts to minimise wind blown and traffic generated dust.

Table 8. Control procedures for mining generated dust sources	
Source	**Control procedures**
Haul road dust	All roads and trafficked areas will be watered using water carts to minimise the generation of dust. All haul roads will have edges clearly defined with marker posts or equivalent to control their locations, especially when crossing large overburden emplacement areas. Obsolete roads will be ripped and re-vegetated.
Minor roads	Development of minor roads will be limited and the locations of these will be clearly defined. Minor roads used regularly for access etc will be watered. Obsolete roads will be, ripped and re-vegetated.
Topsoil stripping	Access tracks used by topsoil stripping machinery during their loading and unloading cycle will be watered.
Topsoil stockpiling	Long term topsoil stockpiles, not used for over 6 months will be re-vegetated.
Drilling	Dust aprons will be lowered during drilling. Drills will be equipped with dust extraction cyclones, or water injection systems. Water injection or dust suppression sprays will be used when high levels of dust are being generated.
Blasting	Adequate stemming will be used at all times and blasting confined to periods when wind speeds are below 5 m/s and not in the direction of residents.
Dump hopper	Automatic sprays are used when tipping raw coal into the hopper.

It is envisaged that the existing monitoring program operated by Muswellbrook Coal will be adequate to monitor the performance of the project, but a PM_{10} monitor in the residential areas to the northwest (near Residence 13/14) would provide data in the area close to that predicted to receive the greatest contribution from emissions from the project and the nearby existing mines.

9. GREENHOUSE GAS EMISSIONS

The project will require energy in the form of electricity for fixed plant and diesel and petrol for mobile plant and diesel for explosives. Use of this electrical energy and fuel will cause emissions of carbon dioxide (CO_2). In addition the combustion of the coal produced by the mine will result in the release of carbon dioxide.

The Muswellbrook Coal Company has provided estimates of annual petrol, diesel and electricity consumption for 2001 and the ten-years during which the project would operate. These have been used to estimate CO_2 emissions for this period. The results are summarized in **Table 9**.

Table 9. Estimated CO_2 emissions

Year	Diesel including fuel for lighting-plant, pumps and earthmoving plant (litres)	Diesel for explosives (litres)	Petrol for light duty vehicles (litres)	Electrical energy (kWh)	Annual production from No. 1 O/C Extension (t)	CO2 Equivalent due to energy usage (kg)
2001	6,587,323	116,799	30,000	4,968,589	-	23,282,121
Y1	1,018,738	-	30,000	151,781	99,700	2,978,957
Y2	1,684,831	25,251	30,000	757,536	497,600	5,468,658
Y3	3,368,825	50,490	30,000	1,840,405	1,208,900	11,192,679
Y4	3,535,945	52,995	30,000	2,976,530	1,507,600	12,830,540
Y5	5,645,539	84,612	30,000	5,031,205	1,514,500	20,727,259
Y6	5,521,378	82,761	30,000	5,020,548	1,507,500	20,377,204
Y7	5,550,357	83,186	30,000	5,009,130	1,500,000	20,444,426
Y8	5,604,729	84,001	30,000	5,009,130	1,500,000	20,592,879
Y9	5,536,674	82,981	30,000	5,007,608	1,499,000	20,405,484
Y10	1,790,349	26,833	30,000	921,040	605,000	5,926,801
Total	**45,844,688**	**689,909**	**330,000**	**36,693,502**	**11,439,800**	**164,227,008**

The estimates of CO_2 emissions in **Table 9** have been based on the following:

- For electricity usage the CO_2 emission factor is 0.00104 tCO_2 eq/kWh
- For diesel and petrol usage the CO_2 emission factor is 2.69 kg/L.

The estimates do not include emissions for land clearing (i.e. from removed vegetation). It has been assumed that rehabilitation would ensure that there is no net emission after the 10-year mining period.

Exposed coal seams will release methane to the atmosphere. It has a shorter life in the atmosphere (about 12 years compared with 50 to 200 years for CO_2 - see **Intergovernmental Panel on Climate Change (IPCC) (1996)**) before it is converted to carbon dioxide and water vapour. Nevertheless methane is a very ''effective'' greenhouse gas, with a warming potential of 21 compared with the warming potential for CO_2 of 1. Methane emissions from open cut mining are not accurately known, but the effective carbon emitted via methane emissions is believed to be minor compared with the emissions from the combustion of the coal and the other sources considered above.

There will be emissions of other greenhouse gases such as carbon monoxide and nitrogen oxides and non-methane volatile organic compounds etc. However these are not currently included in the Australian Greenhouse Offices National Aggregated Inventory. Other gases such as those used in air-cooling etc will be used in sealed systems and recycled to the maximum extent possible. Carbon dioxide will be the only significant greenhouse gas emitted by the project.

The combustion of the coal product by customers will result in the release of carbon dioxide, which will add to the quantity of carbon in the atmosphere. This is of course the largest contributor to greenhouse emissions that will occur as a result of the project. The mine has is planned to produce approximately 11.4 Mt over its ten year life. Approximately 16.3% of this is estimated to be ash and so the carbon content will be slightly less than 9.5 Mt. This will produce approximately 35.0 Mt of CO_2 on combustion over the ten year life of the mine.

In summary the annual average CO_2 emission (averaged over the ten year life of the mine) will be:

- 14,094 t/y attributable to use of electrical energy and fuels for equipment and blasting
- 3,500,000 t/y due to combustion of the coal produced.

These emissions can be compared with the 458.2 Mt CO_2 equivalent estimated by Environment Australia to have been produced by Australia in 1999 (excluding land clearing) (see http://www.greenhouse/facts/pdfs/nggifs1s.pdf). The greenhouse gas emissions (excluding the emissions when customers burn the coal) are estimated to be 0.003% of Australia's 1999 emissions.

Since energy consumption is a significant cost in mining, the mine plan is automatically designed to achieve minimum fuel consumption compatible with efficient operation of the mine and efficient use of capital. Thus measures to minimise emissions are an integral part of the mine plan.

10. CONCLUSIONS

The above analysis has examined the expected air quality impacts due to operation of the proposed mine. Potential air quality impacts examined are those due to emissions of various classes of particulate matter (TSP, PM_{10} and deposition of insoluble solids). The analysis covers three stages of the proposal, covering the entire project life. These stages were modelled to provide results from worst-case scenarios.

The assessment of impacts expected to arise through emissions of particulate matter have focused on testing for compliance with annual average concentration of PM_{10} and TSP and annual average dust (insoluble solids) deposition rates, taking into account all other sources of particulate matter.

It is concluded that no properties would be expected to experience concentrations of either PM_{10} or TSP, or dust deposition levels that are above the appropriate goal or standard.

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APPENDIX A
JOINT WIND SPEED WIND DIRECTION AND STABILITY CLASS TABLES FOR (McLEANS HILL) MT. ARTHUR NORTH METEOROLOGICAL DATA

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.023592	0.043897	0.002700	0.000235	0.000000	0.000000	0.000000	0.000000	0.070423
NE	0.017136	0.020775	0.000822	0.000000	0.000000	0.000000	0.000000	0.000000	0.038732
ENE	0.008920	0.005751	0.000587	0.000117	0.000000	0.000000	0.000000	0.000000	0.015376
E	0.008685	0.012324	0.002347	0.000352	0.000117	0.000000	0.000000	0.000000	0.023826
ESE	0.008099	0.033451	0.037676	0.032042	0.023474	0.014085	0.007746	0.001408	0.157981
SE	0.008333	0.041549	0.069601	0.061033	0.038380	0.017840	0.005869	0.001526	0.244131
SSE	0.005869	0.022418	0.019718	0.007864	0.002113	0.001408	0.000000	0.000000	0.059390
S	0.003404	0.004343	0.001995	0.000352	0.000000	0.000000	0.000000	0.000000	0.010094
SSW	0.003169	0.002582	0.000704	0.000117	0.000000	0.000000	0.000117	0.000000	0.006690
SW	0.004812	0.003404	0.000704	0.000117	0.000000	0.000000	0.000000	0.000000	0.009038
WSW	0.007864	0.007160	0.002113	0.000352	0.000235	0.000000	0.000000	0.000000	0.017723
W	0.014319	0.024178	0.010681	0.004343	0.001174	0.000587	0.000469	0.000352	0.056103
WNW	0.016080	0.024648	0.017254	0.015141	0.013498	0.010798	0.006103	0.001408	0.104930
NW	0.017136	0.023826	0.015962	0.010094	0.005751	0.001291	0.000469	0.000117	0.074648
NNW	0.016667	0.018310	0.008920	0.004812	0.002934	0.000117	0.000235	0.000000	0.051995
N	0.019014	0.029225	0.008920	0.001408	0.000352	0.000000	0.000000	0.000000	0.058920
CALM									0.000000
TOTAL	0.183099	0.317840	0.200704	0.138380	0.088028	0.046127	0.021009	0.004812	1.000000

MEAN WIND SPEED (m/s) = 3.60
NUMBER OF OBSERVATIONS = 8520

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 10.9%
B : 4.9%
C : 9.9%
D : 53.7%
E : 14.3%
F : 6.2%

STATISTICS FOR FILE: C:\MCC\Met\MA9900CL.ISC

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003873	0.002465	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.006455
NE	0.004225	0.002465	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.006808
ENE	0.002113	0.000822	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.003286
E	0.001526	0.003286	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.005164
ESE	0.002113	0.005164	0.001761	0.000117	0.000000	0.000000	0.000000	0.000000	0.009155
SE	0.002113	0.007746	0.002347	0.000117	0.000000	0.000000	0.000000	0.000000	0.012324
SSE	0.001643	0.004930	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.006808
S	0.000822	0.001174	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.002347
SSW	0.000822	0.001056	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001878
SW	0.001291	0.001526	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002817
WSW	0.001995	0.001056	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.003169
W	0.003404	0.005282	0.000939	0.000000	0.000000	0.000000	0.000000	0.000000	0.009624
WNW	0.003286	0.006103	0.001056	0.000000	0.000000	0.000000	0.000000	0.000000	0.010446
NW	0.004812	0.006573	0.000704	0.000117	0.000000	0.000000	0.000000	0.000000	0.012207
NNW	0.004577	0.003638	0.000704	0.000117	0.000000	0.000000	0.000000	0.000000	0.009038
N	0.004460	0.003169	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.007864
CALM									0.000000
TOTAL	0.043075	0.056455	0.009390	0.000469	0.000000	0.000000	0.000000	0.000000	0.109390

MEAN WIND SPEED (m/s) = 1.84
NUMBER OF OBSERVATIONS = 932

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002113	0.000822	0.000469	0.000117	0.000000	0.000000	0.000000	0.000000	0.003521
NE	0.000704	0.000469	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.001408
ENE	0.000469	0.000469	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000939
E	0.000587	0.000704	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.001643
ESE	0.000469	0.002113	0.002582	0.001761	0.000000	0.000000	0.000000	0.000000	0.006925
SE	0.000117	0.001878	0.003756	0.001526	0.000000	0.000000	0.000000	0.000000	0.007277
SSE	0.000235	0.000822	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.001291
S	0.000117	0.000352	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.000587
SSW	0.000117	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000352
SW	0.000000	0.000235	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.000352
WSW	0.000235	0.000939	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.001291
W	0.000939	0.000822	0.000939	0.000000	0.000000	0.000000	0.000000	0.000000	0.002700
WNW	0.001291	0.003169	0.001761	0.000235	0.000000	0.000000	0.000000	0.000000	0.006455
NW	0.002347	0.002230	0.001174	0.000117	0.000000	0.000000	0.000000	0.000000	0.005869
NNW	0.001643	0.001643	0.000822	0.000235	0.000000	0.000000	0.000000	0.000000	0.004343
N	0.001526	0.001408	0.000587	0.000117	0.000000	0.000000	0.000000	0.000000	0.003638
CALM									0.000000
TOTAL	0.012911	0.018310	0.013263	0.004108	0.000000	0.000000	0.000000	0.000000	0.048592

MEAN WIND SPEED (m/s) = 2.56
NUMBER OF OBSERVATIONS = 414

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002817	0.004225	0.000822	0.000000	0.000000	0.000000	0.000000	0.000000	0.007864
NE	0.001878	0.001174	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.003169
ENE	0.000587	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000939
E	0.000352	0.001056	0.000352	0.000235	0.000000	0.000000	0.000000	0.000000	0.001995
ESE	0.000000	0.001995	0.007394	0.009624	0.000000	0.000000	0.000000	0.000000	0.019014
SE	0.000235	0.002347	0.008216	0.009272	0.000000	0.000000	0.000000	0.000000	0.020070
SSE	0.000117	0.000469	0.000235	0.000235	0.000000	0.000000	0.000000	0.000000	0.001056
S	0.000235	0.000235	0.000117	0.000117	0.000000	0.000000	0.000000	0.000000	0.000704
SSW	0.000235	0.000352	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.000822
SW	0.000117	0.000117	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000235
WSW	0.000822	0.000235	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.001408
W	0.001526	0.002347	0.001408	0.001056	0.000000	0.000000	0.000000	0.000000	0.006338
WNW	0.001526	0.002347	0.003756	0.002465	0.000000	0.000000	0.000000	0.000000	0.010094
NW	0.001056	0.002230	0.003404	0.005282	0.000000	0.000000	0.000000	0.000000	0.011972
NNW	0.001291	0.001408	0.001995	0.003169	0.000000	0.000000	0.000000	0.000000	0.007864
N	0.001056	0.002230	0.001878	0.000704	0.000000	0.000000	0.000000	0.000000	0.005869
CALM									0.000000
TOTAL	0.013850	0.023122	0.030282	0.032160	0.000000	0.000000	0.000000	0.000000	0.099413

MEAN WIND SPEED (m/s) = 3.51
NUMBER OF OBSERVATIONS = 847

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.005986	0.026643	0.001291	0.000117	0.000000	0.000117	0.000000	0.000000	0.034155
NE	0.003404	0.011033	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.014789
ENE	0.001878	0.002465	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.004577
E	0.001526	0.004930	0.000939	0.000117	0.000117	0.000000	0.000000	0.000000	0.007629
ESE	0.001643	0.016197	0.022066	0.020540	0.023474	0.014085	0.007746	0.001408	0.107160
SE	0.001878	0.015845	0.044366	0.049061	0.038380	0.017723	0.005869	0.001526	0.174648
SSE	0.000704	0.005986	0.006103	0.006103	0.001995	0.001408	0.000000	0.000000	0.022300
S	0.000469	0.001056	0.000704	0.000235	0.000000	0.000000	0.000000	0.000000	0.002465
SSW	0.000235	0.000469	0.000352	0.000000	0.000000	0.000000	0.000117	0.000000	0.001174
SW	0.000352	0.000822	0.000587	0.000117	0.000000	0.000000	0.000000	0.000000	0.001878
WSW	0.000704	0.002347	0.000704	0.000352	0.000235	0.000000	0.000000	0.000000	0.004343
W	0.002465	0.008803	0.003873	0.003052	0.001291	0.000587	0.000469	0.000352	0.020892
WNW	0.003169	0.007394	0.007629	0.011268	0.013498	0.010798	0.006103	0.001408	0.061268
NW	0.003873	0.009155	0.008803	0.003991	0.005751	0.001291	0.000469	0.000117	0.033451
NNW	0.002230	0.007042	0.005164	0.001291	0.002934	0.000117	0.000235	0.000000	0.019014
N	0.004343	0.016549	0.005751	0.000587	0.000352	0.000000	0.000000	0.000000	0.027582
CALM									0.000000
TOTAL	0.034859	0.136737	0.108920	0.096831	0.088028	0.046127	0.021009	0.004812	0.537324

MEAN WIND SPEED (m/s) = 4.63
NUMBER OF OBSERVATIONS = 4578

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003991	0.007864	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011854
NE	0.003638	0.005164	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008803
ENE	0.001174	0.001056	0.000000	0.000117	0.000000	0.000000	0.000000	0.000000	0.002347
E	0.002113	0.001995	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.004460
ESE	0.001408	0.007277	0.003756	0.000000	0.000000	0.000000	0.000000	0.000000	0.012441
SE	0.002700	0.011502	0.011033	0.001056	0.000000	0.000000	0.000000	0.000000	0.026291
SSE	0.001291	0.007981	0.012911	0.001526	0.000000	0.000000	0.000000	0.000000	0.023709
S	0.000704	0.001056	0.000704	0.000000	0.000000	0.000000	0.000000	0.000000	0.002465
SSW	0.000352	0.000117	0.000117	0.000117	0.000000	0.000000	0.000000	0.000000	0.000704
SW	0.000587	0.000469	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001056
WSW	0.001174	0.001408	0.000822	0.000000	0.000000	0.000000	0.000000	0.000000	0.003404
W	0.002465	0.005164	0.003521	0.000235	0.000000	0.000000	0.000000	0.000000	0.011385
WNW	0.003169	0.003638	0.003052	0.001174	0.000000	0.000000	0.000000	0.000000	0.011033
NW	0.001878	0.003052	0.001878	0.000587	0.000000	0.000000	0.000000	0.000000	0.007394
NNW	0.003756	0.002934	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.006925
N	0.004108	0.004577	0.000469	0.000000	0.000000	0.000000	0.000000	0.000000	0.009155
CALM									0.000000
TOTAL	0.034507	0.065258	0.038850	0.004812	0.000000	0.000000	0.000000	0.000000	0.143427

MEAN WIND SPEED (m/s) = 2.43
NUMBER OF OBSERVATIONS = 1222

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.004812	0.001878	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006690
NE	0.003286	0.000469	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003756
ENE	0.002700	0.000587	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003286
E	0.002582	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002934
ESE	0.002465	0.000704	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003169
SE	0.001291	0.002230	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003521
SSE	0.001878	0.002230	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004108
S	0.001056	0.000469	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001526
SSW	0.001408	0.000352	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001761
SW	0.002465	0.000235	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002700
WSW	0.002934	0.001174	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004108
W	0.003521	0.001761	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005282
WNW	0.003638	0.001995	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005634
NW	0.003169	0.000587	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003756
NNW	0.003169	0.001643	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004812
N	0.003521	0.001291	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004812
CALM									0.000000
TOTAL	0.043897	0.017958	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.061854

MEAN WIND SPEED (m/s) = 1.37
NUMBER OF OBSERVATIONS = 527

APPENDIX B
MONTHLY DUST (INSOLUBLE SOLIDS) DEPOSITION DATA

	Site 2	Site 7	Site 10	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 22	Site 23	Site 24	Site 26	Site 27
Jan-88	1.5	2.1			11.4	1.1									
Feb-88	1.1	0.7			9.1	1.6									
Mar-88	0.9	3.0			5.0	0.6									
Apr-88	0.5	0.7	0.6		5.3	0.6									
May-88	3.2	0.8	2.9		3.3	0.4									
Jun-88	0.9	0.7	1.1		2.0	0.6									
Jul-88	0.9		1.0		1.5	0.5									
Aug-88	1.3	0.6	5.3		1.4	0.7									
Sep-88	0.8	1.3			2.6	1.0									
Oct-88	0.7	1.0			6.2	0.5									
Nov-88	1.6	1.3	2.3		4.3	0.8									
Dec-88															
Annual	**1.2**	**1.2**	**2.2**	-	**4.7**	**0.8**	-	-	-	-	-	-	-	-	-
Jan-89	2.0	2.5	1.3		14.5	2.9									
Feb-89	1.4	1.1	2.5		27.9	1.1									
Mar-89	1.4	1.2	2.2		11.2	1.8									
Apr-89	1.2	5.9	1.2		5.7	1.3									
May-89	1.1		2.4		4.7										
Jun-89	0.9	0.4			0.8	0.4									
Jul-89	0.9	0.4	0.0		0.8	0.4									
Aug-89	3.0	2.2	1.9		3.8	1.8									
Sep-89	2.5	1.0			2.7	1.1									
Oct-89	1.2		1.2		4.0	1.7									
Nov-89	0.9	1.3	0.3		18.4	2.7									
Dec-89	1.0	0.3	1.4		11.4	1.3									
Annual	**1.4**	**1.6**	**1.4**	-	**8.8**	**1.5**	-	-	-	-	-	-	-	-	-
Jan-90	0.6	0.8	0.9		10.0	1.5									
Feb-90	1.4	1.9	1.4		7.5	3.4									
Mar-90	1.3		4.3		6.5	3.3									
Apr-90	0.3		1.8		1.4	0.4									
May-90	0.5	1.0	1.3		2.3	1.9									
Jun-90	0.4	0.8	1.8			0.8									
Jul-90	0.4	0.4	2.4			1.1									
Aug-90	0.0	0.0	0.6			0.1									
Sep-90	0.1	0.3	4.4			1.9									
Oct-90	0.8	0.8				2.3									
Nov-90	1.4	1.6	3.0			1.9									
Dec-90		0.8	3.0			1.5									
Annual	**0.6**	**0.8**	**2.3**	-	**5.5**	**1.7**	-	-	-	-	-	-	-	-	-
Jan-91	1.5	0.8	4.4		0.8	1.3									
Feb-91	2.4	0.3	5.8		1.0	1.0									
Mar-91	2.9		2.7		1.4	2.4									
Apr-91	2.5	1.1	4.4		0.9	1.6									
May-91	1.4	3.4	12.6		8.0	4.6									
Jun-91	0.5	0.3	0.5			1.0									
Jul-91		0.4	5.4		0.4	0.8									
Aug-91	0.5	0.5	1.7		0.5	1.8									
Sep-91	3.1	3.2	3.7		2.4	5.4									
Oct-91	1.3	1.7	2.3		1.3	2.4									
Nov-91	1.5	2.2	2.4		0.9	3.4									
Dec-91	0.8	3.0	16.6		1.3	3.1									
Annual	**1.7**	**1.5**	**5.2**	-	**1.7**	**2.4**	-	-	-	-	-	-	-	-	-
Jan-92	2.6		3.7		3.9	3.4									
Feb-92	0.9	1.3	2.2		0.6	1.0									
Mar-92	1.7		8.2		1.1	4.8									
Apr-92	0.8	0.9	4.0		1.5	2.2									
May-92	0.6	0.8	9.0		1.1	2.9									
Jun-92	1.0	1.2	10.5		0.1	1.2									
Jul-92	0.6	1.7	10.3		0.5	2.3									
Aug-92	1.2	1.2	13.1		1.2	2.3									
Sep-92	1.5	0.6	4.0		0.6	1.4									
Oct-92	4.5	1.8	3.9		1.0	2.9									
Nov-92	5.0	2.2	2.9		1.1	2.0									
Dec-92	3.5	5.9	1.5		2.9	3.9									
Annual	**2.0**	**1.8**	**6.1**	-	**1.3**	**2.5**	-	-	-	-	-	-	-	-	-

	Site 2	Site 7	Site 10	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 22	Site 23	Site 24	Site 26	Site 27
Jan-93	4.2		4.7		1.6	2.3									
Feb-93	4.0	1.2	3.2		1.6	2.2									
Mar-93	2.7	1.5	1.3		0.4	2.9									
Apr-93	1.3	1.8	2.0		2.5	1.8									
May-93	2.6	1.5	2.3		1.5	3.7									
Jun-93	0.6	0.4	2.9		0.2	2.8									
Jul-93	1.1	1.0	5.8		0.6	2.4									
Aug-93	1.7	2.8	3.5		0.6	1.7									
Sep-93		0.8	4.6		1.6	2.1									
Oct-93		2.6	5.9		0.7	2.6									
Nov-93	8.7	2.0	1.9		1.0										
Dec-93	0.7	2.5	2.8		3.1	5.1									
Annual	**2.8**	**1.6**	**3.4**	-	**1.3**	**2.7**	-	-	-	-	-	-	-	-	-
Jan-94	2.4	1.7			2.1	4.4									
Feb-94	1.4	1.4	2.9		6.3	4.5									
Mar-94	0.5	0.8	0.6		2.0	1.5									
Apr-94	0.5	0.8	0.6		2.0	1.5									
May-94	0.7	0.5			4.3	4.2									
Jun-94	0.8	0.8	2.6		2.2	2.2									
Jul-94	2.3	0.5	3.0		0.7	2.1									
Aug-94	1.5	0.7	2.3		1.5	2.1									
Sep-94	3.5	1.8	2.8		2.0	1.5									
Oct-94	2.9	1.5	2.9		1.6	3.0									
Nov-94	2.6	1.0	2.6		8.7	2.7									
Dec-94	3.6	1.0	2.3	0.7	1.3	0.6	1.8								
Annual	**1.9**	**1.0**	**2.3**	**0.7**	**2.9**	**2.5**	**1.8**	-	-	-	-	-	-	-	-
Jan-95	3.9	1.2	2.2	2.0	3.1	5.3	1.9								
Feb-95		0.6	1.3	0.7	1.6		1.0								
Mar-95	2.1	0.8	1.0	1.2	1.6	0.9	1.4								
Apr-95	2.0	1.2	2.3	0.8	1.7	1.4	2.0								
May-95	0.7	0.3	1.7	0.6	2.1	0.7	0.7			1.2					
Jun-95	1.4	0.9	4.1	0.5	3.6	1.1	0.7			1					
Jul-95	0.4	0.1	2.5	0.3	0.4	1.0	0.3			1.5					
Aug-95	1.4		2.0	0.7	1.5	0.7	0.7			0.6					
Sep-95	2.7	0.9	3.1	0.9	1.9	0.8	1.3			0.7					
Oct-95	3.0	1.1	2.2	0.9	1.8	0.7	0.8			0.4					
Nov-95	1.2	2.6	2.1	0.6	1.6	0.8	1.3			0.6					
Dec-95	1.9	1.6	1.9	1.0	4.5	1.4	1.9	0.9	0.9	1.2					
Annual	**1.9**	**1.0**	**2.2**	**0.9**	**2.1**	**1.3**	**1.2**	**0.9**	**0.9**	1.2	-	-	-	-	-
Jan-96	1.3	1.4	1.6	0.9	1.4	1.5	1.2	2.2	3.3	1.0					
Feb-96	1.5	2.0	2.3	1.6	1.1	2.3	1.3	1.5	1.0	1.5					
Mar-96	1.2	0.7	3.6	1.3	0.9	1.5	1.4	0.9	0.7	0.6					
Apr-96	1.2	1.1	2.9	0.5	0.7	0.8	1.4	0.8	0.8	0.7	1.4	1.0	2.4		
May-96	0.7	0.6	2.5	0.4	0.5	0.6	0.8	0.5	0.6	0.4	0.7	0.4	1.1		
Jun-96	1.2	0.8	3.1	0.7	2.7	0.7	0.6	0.6	0.6	0.6	1.0	0.5	1.7		
Jul-96	1.2	0.5	4.0	0.6	1.6	0.6	0.7	0.5	0.6	0.6	0.7	0.3	0.9		
Aug-96	0.7	0.5	2.5		2.9	0.4	0.4	0.3	0.3	0.5	1.1	0.4	2.7		
Sep-96	3.4	1.8	5.4	2.1	2.8	2.3	1.6	1.7	2.1	0.7	2.2	1.7	4.9		
Oct-96	1.0	1.0	2.2	0.8	2.5	3.1	1.4	0.9	2.1	0.5	0.8	0.6	2.2	0.7	0.9
Nov-96	1.7	1.0	4.4	1.6	5.7	1.7	1.4	1.0	1.0	0.9	1.0	1.3	1.5	9.0	1.2
Dec-96	2.8	0.9	1.3	1.0	1.6	1.9	0.8	0.8	0.7	0.9	0.9	0.7	3.2	1.1	1.0
Annual	**1.5**	**1.0**	**3.0**	**1.0**	**2.0**	**1.5**	**1.1**	**1.0**	**1.2**	0.7	**1.1**	**0.8**	**2.3**	**3.6**	**1.0**
Jan-97	2.8	1.0	1.8	1.3	1.2	3.3	2.9	0.8	1.4	0.9	1.1	0.7	3.2	1.1	1.0
Feb-97	1.9	0.6	1.4	0.7	4.2	1.4	1.4	1.0	1.0	6.7	0.6	7.8	2.3	0.6	1.2
Mar-97	0.4	0.3	0.9	1.3	1.3	0.9	4.2	0.9	1.0	0.5	0.8	0.2	4.5	0.5	0.3
Apr-97	1.8	1.0	3.3	1.0	1.5	1.9	2.6	1.5	3.4	1.6	1.3	1.3	2.6	1.2	1.5
May-97	2.3	0.1	1.8	0.4	0.8	3.5	1.8	0.7	1.3	0.5	0.5	0.3	2.4	0.8	1.0
Jun-97	2.1	0.4	2.1	0.8	1.5	4.5	1.3	0.7	1.9	0.5	0.6	0.6	2.2	1.0	1.1
Jul-97	0.8	0.4	13.4	0.8	4.8	1.1	1.2	0.5	0.8	0.4	0.7	0.5	1.2	13.3	0.7
Aug-97	1.5	0.5	2.1	1.2	3.3	2.0	1.1	0.7	0.6	0.6	0.8	0.5	2.9	1.0	0.8
Sep-97	4.7	0.5	1.4	0.6	0.6	4.5	1.2	0.5	0.8	0.4	1.2	1.6	2.2	0.7	1.4
Oct-97	2.7	1.1	1.9	1.4	6.1	3.0	2.7	1.0	1.4	0.5	0.9	2.9	2.7	0.9	
Nov-97	2.8	1.8	3.6	2.5	5.7	3.7	1.9	4.4	1.0	0.9	1.7	1.2	1.6	3.2	0.7
Dec-97	6.2	2.3	3.1	1.0	6.5	3.6	3.5	1.0	1.3	1.2	1.6	1.2	3.9	1.3	1.3
Annual	**2.5**	**0.8**	**3.1**	**1.1**	**3.1**	**2.8**	**2.2**	**1.1**	**1.3**	1.2	**1.0**	**1.6**	**2.6**	**2.1**	**1.0**
Jan-98		1.2	1.5	2.8	3.2	2.9	3.2	1.5	1.9	2.4	2.4	0.9	2.7	0.7	1.4
Feb-98	1.4		3.8	2.4	1.8	1.3	2.6	1.2	1.8	1.1	1.3	13.7	1.7	1.1	2
Mar-98	1.9	0.8	1.8	0.3	2.7	2.4	1.7	1.3	1	0.3	0.7	0.6	3.2	0.8	1.1
Apr-98	2	2	1.9	1.2	3.6	3.7	3.2	1.3	0.9	1.1	1.2	1	2.6	0.9	1.7
May-98	0.9		0.9	0.5	0.8	3	0.8	0.2	11.4	0.3	1	0.2	0.8	0.4	0.6
Jun-98	1.4			1	1.7	2.6	1	0.7		1.2	1.4	0.5	1.4	0.8	1
Jul-98	1.3	1.2		0.9	2.7	2.9	0.6	0.2	8.6	0.4	0.9	0.3	1.9	0.5	0.7
Aug-98	0.8	0.2		0.4	9	6.2	1.1	0.2	3.7	0.4	0.7	0.3	4.2	0.4	0.5
Sep-98	1.9	0.6	1.7	0.5	1.4	1.8	1.3	0.7	29.	3.2	0.7	0.3	1.7	0.5	0.5

	Site 2	Site 7	Site 10	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 22	Site 23	Site 24	Site 26	Site 27
									9						
Oct-98	1.2	0.6	2.7	1.1	1.2	6.8	1.1	0.6	1	0.7	1.5	0.5	1.2	0.9	0.8
Nov-98	4.1	0.8	1.9	5.5	0.9	3.1	1.9	0.7	0.9	2.8	0.9	0.8	2.5	0.9	3.3
Dec-98	3.1	0.8	1.7	1	0.8	-	1.3	0.7	0.6	1.0	0.8	0.5	1.9	0.58	1.4
Annual	**1.8**	**0.9**	**2.0**	**1.5**	**2.5**	**3.3**	**1.7**	**0.8**	**5.6**	1.2	**1.1**	**1.6**	**2.2**	**0.7**	**1.3**
Jan-99	3.4	1.8	NR	1	1.1	4.3	2.1	0.6	0.9	1.3	1.2	1.2	0.9	0.8	0.9
Feb-99	2.6	0.9	3	0.8	0.9	3.9	2.7	1.1	1.1	1.0	0.6	1.7	1.9	1.1	0.8
Mar-99		0.6	1.7	1.4	7.1	2.5	1.9	1	0.7	0.5	1.1	0.6	2.8	0.8	0.8
Apr-99															
May-99	5.9	0.6	1.2	0.6	1.2	1.4	1.9	0.9	0.8	2.9	0.6	0.4	1.1	0.8	1.8
Jun-99	1.2	0.5	1.9	0.6	1.1	1.8	3.9	0.6	0.5	0.8	0.8	0.4	0.9	0.7	2
Jul-99	1.4	0.4		0.4	0.6	1.9	1	0.3	0.3	0.4	0.5	0.2	0.8	0.4	2.3
Aug-99	1.8	0.5	2.5	0.8	1.3	4.3	1.3	0.7	0.5	0.4	1	0.3	1	0.7	1.5
Sep-99	3.3	0.9	3.8	0.9	3.3	3.2	1	0.7	2.6	0.8	0.7	0.3	0.7	0.7	1.9
Oct-99	2.7	2	4	0.9	13.2	3.3	13.8	0.9	3.5	0.6	0.9	2.8	1.6	0.9	1.4
Nov-99	1.5	2.8	1.1	0.9	2.1	2.7	2	0.9	1	3.0	1	0.7	2	2.1	1.7
Dec-99	1.3	0.9	1.3	1.7	1.9	2.3	1.7	1.7	1	2.1	1.4	0.5	1.3	0.5	0.9
Annual	**2.5**	**1.1**	**2.3**	**0.9**	**3.1**	**2.9**	**3.0**	**0.9**	**1.2**	1.3	**0.9**	**0.8**	**1.4**	**0.9**	**1.5**
Jan-00	2.7	1.9	1.1	1	1.3	1.4	1.1	0.6	0.8	5.4	0.5	2	1	0.7	1.3
Feb-00	3.4	0.9	6.9	0.8	1.7	1.5	2.7	0.6	0.4	6.9	0.9	2.3	1.7	0.8	0.8
Mar-00	3.6	1.1	2.6	1.3	1.3	2.3	2.2	0.7	7.8	0.9	0.5	2.1	1.3	7.5	12.5
Apr-00	1.1	0.5	1.4	1.4	6.3		0.8	0.6	13.9	0.7	0.5	0.7		0.9	3.8
May-00	3.5	0.8	0.9		0.8		2.9	0.4	0.9	1.9	1.6	0.3	0.3	0.7	9.6
Jun-00	1.8	1.3	1		0.8	2.9	1	0.6	1.6	0.5	2	0.2	0.3	2.5	2.3
Jul-00	0.5	1.8	1.3		3	1.5	0.6	0.5	1.5	0.7	2	0.6	0.5	3.1	2.3
Aug-00	1.2	1.2	0.6		2.2	2	1.4	0.7	0.8	1.9	1.8	0.8	1.7	4.8	0.3
Sep-00															
Oct-00	0.9	0.3	1.3		1.7	1	0.6	0.3	1.1	0.9	0.7	0.6	0.3	2.4	4.6
Nov-00	0.3	0.1	0.3		1.7	0.7	0.2	0.1	0.8	0.3	0.5	0.6	1.9	1.4	
Dec-00															
Annual	**1.9**	**1.0**	**1.7**	**1.1**	**2.1**	**1.7**	**1.4**	**0.5**	**3.0**	2.0	**1.1**	**1.0**	**1.0**	**2.5**	**4.2**
Jan-01	1	0.6	2.5		2.2	2.6	3.1	0.8	0.6	2.5	1.2	0.5	0.6	0.9	1.4
Feb-01	3.3	0.8	0.7		2.2	1.3	1.2	0.9	1.4	0.5	0.6	0.7	1.2	4.6	1.2
Mar-01	1.8	1.4	1		1.1	0.6	0.4	2.6	2	0.7	0.9	0.3	1	3.8	3.4
Apr-01	0.8	0.8	0.9		2.9	1.3	1	0.5	0.8	6.0	0.4	0.5	2.8	0.8	0.9
May-01	0.4	0.5	1.8		3.3	1.7	1.9	1	1.1	1.1	2.1	1.1	2.3	1.7	1.8
Jun-01	0.5	0.5	2		1.2	0.4	0.6	0.4	0.4	0.8	2.3	0.4	1	0.8	0.6
Jul-01	1	0.4	1.9		1.2	1.2	1.5	0.7	0.4	0.9	3	0.6	1.4	3.2	1.4
Aug-01	0.3	0.2	1.5		2.3	0.9	0.8	0.7	0.5	0.4	0.5	0.3	1.2	2.5	1.3
Sep-01	1.1	0.7	1.7		7.6	2.4	2.4	1.2	0.9	0.4	1	1.8	2.8	1.8	2.1
Oct-01	0.8	0.7	3.6		16.1	1.3	1.2	0.9	0.7	0.9	1.5	0.6	1.1	1.9	0.6
Nov-01	1.6	1.3	0.9		2.7	3.1	1.4	0.8	0.8		0.8	0.3	2.1	1.1	0.8
Dec-01	1.0	0.8	1.5		2.0		2.6	6.0	1.6		2.3	2.3	5.8	4.0	2.5
Annual	1.1	0.7	1.7		3.7	1.5	1.5	1.4	0.9	1.4	1.4	0.8	1.9	2.3	1.5

APPENDIX C
DUST EMISSIONS ESTIMATES – DETAILS OF CALCULATIONS FOR MODELLING

YEAR 1- ESTIMATED DUST EMISSIONS

Introduction
This section presents the detailed calculations used to develop the emissions inventory required for the model predictions of dust dispersion. The inventory has been estimated using emission factor equations provided in the **US EPA's (1985)** (and subsequent updates) publication referred to as **AP-42** and from factors determined by **NERDDC (1986)** and from mine planning information provided by Coal and Allied. There is considerable repetition in the information provided for each of the inventories presented in this appendix. This is done to allow the reader to focus on a particular year without the need to cross-reference to information in other years.

Estimated TSP emissions have been presented to an accuracy of one kilogram. This is done to assist in checking that the mathematics has been followed through correctly. It should not be used to infer that the accuracy of the estimated TSP emission is to within one kilogram. The accuracy of TSP emissions from individual activities is essentially unquantifiable. However, based on model validation studies (**Dames and Moore, 1983**) it can be assumed that overall 80% of predicted long-term deposition rates will lie within ± 40% of measured rates.

Estimated emissions are presented for all significant dust generating activities associated with the extension.

It has been assumed that mining activities occur 24 hours per day, 7 days per week. Dust from wind erosion is assumed to occur over 24 hours per day, but wind erosion is also assumed to be proportional to the third power of wind speed. Generally, this will mean that most wind erosion occurs in the day when wind speeds are highest.

OPERATIONS ON OVERBURDEN

Drilling overburden
Approximately 50% of material will need to be blasted. In Year 1 the total quantity of material blasted in Year 1 is estimated to be 2,076,500 bcm [4,153,000/2] bcm. Assuming a hole spacing of 7.5 m and depth of 15 m it is estimated that this will involve approximately 2,461 [2,076,500 m^3 / (15 m x 7.5 m x 7.5 m] holes being drilled. It is assumed that 0.59 kg of TSP will be generated in drilling each hole **(US EPA, 1985)**, and so the total TSP emission from blasting overburden is estimated to be 1,452 kg/y [2,461 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 1**.

Equation 1

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad \text{kg/blast}$$

where :

A = area to be blasted in m^2

The area of a typical blast has been estimated to be 2,500 m^2. The estimated TSP emission from a typical blast is 27.5 kg. Assuming that there will be 55 [2,076,500 bcm/(15 m x 2.500 m^2)] shots in the life of the project the TSP emission is estimated to be 1,513 kg [27.5 kg/blast x 55 blasts/year].

Dozers on overburden dumps
For Year 1 it is assumed that 7,000 dozer-hours will be worked (500 hours for drill preparation, 500 hours for shot cleanup, 2,000 h for cleanup around the excavator and 4,000 h on dumps and roads). The US EPA emission factor equation is given in **Equation 2**.

Equation 2

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

where,

s = silt content (%), and

M = moisture content (%)

Taking M to be 4% and s to be 10%, the emission factor is estimated to be 6.8 kg/hour. The total TSP emission from the dozers is therefore 47,600 kg/y [7,000 h/y x 6.8 kg/h].

This TSP emission would be distributed as follows:

- Drill preparation 3,400 kg/y
- Shot cleanup 3,400 kg/y
- Assisting excavator 13,600 kg/y
- Dumps and roads 27,200 kg/y.

Loading overburden to trucks
In Year 1 approximately 4,153,000 bcm of overburden and interburden will be loaded into trucks and transported to the dump area.

Assuming a density of 2.4 t/bcm this is equivalent to approximately 9,967,200 t [4,153,000 m^3 x 2.4 t/m^3]. The TSP emission from each tonne of material loaded will depend on the wind speed and the moisture content or the material. **Equation 3** shows the relationship between these variables.

Equation 3

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

where,

$k = 0.74$

U = wind speed (m/s)

M = moisture content (%)

[where $0.25 \le M \le 4.8$]

For the Mt. Arthur North meteorological data set the annual average value of $(u/2.2)^{1.3}$ is 2.0295

Assuming a moisture content of 4%, the total emission for Year 1 is therefore given by;

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where;

U = the wind speed in m/s.

The annual average emission factor for TSP emission from loading overburden to trucks is therefore 0.0009 kg/t. For Year 1 9,967,200 t [2.4 t/bcm x 4,1563,000 bcm] of overburden will be loaded so the annual TSP emission is 8,970 kg [9,967,200 t x 0.0009 kg/t]

Hauling overburden to waste dump
A total of approximately 4,153,000 bcm of overburden will be hauled to the waste dump area using 190 t trucks. Assuming a return trip of approximately 2 km for overburden emplacement the annual TSP emission for hauling overburden will be 104,918 kg [(9,967,200 t / 190 t/trip x 2 km/trip x 1 kg/VKT].

Unloading overburden to waste dump
In Year 1 a total of approximately 9,967,200 t of material will be unloaded from trucks. The emission factor used for this process is 0.0009 kg/t (i.e the same as for loading overburden to trucks). The annual TSP generated from unloading overburden is therefore expected to be 8,970 kg [9,967,200 t x 0.0009 kg/t].

OPERATIONS ON COAL

Drilling coal
The will be no drilling of coal.

Blasting coal
The will be no blasting of coal.

Dozers working on coal
In Year 1 it is assumed that 3,000 dozer-hours will be devoted to working on coal (ripping and pushing). The US EPA emission factor equation is given in **Equation 7**

Equation 7

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \quad \text{kg/hour}$$

where,

s = silt content (%), and

M = moisture content (%)

Taking M to be 4% and s to be 8%, the emission factor is estimated to be approximately 61.9 kg/hour. The total TSP emission from the dozers is therefore approximately 185,700 kg/y [3,000 h/y x 61.9 kg/h].

Loading coal to trucks
In Year 1 1,135,000 t of ROM coal will be loaded into trucks. The emission factor used for this process is given in **Equation 8**

Equation 8

$$E_{TSP} = \frac{0.580}{M^{1.2}} \quad \text{kg/t}$$

where,

M = moisture content (%)

Taking M to be 4%, the emission factor is estimated to be approximately 0.110 kg/t. The total TSP emissions from loading coal to trucks are approximately 124,850 kg/y [1,135,000 t/y x 0.110 kg/t].

Hauling coal to CPP
In Year1 1,135,000 t of ROM coal will be hauled to the hopper or ROM stockpile, using Cat 789, 85 t trucks. The TSP emission is 26,706 kg [1,135,000 t / 85 t/trip x 2 km/trip x 1 kg/VKT].

Unloading coal to hopper
In Year 1 2,158,000 t of ROM coal will be unloaded from trucks to the hopper or ROM stockpile. Assuming that the emission factor is 0.01 kg/t the annual TSP emission will be 13,500 kg/y [1,135,000 t x 0.010 kg/t].

Re-handle coal at the ROM hopper
Allow for 50% of ROM coal [567,500 t] to be dumped to the temporary stockpile and reloaded to the hopper. The emission factor for dumping is 0.01 kg/t and reloading is 0.110 kg/t thus the TSP generated by this process is 68,100 kg/y [567,500 t/y x (0.01 + 0.110)].

Loading coal to stockpiles
In Year 1 approximately 1,135,000 t of product coal will be loaded to the stockpiles. The emission factor used for this process is 0.004 kg/t. The total TSP generated from this

operation is 5,400 kg/y [1,350,000 t x 0.004 kg/t].

Loading coal to trucks for export off-site
In Year 1, 1,350,000 t of product coal will be loaded to 25 t trucks for export off-site. The emission factor used for this process is taken to be the same as for loading the coal in the pit and therefore the TSP emissions is estimated to be approximately 124,850 kg/y [1,135,000 t/y x 0.110 kg/t].

Hauling coal off-site to Ravensworth CT
In Year1 1,135,000 t of ROM coal will be hauled to the the Ravensworth Coal Loader. This will be done using 25 t trucks running on sealed roads. Assuming an emission factor of 0.2 kg/VKT for trucks on sealed roads and considering only the first 4 km of the trip gives a TSP emission of 72,640 kg [1,135,000 t / 25 t/trip x 8 km/trip x 0.2 kg/VKT].

MISCELLANEOUS ACTIVITIES

Graders on roads
Estimates of TSP emissions from the grader on the roads have been made using the **US EPA (1985)** emission factor equation **Equation 4**.

Equation 4

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad \text{kg/vkt}$$

where S = speed of the grader in km/h

Assuming an average speed of 8 km/h, the emission factor is 0.62 kg/vkt. Assuming 5 km of grader travel per day over 365 days/year the distance travelled annually by the grader will be 1,825 km, which will result in TSP emissions of 1,132 kg/y [1,825 km/y x 0.62 kg/km].

WIND EROSION
The emission factor for wind erosion is given in **Equation 5:**

Equation 5

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

where,

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

For this location the typical number of raindays per year is approximately 81 (Data from Muswellbrook school). From the meteorological data used in the modelling the percentage of winds above 5.4 m/s is 20.9%. For a silt content of 10% the emission factor is 2.1 kg/ha/day.

Wind erosion from exposed working areas
In Year 1 there will be 20 ha of exposed land, susceptible to wind erosion associated with the active pit and the annual TSP emission will be approximately 15,330 kg/y [20 ha x 2.1 kg/ha/day x 365 day/y]. Assume that half of this in-pit emission is retained in the pit then the effective annual emission will be 7,665 kg.

There will also be a further 15 ha of out of pit exposed land which will generate approximately 11,498 kg/y [15 ha x 2.1 kg/ha/day x 365 day/y] of TSP.

Wind erosion from stockpiles
Assume an area of 4 ha for stockpiles. The annual TSP emission will be approximately 3,066 kg/y [4 ha x 2.1 kg/ha/day x 365 day/y].

YEAR 4- ESTIMATED DUST EMISSIONS

Introduction
This section presents the detailed calculations used to develop the emissions inventory required for the model predictions of dust dispersion. The inventory has been estimated using emission factor equations provided in the **US EPA's (1985)** (and subsequent updates) publication referred to as **AP-42** and from factors determined by **NERDDC (1986)** and from mine planning information provided by Mining Operation Services Pty Ltd. There is considerable repetition in the information provided for each of the inventories presented in this appendix. This is done to allow the reader to focus on a particular year without the need to cross-reference to information in other years.

Estimated TSP emissions have been presented to an accuracy of one kilogram. This is done to assist in checking that the mathematics has been followed through correctly. It should not be used to infer that the accuracy of the estimated TSP emission is to within one kilogram. The accuracy of TSP emissions from individual activities is essentially unquantifiable. However, based on model validation studies (**Dames and Moore, 1983**) it can be assumed that overall 80% of predicted long-term deposition rates will lie within ± 40% of measured rates.

Estimated emissions are presented for all significant dust generating activities associated with the extension.

It has been assumed that mining activities occur 24 hours per day, 7 days per week. Dust from wind erosion is assumed to occur over 24 hours per day, but wind erosion is also assumed to be proportional to the third power of wind speed. Generally, this will mean that most wind erosion occurs in the day when wind speeds are highest.

OPERATIONS ON OVERBURDEN

Drilling overburden
Approximately 50% of material will need to be blasted. In Year 4 the total quantity of material blasted in Year 4 is estimated to be 3,166,000 bcm [6,322,000/2] bcm. Assuming a hole spacing of 7.5 m and depth of 15 m it is estimated that this will involve approximately 3,752 [3,166,000 m^3 / (15 m x 7.5 m x 7.5 m] holes being drilled. It is assumed that 0.59 kg of TSP will be generated in drilling each hole **(US EPA, 1985)**, and so the total TSP emission from blasting overburden is estimated to be 2,214 kg/y [3,752 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 1**.

Equation 1

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad \text{kg/blast}$$

where :

A = area to be blasted in m^2

The area of a typical blast has been estimated to be 2,500 m^2. The estimated TSP emission from a typical blast is 27.5 kg. Assuming that there will be 84 [3,166,000 bcm/(15 m x 2,500 m^2)] shots in the life of the project the TSP emission is estimated to be 2,310 kg [27.5 kg/blast x 84 blasts/year].

Dozers on overburden dumps
For Year 4 it is assumed that 7,000 dozer-hours will be worked (500 hours for drill preparation, 500 hours for shot cleanup, 2,000 h for cleanup around the excavator and 4,000 h on dumps and roads). The US EPA emission factor equation is given in **Equation 2**.

Equation 2

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

where,

s = silt content (%), and

M = moisture content (%)

Taking M to be 4% and s to be 10%, the emission factor is estimated to be 6.8 kg/hour. The total TSP emission from the dozers is therefore 47,600 kg/y [7,000 h/y x 6.8 kg/h].

This TSP emission would be distributed as follows:

- Drill preparation 3,400 kg/y
- Shot cleanup 3,400 kg/y
- Assisting excavator 13,600 kg/y
- Dumps and roads 27,200 kg/y.

Loading overburden to trucks
In Year 4 approximately 6,332,000 bcm of overburden and interburden will be loaded into trucks and transported to the dump area.

Assuming a density of 2.4 t/bcm this is equivalent to approximately 15,196,800 t [6,332,000 m^3 x 2.4 t/m^3]. The TSP emission from each tonne of material loaded will depend on the wind speed and the moisture content or the material. **Equation 3** shows the relationship between these variables.

Equation 3

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

where,

$k = 0.74$

U = wind speed (m/s)

M = moisture content (%)

[where $0.25 \le M \le 4.8$]

For the Mt. Arthur North meteorological data set the annual average value of $(u/2.2)^{1.3}$ is 2.0295

Assuming a moisture content of 4%, the total emission for Year 4 is therefore given by;

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where;

U = the wind speed in m/s.

The annual average emission factor for TSP emission from loading overburden to trucks is therefore 0.0009 kg/t. For Year 4 15,196,800 t [2.4 t/bcm x 6,332,000 bcm] of overburden will be loaded so the annual TSP emission is 13,677 kg [15,196,800 t x 0.0009 kg/t]

Hauling overburden to waste dump
A total of approximately 6,332,000 bcm of overburden will be hauled to the waste dump area using 190 t trucks. Assuming a return trip of approximately 2 km for overburden emplacement the annual TSP emission for hauling overburden will be 159,966 kg [(15,196,800 t / 190 t/trip x 2 km/trip x 1 kg/VKT].

Unloading overburden to waste dump
In Year 4 a total of approximately 15,196,800 t of material will be unloaded from trucks. The emission factor used for this process is 0.0009 kg/t (i.e the same as for loading overburden to trucks). The annual TSP generated from unloading overburden is therefore expected to be 13,677 kg [15,196,800 t x 0.0009 kg/t].

OPERATIONS ON COAL

Drilling coal
The will be no drilling of coal.

Blasting coal
The will be no blasting of coal.

Dozers working on coal
In Year 4 it is assumed that 3,000 dozer-hours will be devoted to working on coal (ripping and pushing). The US EPA emission factor equation is given in **Equation 7**

Equation 7

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \quad \text{kg/hour}$$

where,

s = silt content (%), and

M = moisture content (%)

Taking M to be 4% and s to be 8%, the emission factor is estimated to be approximately 61.9 kg/hour. The total TSP emission from the dozers is therefore approximately 185,700 kg/y [3,000 h/y x 61.9 kg/h].

Loading coal to trucks
In Year 4 1,208,000 t of ROM coal will be loaded into trucks. The emission factor used for this process is given in **Equation 8**

Equation 8

$$E_{TSP} = \frac{0.580}{M^{1.2}} \quad \text{kg/t}$$

where,

M = moisture content (%)

Taking M to be 4%, the emission factor is estimated to be approximately 0.110 kg/t. The total TSP emissions from loading coal to trucks are approximately 132,880 kg/y [1,208,000 t/y x 0.110 kg/t].

Hauling coal to CPP
In Year1 1,208,000 t of ROM coal will be hauled to the hopper or ROM stockpile, using Cat 789, 85 t trucks. The TSP emission is 28,424 kg [1,208,000 t / 85 t/trip x 2 km/trip x 1 kg/VKT].

Unloading coal to hopper
In Year 4 1,208,000 t of ROM coal will be unloaded from trucks to the hopper or ROM stockpile. Assuming that the emission factor is 0.01 kg/t the annual TSP emission will be 12,080 kg/y [1,208,000 t x 0.010 kg/t].

Re-handle coal at the ROM hopper
Allow for 50% of ROM coal [604,000 t] to be dumped to the temporary stockpile and reloaded to the hopper. The emission factor for dumping is 0.01 kg/t and reloading is 0.110 kg/t thus the TSP generated by this process is 72,480 kg/y [604,000 t/y x (0.01 + 0.110)].

Loading coal to stockpiles
In Year 4 approximately 1,208,000 t of product coal will be loaded to the stockpiles. The emission factor used for this process is 0.004 kg/t. The total TSP generated from this

operation is 4,832 kg/y [1,208,000 t x 0.004 kg/t].

Loading coal to trucks for export off-site
In Year 4, 1,208,000 t of product coal will be loaded to 25 t trucks for export off-site. Using the same emission factor as used to load coal in the pit. The TSP emission is approximately 132,880 kg/y.

Hauling coal off-site to Ravensworth CT
In Year1 4, 1,208,000 t of ROM coal will be hauled to the the Ravensworth Coal Loader. This will be done using 25 t trucks running on sealed roads. Assuming an emission factor of 0.2 kg/VKT for trucks on sealed roads and considering only the first 4 km of the trip gives a TSP emission of 77,312 kg [1,208,000 t / 25 t/trip x 8 km/trip x 0.2 kg/VKT].

MISCELLANEOUS ACTIVITIES

Graders on roads
Estimates of TSP emissions from the grader on the roads have been made using the **US EPA (1985)** emission factor equation **Equation 4**.

Equation 4

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad \text{kg/vkt}$$

where S = speed of the grader in km/h

Assuming an average speed of 8 km/h, the emission factor is 0.62 kg/vkt. Assuming 5 km of grader travel per day over 365 days/year the distance travelled annually by the grader will be 1,825 km, which will result in TSP emissions of 1,132 kg/y [1,825 km/y x 0.62 kg/km].

WIND EROSION
The emission factor for wind erosion is given in **Equation 5:**

Equation 5

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

where,

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

For this location the typical number of raindays per year is approximately 81 (Bureau of Meteorology record for Muswellbrook). From the meteorological data used in the modelling the percentage of winds above 5.4 m/s is 20.9%. For a silt content of 10% the emission factor is 2.1 kg/ha/day.

Wind erosion from exposed working areas
In Year 4 there will be 20 ha of exposed land, susceptible to wind erosion associated with the active pit and the annual TSP emission will be approximately 15,330 kg/y [20 ha x 2.1 kg/ha/day x 365 day/y]. Assume that half of this in-pit emission is retained in the pit then the effective annual emission will be 7,665 kg.

There will also be a further 15 ha of out of pit exposed land which will generate approximately 11,498 kg/y [15 ha x 2.1 kg/ha/day x 365 day/y] of TSP.

Wind erosion from stockpiles
Assume an area of 4 ha for stockpiles. The annual TSP emission will be approximately 3,066 kg/y [4 ha x 2.1 kg/ha/day x 365 day/y].

YEAR 9- ESTIMATED DUST EMISSIONS

Introduction
This section presents the detailed calculations used to develop the emissions inventory required for the model predictions of dust dispersion. The inventory has been estimated using emission factor equations provided in the **US EPA's (1985)** (and subsequent updates) publication referred to as **AP-42** and from factors determined by **NERDDC (1986)** and from mine planning information provided by Mining Operation Services Pty Ltd. There is considerable repetition in the information provided for each of the inventories presented in this appendix. This is done to allow the reader to focus on a particular year without the need to cross-reference to information in other years.

Estimated TSP emissions have been presented to an accuracy of one kilogram. This is done to assist in checking that the mathematics has been followed through correctly. It should not be used to infer that the accuracy of the estimated TSP emission is to within one kilogram. The accuracy of TSP emissions from individual activities is essentially unquantifiable. However, based on model validation studies (**Dames and Moore, 1983**) it can be assumed that overall 80% of predicted long-term deposition rates will lie within ± 40% of measured rates.

Estimated emissions are presented for all significant dust generating activities associated with the extension.

It has been assumed that mining activities occur 24 hours per day, 7 days per week. Dust from wind erosion is assumed to occur over 24 hours per day, but wind erosion is also assumed to be proportional to the third power of wind speed. Generally, this will mean that most wind erosion occurs in the day when wind speeds are highest.

OPERATIONS ON OVERBURDEN

Drilling overburden
Approximately 50% of material will need to be blasted. In Year 9 the total quantity of material blasted in Year 9 is estimated to be 4,333,000 bcm [8,666,000/2] bcm. Assuming a hole spacing of 7.5 m and depth of 15 m it is estimated that this will involve approximately 5,135 [4,333,000 m^3 / (15 m x 7.5 m x 7.5 m] holes being drilled. It is assumed that 0.59 kg of TSP will be generated in drilling each hole **(US EPA, 1985)**, and so the total TSP emission from blasting overburden is estimated to be 3,030 kg/y [5,135 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 1**.

Equation 1

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad \text{kg/blast}$$

where :

A = area to be blasted in m^2

The area of a typical blast has been estimated to be 2,500 m^2. The estimated TSP emission from a typical blast is 27.5 kg. Assuming that there will be 116 [4,333,000 bcm/(15 m x 2,500 m^2)] shots in the life of the project the TSP emission is estimated to be 3,190 kg [27.5 kg/blast x 116 blasts/year].

Dozers on overburden dumps
For Year 9 it is assumed that 7,000 dozer-hours will be worked (500 hours for drill preparation, 500 hours for shot cleanup, 2,000 h for cleanup around the excavator and 4,000 h on dumps and roads). The US EPA emission factor equation is given in **Equation 2**.

Equation 2

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

where,

s = silt content (%), and

M = moisture content (%)

Taking M to be 4% and s to be 10%, the emission factor is estimated to be 6.8 kg/hour. The total TSP emission from the dozers is therefore 47,600 kg/y [7,000 h/y x 6.8 kg/h].

This TSP emission would be distributed as follows:

- Drill preparation 3,400 kg/y
- Shot cleanup 3,400 kg/y
- Assisting excavator 13,600 kg/y
- Dumps and roads 27,200 kg/y.

Loading overburden to trucks
In Year 9 approximately 8,666,000 bcm of overburden and interburden will be loaded into trucks and transported to the dump area.

Assuming a density of 2.4 t/bcm this is equivalent to approximately 20,798,400 t [8,666,000 m^3 x 2.4 t/m^3]. The TSP emission from each tonne of material loaded will depend on the wind speed and the moisture content or the material. **Equation 3** shows the relationship between these variables.

Equation 3

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

where,

$k = 0.74$

$U =$ wind speed (m/s)

$M =$ moisture content (%)

[where $0.25 \le M \le 4.8$]

For the Mt. Arthur North meteorological data set the annual average value of $(u/2.2)^{1.3}$ is 2.0295

Assuming a moisture content of 2%, the total emission for Year 9 is therefore given by;

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where;

$U =$ the wind speed in m/s.

The annual average emission factor for TSP emission from loading overburden to trucks is therefore 0.0009 kg/t. For Year 9 20,798,400 t [2.4 t/bcm x 8,666,000 bcm] of overburden will be loaded so the annual TSP emission is 18,719 kg [20,798,400 t x 0.0009 kg/t]

Hauling overburden to waste dump
A total of approximately 8,666,000 bcm of overburden will be hauled to the waste dump area using 190 t trucks. Assuming a return trip of approximately 2 km for overburden emplacement the annual TSP emission for hauling overburden will be 218,931 kg [(20,798,400 t / 190 t/trip x 2 km/trip x 1 kg/VKT].

Unloading overburden to waste dump
In Year 9 a total of approximately 20,798,400 t of material will be unloaded from trucks. The emission factor used for this process is 0.0009 kg/t (i.e the same as for loading overburden to trucks). The annual TSP generated from unloading overburden is therefore expected to be 18,719 kg [20,798,400 t x 0.0009 kg/t].

OPERATIONS ON COAL

Drilling coal
The will be no drilling of coal.

Blasting coal
The will be no blasting of coal.

Dozers working on coal
In Year 9 it is assumed that 3,000 dozer-hours will be devoted to working on coal (ripping and pushing). The US EPA emission factor equation is given in **Equation 7**

Equation 7

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad \text{kg/hour}$$

where,

$s =$ silt content (%), and

$M =$ moisture content (%)

Taking M to be 4% and s to be 8%, the emission factor is estimated to be approximately 61.9 kg/hour. The total TSP emission from the dozers is therefore approximately 185,700 kg/y [3,000 h/y x 61.9 kg/h].

Loading coal to trucks
In Year 9 1,135,000 t of ROM coal will be loaded into trucks. The emission factor used for this process is given in **Equation 8**

Equation 8

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad \text{kg/t}$$

where,

$M =$ moisture content (%)

Taking M to be 4%, the emission factor is estimated to be approximately 0.110 kg/t. The total TSP emissions from loading coal to trucks are approximately 124,850 kg/y [1,135,000 t/y x 0.110 kg/t].

Hauling coal to CPP
In Year1 1,250,000 t of ROM coal will be hauled to the hopper or ROM stockpile, using Cat 789, 85 t trucks. The TSP emission is 29,412 kg [1,250,000 t / 85 t/trip x 2 km/trip x 1 kg/VKT].

Unloading coal to hopper
In Year 9 1,250,000 t of ROM coal will be unloaded from trucks to the hopper or ROM stockpile. Assuming that the emission factor is 0.01 kg/t the annual TSP emission will be 12,500 kg/y [1,250,000 t x 0.010 kg/t].

Re-handle coal at the ROM hopper
Allow for 50% of ROM coal [625,000 t] to be dumped to the temporary stockpile and reloaded to the hopper. The emission factor for dumping is 0.01 kg/t and reloading is 0.110 kg/t thus the TSP generated by this process is 75,000 kg/y [625,000 t/y x (0.01 + 0.110)].

Loading coal to stockpiles
In Year 9 approximately 1,250,000 t of product coal will be loaded to the stockpiles. The emission factor used for this process is 0.004 kg/t. The total TSP generated from this

operation is 5,000 kg/y [1,250,000 t x 0.004 kg/t].

Loading coal to trucks for export off-site
In Year 9, 1,250,000 t of product coal will be loaded to 25 t trucks for export off-site. The total TSP emissions from loading coal to trucks is approximately 124,850 kg/y [1,135,000 t/y x 0.110 kg/t] i.e. the same as for loading coal in the pit.

Hauling coal off-site to Ravensworth CT
In Year1 9, 1,250,000 t of ROM coal will be hauled to the Ravensworth Coal Loader. This will be done using 25 t trucks running on sealed roads. Assuming an emission factor of 0.2 kg/VKT for trucks on sealed roads and considering only the first 4 km of the trip gives a TSP emission of 80,000 kg [1,125,000 t / 25 t/trip x 8 km/trip x 0.2 kg/VKT].

MISCELLANEOUS ACTIVITIES

Graders on roads
Estimates of TSP emissions from the grader on the roads have been made using the **US EPA (1985)** emission factor equation **Equation 4**.

Equation 4

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad \text{kg/vkt}$$

where S = speed of the grader in km/h

Assuming an average speed of 8 km/h, the emission factor is 0.62 kg/vkt. Assuming 5 km of grader travel per day over 365 days/year the distance travelled annually by the grader will be 1,825 km, which will result in TSP emissions of 1,132 kg/y [1,825 km/y x 0.62 kg/km].

WIND EROSION
The emission factor for wind erosion is given in **Equation 5:**

Equation 5

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

where,

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

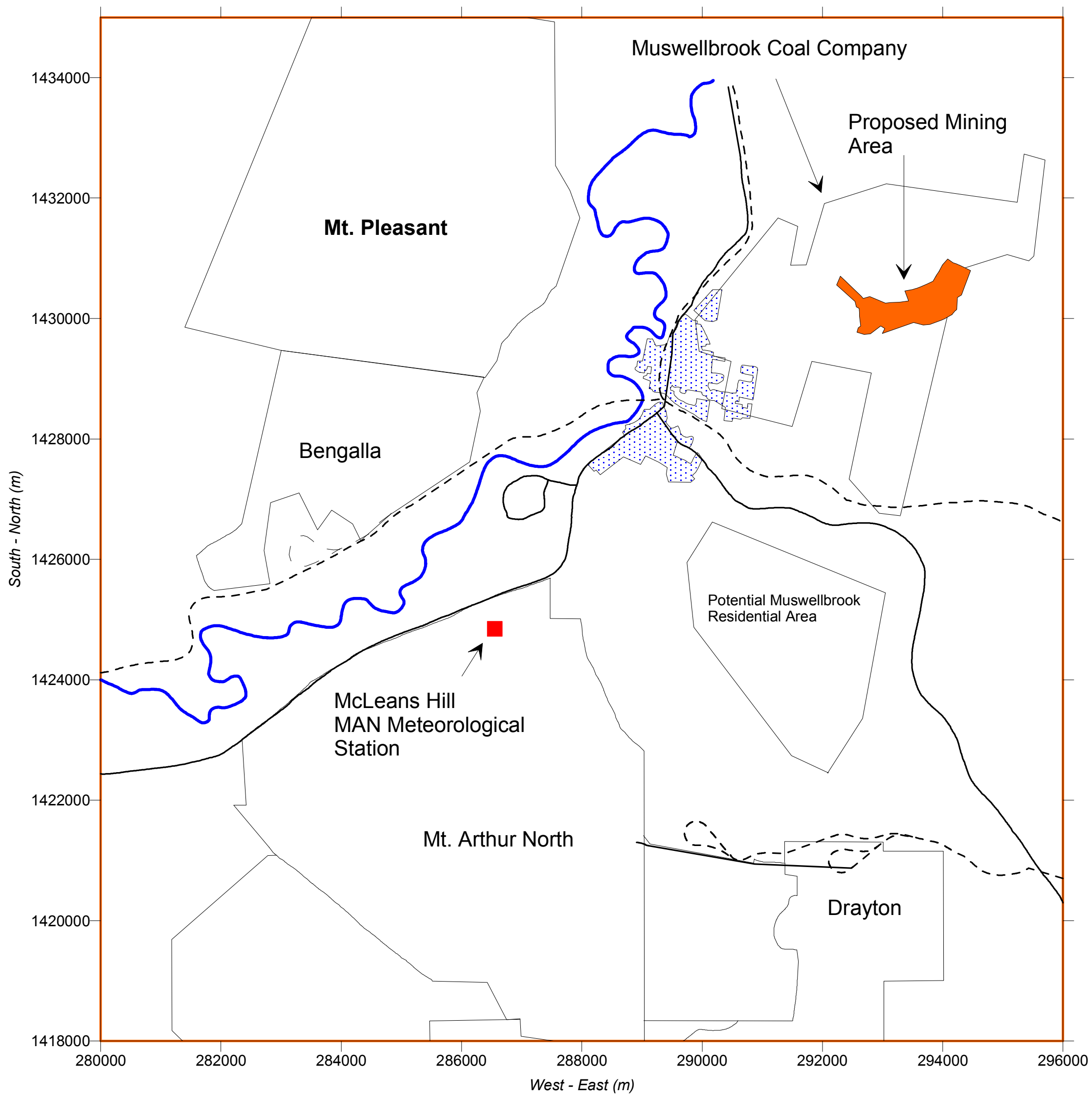
For this location the typical number of raindays per year is approximately 81 (Bureau of Meteorology data for Muswellbrook). From the meteorological data used in the modelling the percentage of winds above 5.4 m/s is 20.9%. For a silt content of 10% the emission factor is 2.1 kg/ha/day.

Wind erosion from exposed working areas
In Year 9 there will be 20 ha of exposed land, susceptible to wind erosion associated with the active pit and the annual TSP emission will be approximately 15,330 kg/y [20 ha x 2.1 kg/ha/day x 365 day/y]. Assume that half of this in-pit emission is retained in the pit then the effective annual emission will be 7,665 kg.

There will also be a further 15 ha of out of pit exposed land which will generate approximately 11,498 kg/y [15 ha x 2.1 kg/ha/day x 365 day/y] of TSP.

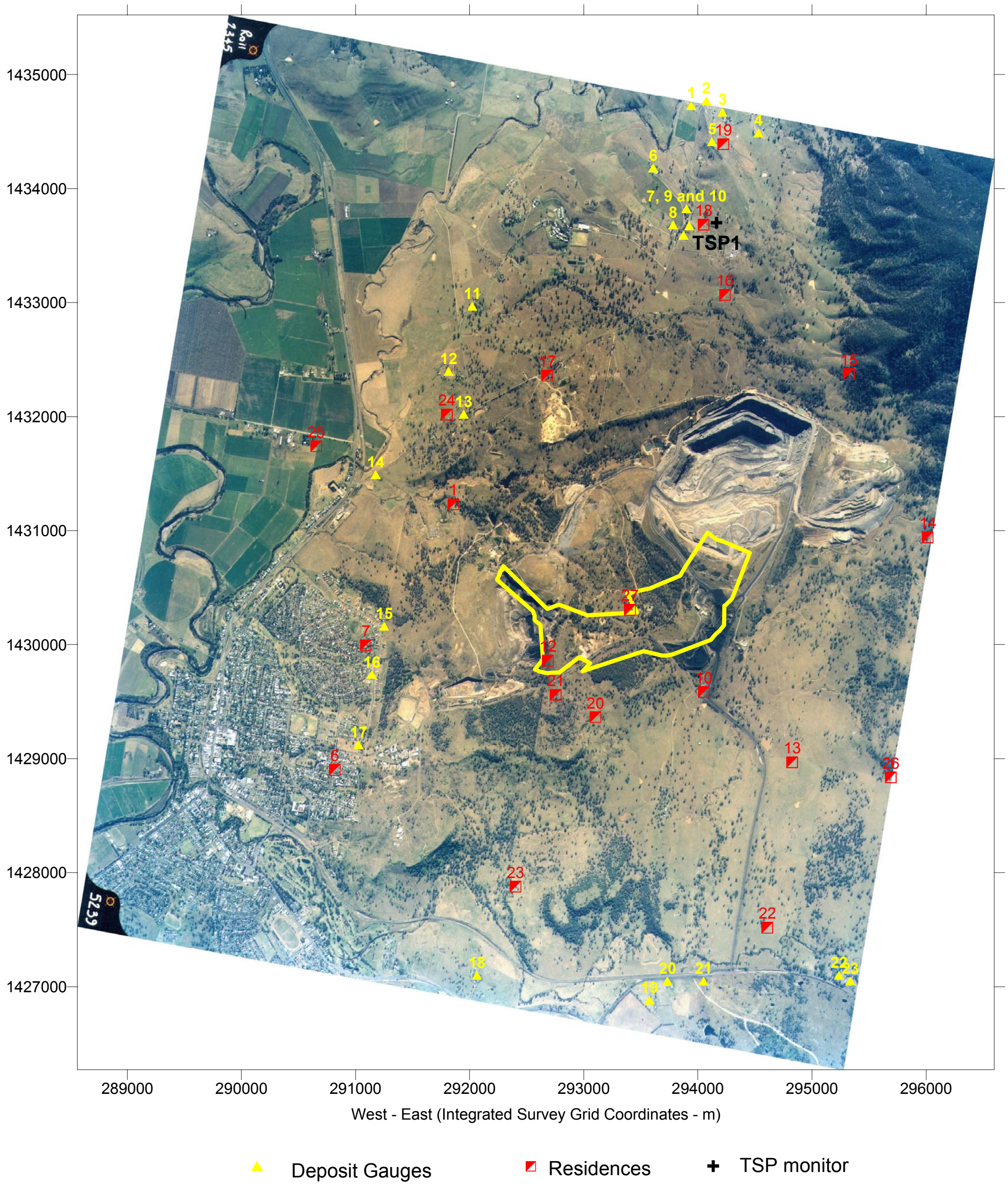
Wind erosion from stockpiles
Assume an area of 4 ha for stockpiles. The annual TSP emission will be approximately 3,066 kg/y [4 ha x 2.1 kg/ha/day x 365 day/y].

FIGURES



Location of Project

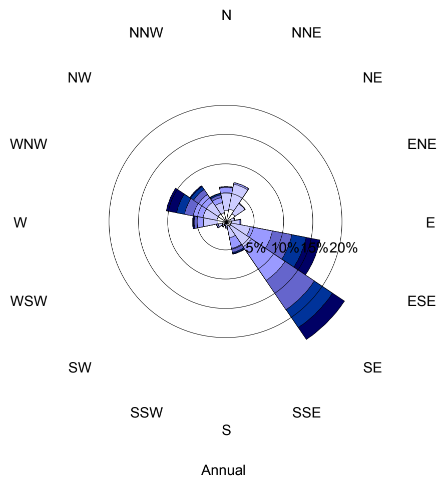
Figure 1

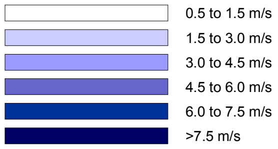


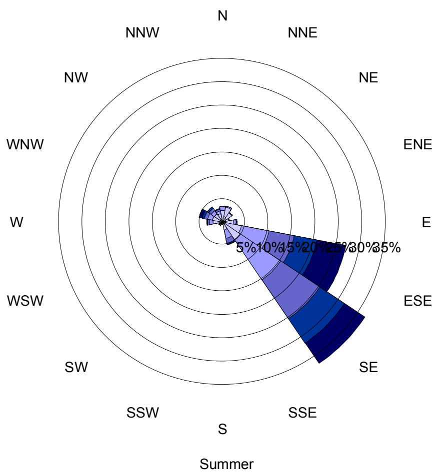
Location of Dust Monitors and Nearby Residences

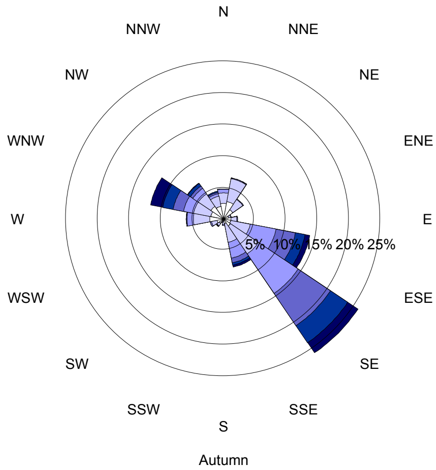
Figure 2

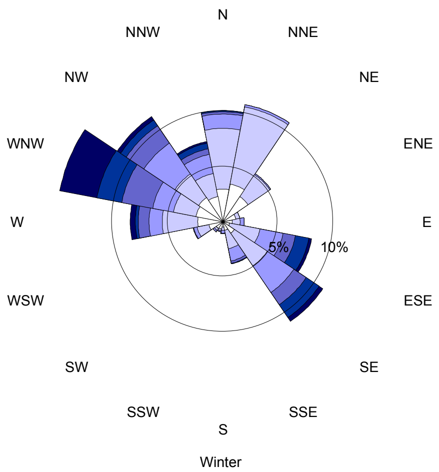
Annual and Seasonal Windroses for McLeans Hill (MAN Meteorological Station) for 31 July 1999 to 25 July 2000











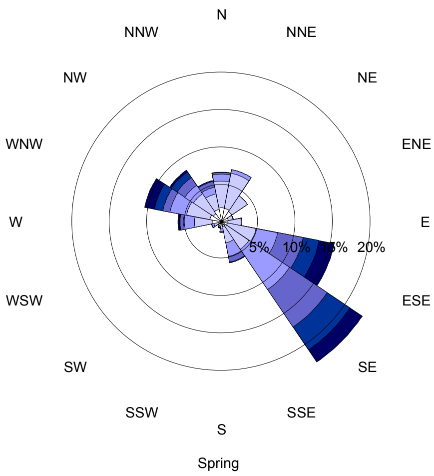


Figure 3

Measured 24-hour Average TSP Concentrations at TSP1 (see Figure 2)

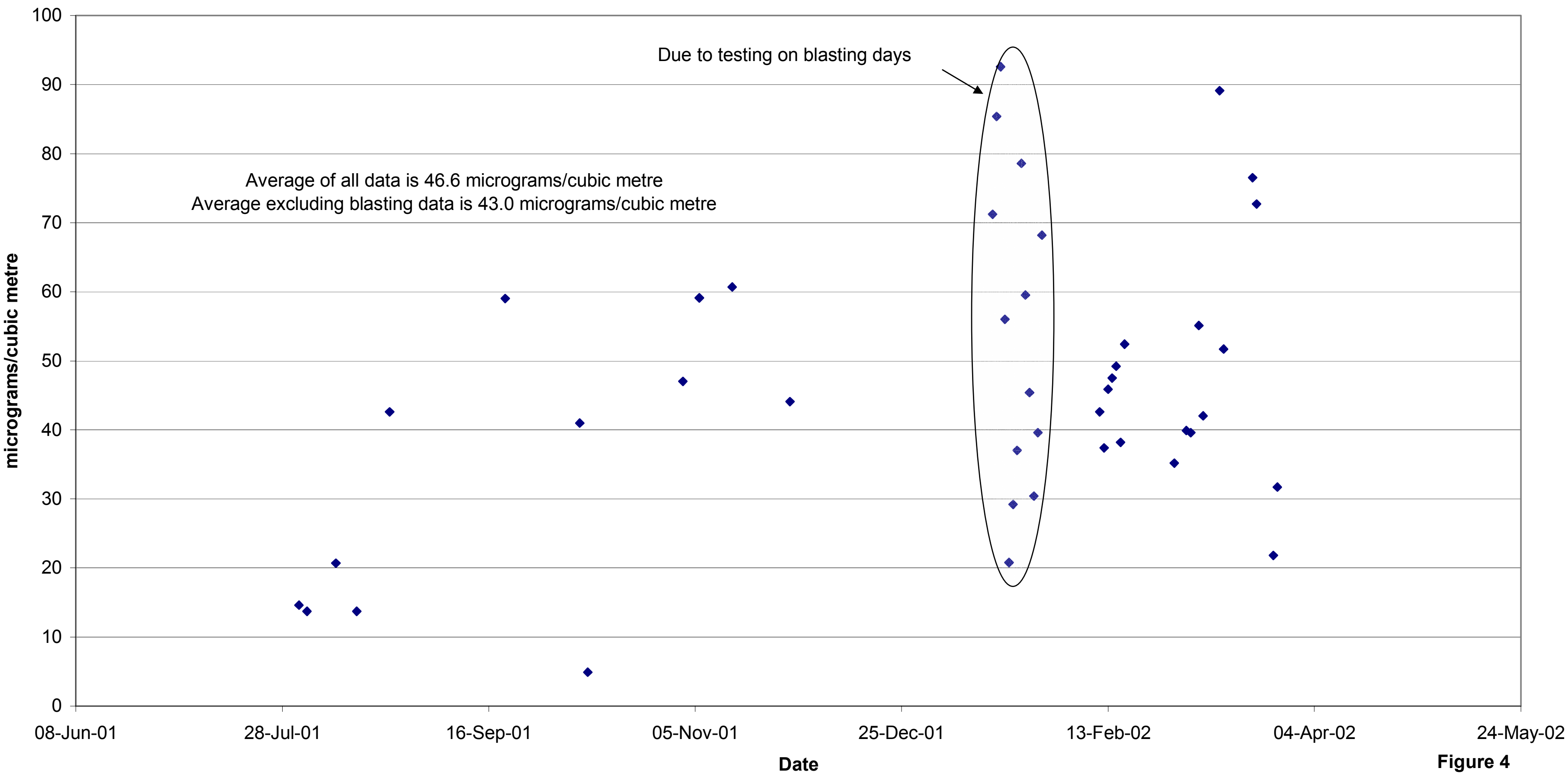
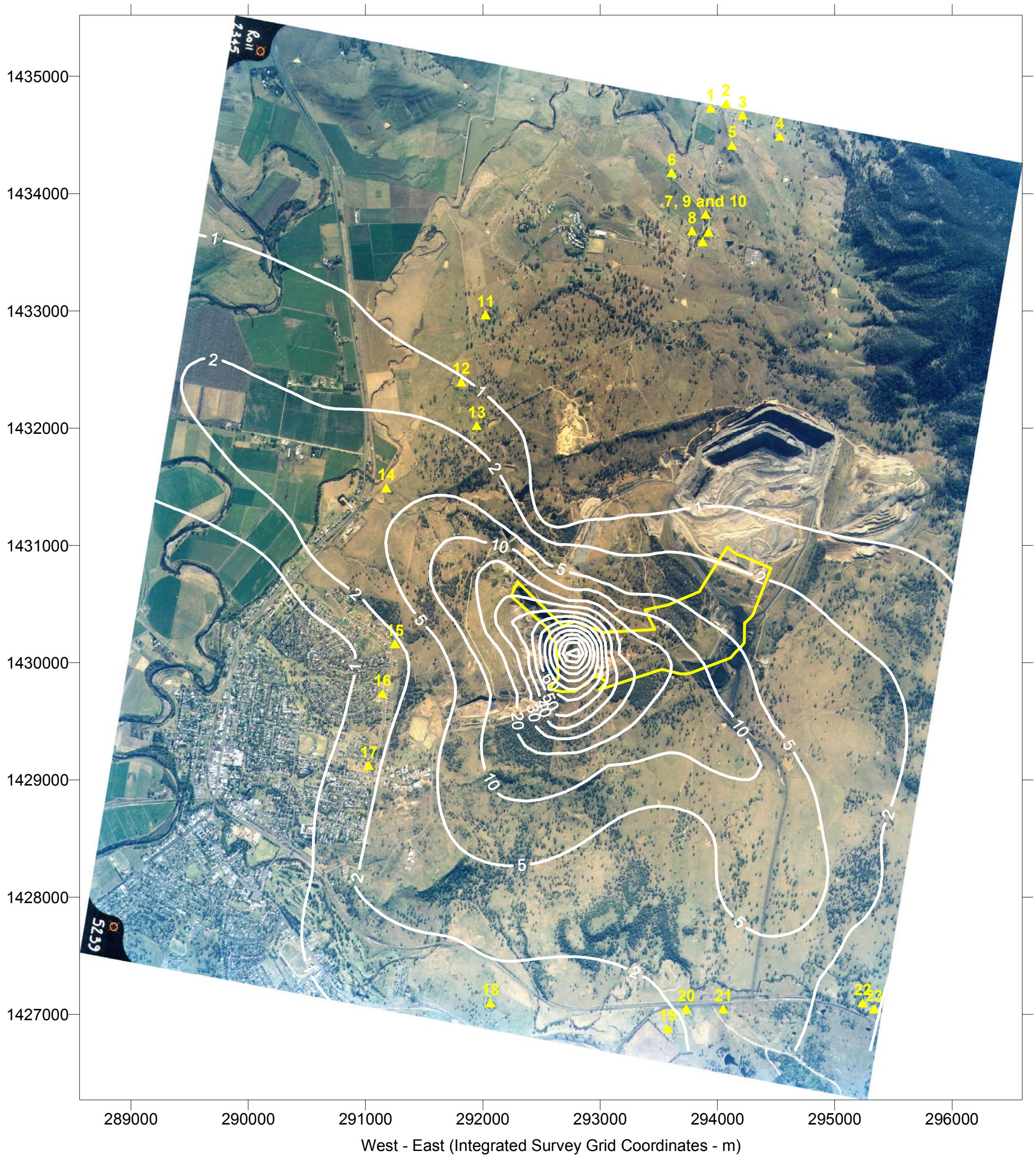


Figure 4

Start Screen

Search

Appendices



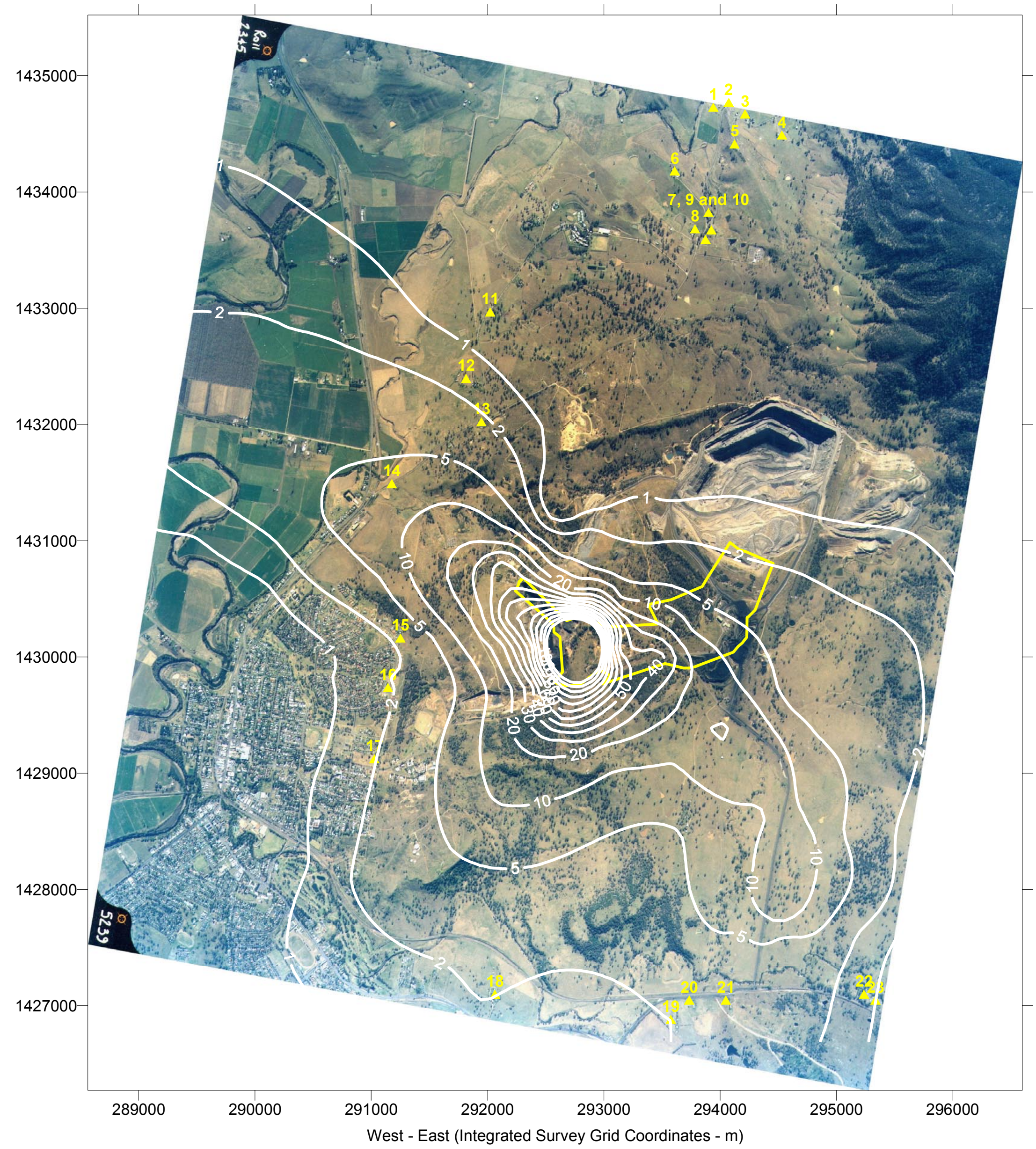
Predicted Annual Average PM_{10} Concentrations due to Emissions from No. 1 Open Cut Extension Project in Year 1 - $\mu g/m^3$

Figure 5

Start Screen

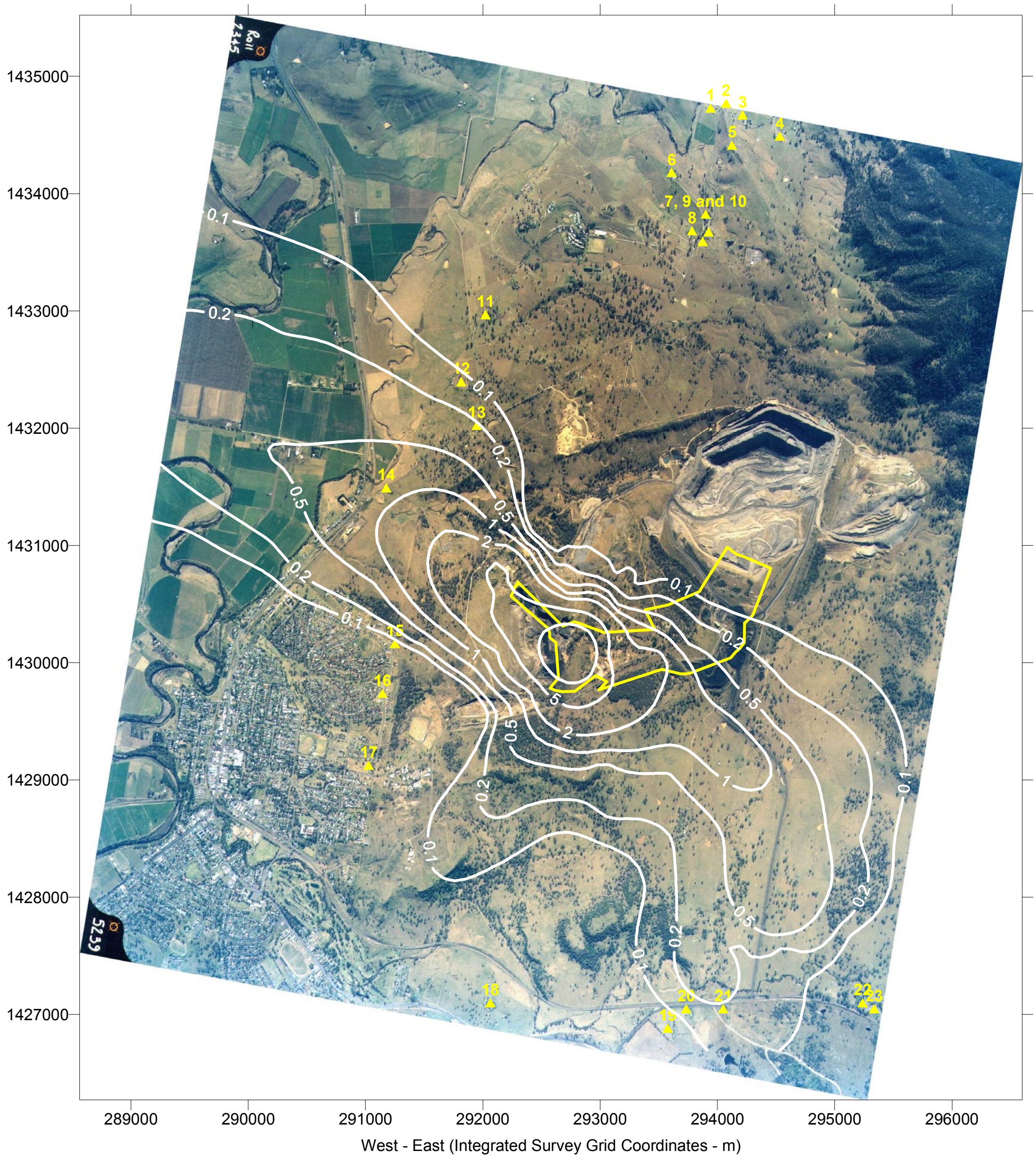
Search

Appendices



Predicted Annual Average TSP Concentrations due to Emissions from No. 1 Open Cut Extension Project in Year 1 - μg/m^3

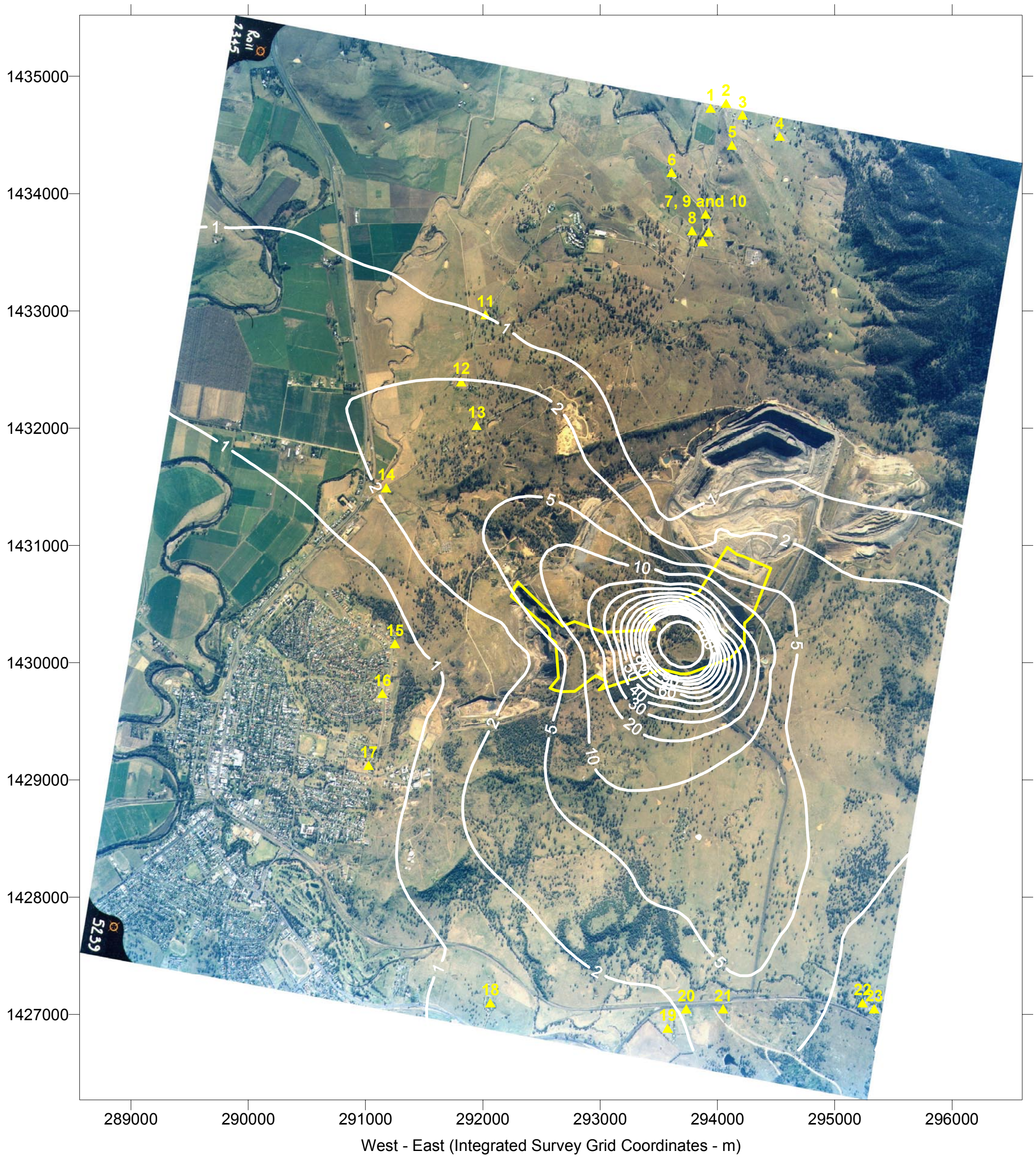
Figure 6



Predicted Annual Average Dust Depsotion (Insoluble Solids) due to Emissions from No. 1 Open Cut Extension Project in Year 1 - g/m^2 /month

Figure 7

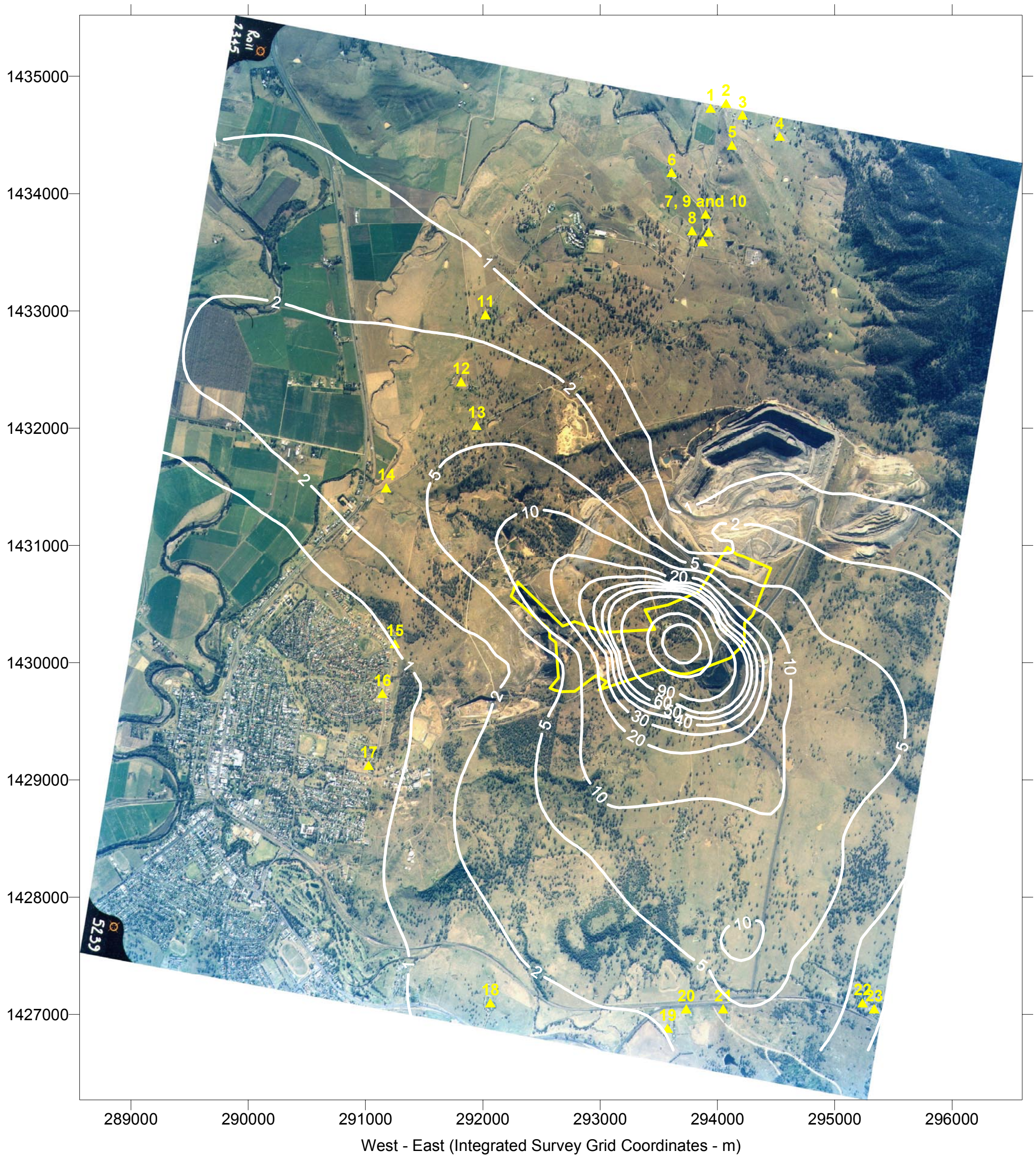
Start Screen Search Appendices



Predicted Annual Average PM_{10} Concentrations due to Emissions from No. 1 Open Cut Extension Project in Year 4 - $\mu g/m^3$

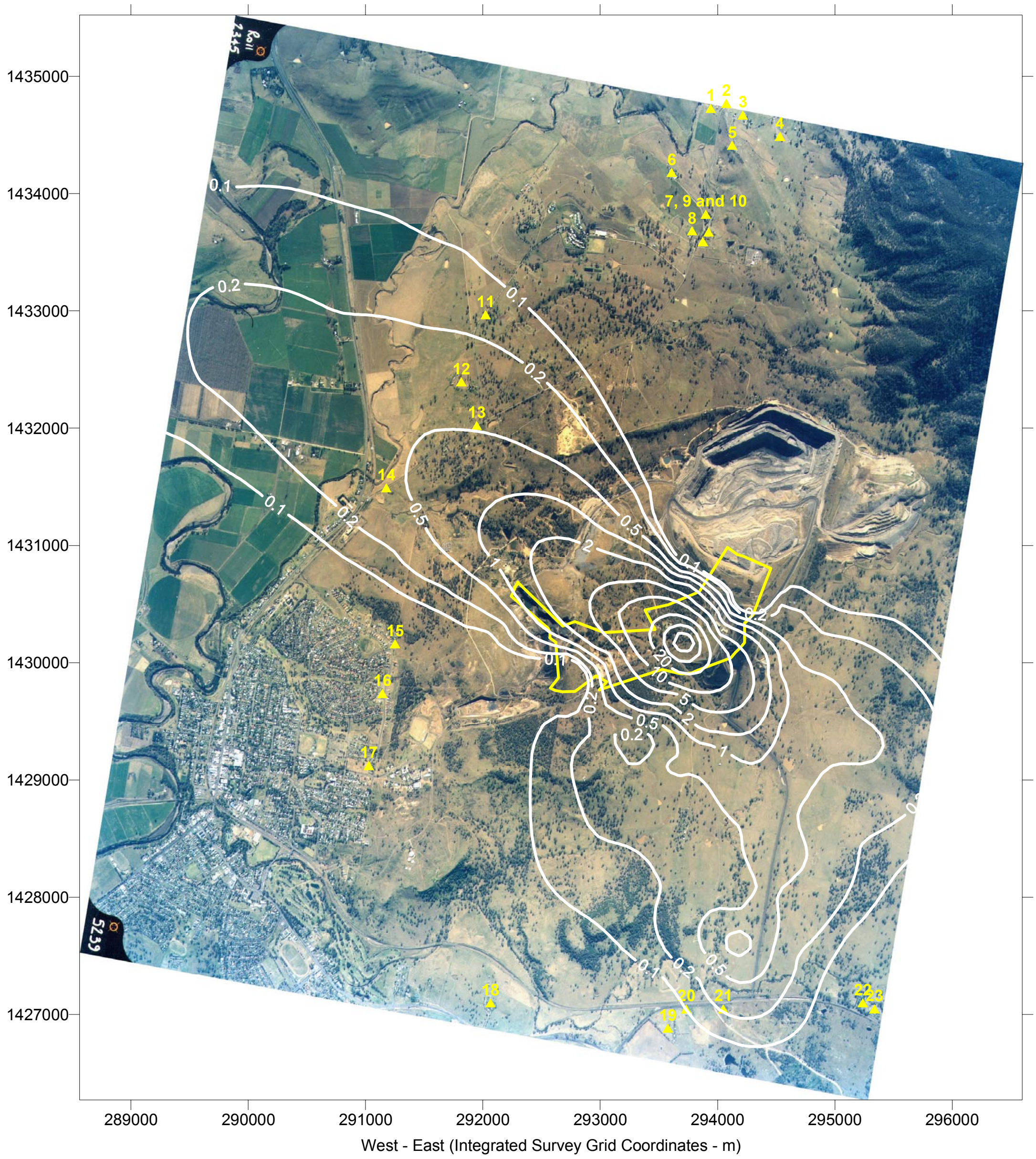
Figure 8

HLA



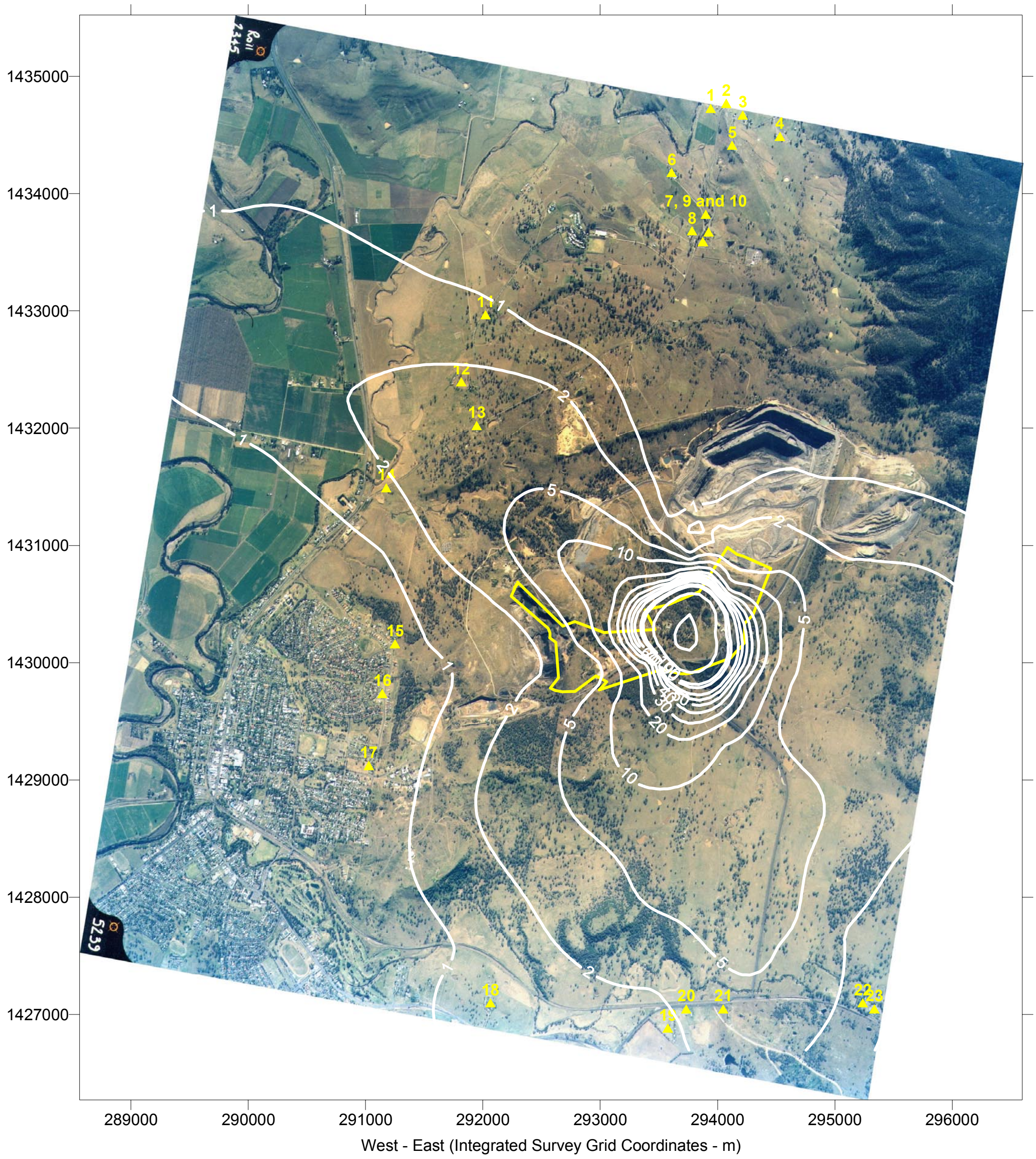
Predicted Annual Average TSP Concentrations due to Emissions from No. 1 Open Cut Extension Project in Year 4 - µg/m^3

Figure 9



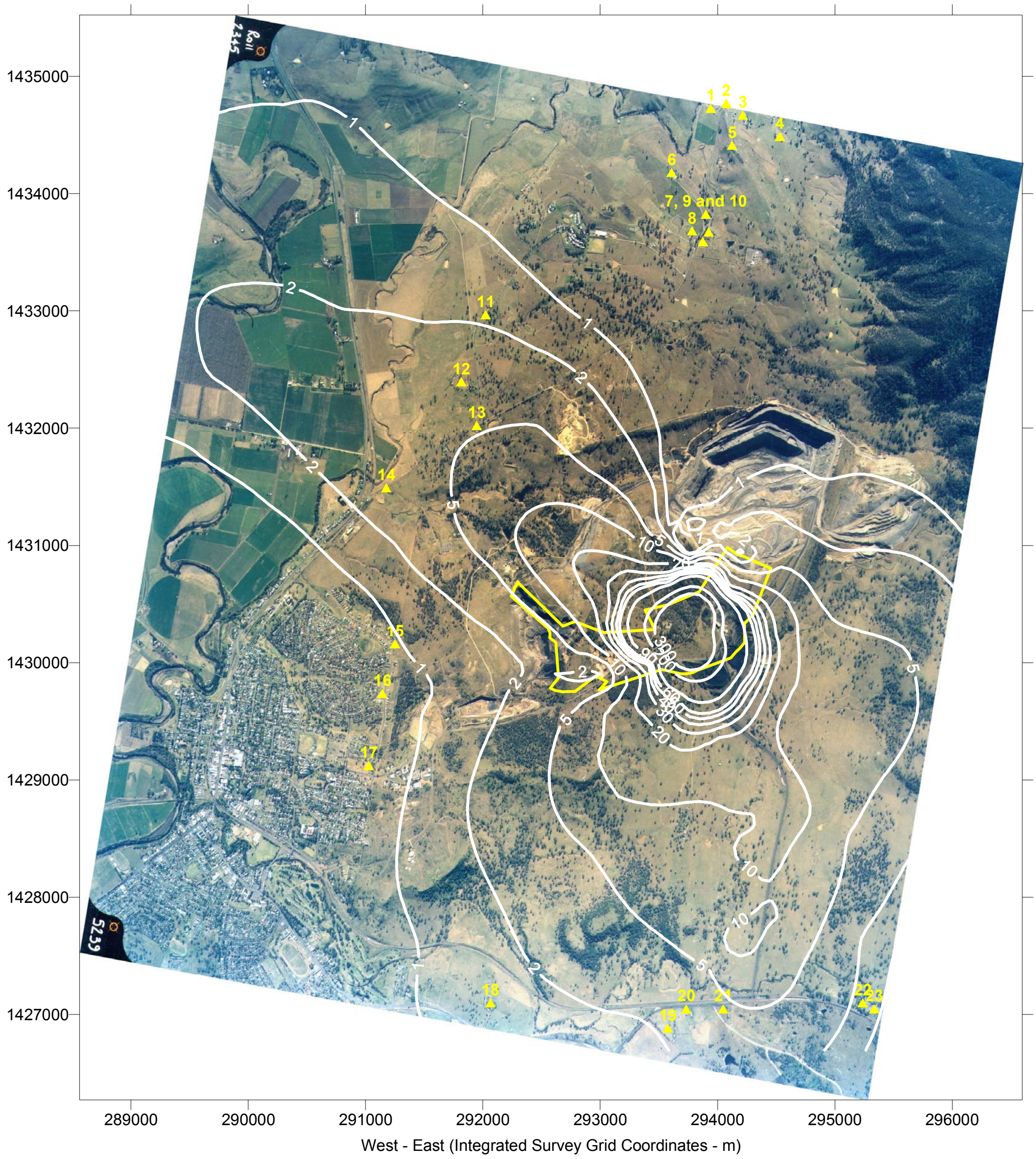
Predicted Annual Average Dust Depsotion (Insoluble Solids) due to Emissions from No. 1 Open Cut Extension Project in Year 4 - g/m^2 /month

Figure 10



Predicted Annual Average PM_{10} Concentrations due to Emissions from No. 1 Open Cut Extension Project in Year 9 - μg/m^3

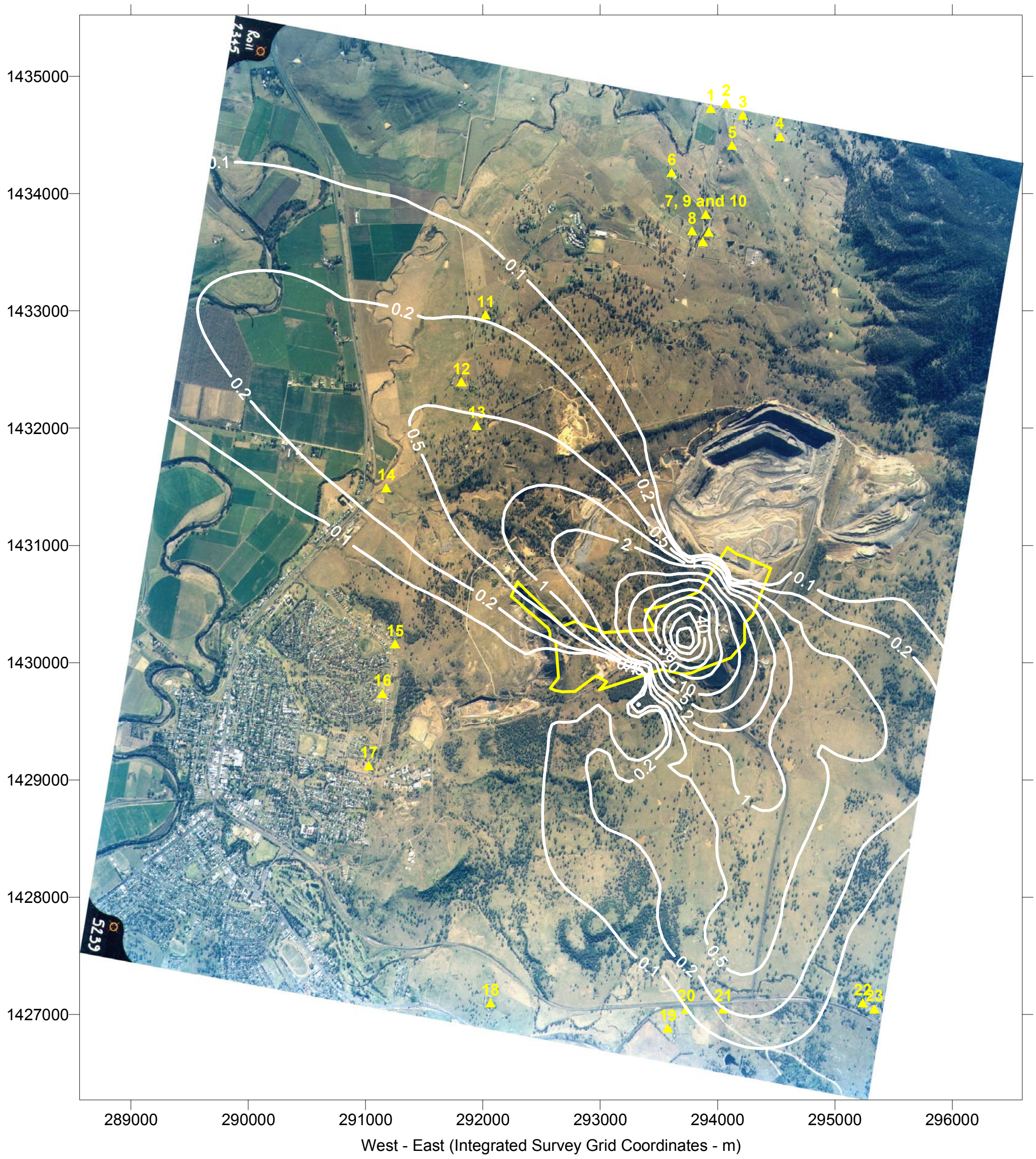
Figure 11



Predicted Annual Average TSP Concentrations due to Emissions from No. 1 Open Cut Extension Project in Year 9 - µg/m^3

Figure 12

Start Screen | Search | Appendices



Predicted Annual Average Dust Depsotion (Insoluble Solids) due to Emissions from No. 1 Open Cut Extension Project in Year 9 - g/m^2 /month

Figure 13

HLA