Appendix F – Air Quality Study

AIR QUALITY IMPACT ASSESSMENT: PROPOSED KAOLIN MINE AT NEWNES JUNCTION, NSW

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1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for International Environmental Consultants Pty Ltd who are in turn acting on behalf of Newnes Kaolin Pty Ltd. The purpose of this report is to assess any air quality impacts that may be associated with a proposed kaolin mine near Lithgow in New South Wales (NSW).

The assessment is based on the use of a computer dispersion model to predict ground-level dust concentrations and deposition levels in the vicinity of the site. To assess the effect that the dust emissions would have on existing air quality, the dispersion model predictions have been compared to relevant air quality goals.

Predictions of dust concentration and deposition levels have been made using the US EPA's short-term industrial source complex dispersion model known as ISCST3 (**US EPA, 1995A**).

2. BACKGROUND TO THE STUDY

2.1 The Study Area

Newnes Kaolin Pty Ltd propose to develop and operate a kaolin mine near Newnes Junction, west of Sydney in NSW. The site is located approximately 10 km to the east of Lithgow on the northern side of Bells Line of Road and is situated amongst quite undulating terrain. **Figures 1** and **2** show the site location and a three-dimensional representation of the local terrain respectively. Also shown are the nearest residences to the project area. Local landuse within the study area is considered be rural.

2.2 Description of Proposed Activities

The total reserves of the mine are estimated to be 23.7 Mt. These reserves consist mainly of construction and industrial sands with smaller proportions of pea gravel, kaolin and silt. Mining life is anticipated to be 21 years. Over the life of the mine approximately 119,000 tonnes per annum (tpa) of kaolin and up to 1.281 million tpa of high grade sand would be produced. Maximum production per year would total approximately 1.4 Mt.

Key mining activities would include:

- Removal and stockpiling of topsoil using bulldozers,
- Extraction of kaolin ore by ripping and/or digging,
- Loading ore to haul trucks for transport to processing area,
- Crushing the Run-of-Mine (ROM) ore at the crusher station,
- Conveying material to covered stockpiles before removal offsite via train for further processing of the ore.

Figure 3 shows the proposed layout of the mine pit and associated infrastructure. Mining would be conducted in stages with the activities progressing in a north to south direction. Rehabilitation of the mine walls would be carried out with the completion of each stage of mining.

Since the processing of the ore would be conducted offsite, large stockpiles of material would not be required on the site. There would, however, be temporary stockpiling of material in-pit before transportation to the processing site.

Hours of operation are expected to be 10 hours per day for 5.5 days per week and for 50 weeks per year.

3. AIR QUALITY ASSESSMENT METHODS AND CRITERIA

Table 1 and **Table 2** summarise the air quality goals that are relevant to this study. The air quality goals relate to the total dust burden in the air and not just the dust from the project. In other words, some consideration of background levels needs to be made when using these goals to assess impacts. This will be discussed later.

Table 1. Air quality standards/goals for particulate matter concentrations

POLLUTANT	STANDARD / GOAL	AVERAGING PERIOD	AGENCY
Total suspended particulate matter (TSP)	90 µg/m³	Annual mean	NHMRC
Particulate matter < 10 µm (PM_{10})	50 µg/m³	24-hour maximum	NSW EPA
	30 µg/m³	Annual mean	NSW EPA long-term reporting goal
	50 µg/m³	(24-hour average, 5 exceedances permitted per year)	NEPM
Particulate matter < 2.5 µm ($PM_{2.5}$)	15 µg/m³	Annual mean	US EPA[1]
	65 µg/m³	24-hour maximum[2]	US EPA

Also included in **Table 1** are the US EPA goals for the fine fraction of PM_{10} namely $PM_{2.5}$. Epidemiological studies (**Dockery et al, 1993** for example) indicate that it is the finer particles, that is those below 2.5 µm in diameter and referred to as $PM_{2.5}$, that cause health impacts as they are taken deeper into the lung.

In addition to health impacts, airborne dust also has the potential to cause nuisance impacts by depositing on surfaces. **Table 2** shows the maximum acceptable increase in dust deposition over the existing dust levels. These criteria for dust fallout levels are set to protect against nuisance impacts (**NSW EPA 2001**).

Table 2. NSW EPA criteria for dust fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m²/month	4 g/m²/month

[1] Australian standard under development
[2] 99th percentile averaged over three years

4. EXISTING ENVIRONMENT

This section describes the dispersion meteorology and existing dust levels in the area.

4.1 Dispersion Meteorology

The Gaussian dispersion model used for this assessment, ISCST3, requires information about the dispersion characteristics of the area. In particular, data are required on wind speed, wind direction, atmospheric stability class[3] and mixing height[4].

The closest known meteorological station with data suitable for dispersion modelling purposes is at Mount Piper (collected by Mount Piper Power Station). This site is located approximately 20 km to the WNW of the proposed kaolin mine site and the data contains one year of hourly records for 1997. Windroses prepared from these data are shown in **Figure 4**.

On an annual basis, it can be seen that most winds at Mount Piper were from the SW and WSW in 1997. This pattern is evident in all seasons except summer, where there is a significant contribution of winds from the ESE. To determine if the Mount Piper data would be representative of the wind patterns at Newnes Junction, these data have been compared with data collected at Lithgow by the Bureau of Meteorology and also with data generated for the site by The Air Pollution Model (TAPM).

Figure 5 shows annual and seasonal windroses for Lithgow based on spot observations made at 9 am and 3 pm by the Bureau of Meteorology. These data differ from the 1997 data in that they present a long term picture of the wind patterns over the life of the meteorological station.

Annually, the Lithgow data show that the most common winds are from the west. This is similar to the annual pattern of winds at Mount Piper, albeit a slight shift clockwise to the wind direction. Some seasonal similarities between the Lithgow and Mount Piper data are also evident.

Annual and seasonal windroses created from data generated by TAPM are shown in **Figure 6**. These data show strong similarities to the Mount Piper data with the most common winds from the WSW on an annual basis. Seasonal patterns from the TAPM data also show similar patterns to the Mount Piper data.

Given similarities between three datasets for the area it is considered that the Mount Piper data would give a reasonable indication of the likely frequency and pattern of winds in the Newnes Junction site. These data have therefore been adopted for the purposes of this assessment.

To use the wind data to assess dispersion it is necessary to also have available data on atmospheric stability. A stability class was assigned to each hour of the meteorological data using sigma-theta according to the method recommended by the US EPA (**US EPA, 1986**). **Table**

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[3] 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.

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

3 shows the frequency of occurrence of the different stability categories expected in the area. The high frequency of D class stabilities indicates that dispersion conditions will be such that dust will disperse rapidly for a significant proportion of the time (35 per cent D-class). Mixing height was determined using a scheme defined by Powell (**Powell, 1976**) for daytime conditions and an approach described by Venkatram (**Venkatram, 1980**) for night time conditions. These two methods provide the best estimate of mixing height in the absence of upper air data.

Joint wind speed, wind direction and stability class frequency tables for the Mount Piper data are presented in **Appendix A**.

Table 3. Frequency of occurrence of stability classes at Mount Piper

Stability Class	1997
A	13.3
B	7.1
C	11.5
D	34.8
E	13.0
F	20.3
Total	**100**

4.2 Existing air quality

No site specific monitoring of existing ambient dust concentrations and dust deposition levels are available for this project. Existing dust concentrations and deposition levels would be highly influenced by all existing dust generating activities in the area. The major dust sources would be the Clarence Colliery to the north of the proposed site and the Rocla sand quarry to the south. It will be seen later (**Section 8**) that the proposed kaolin mining operations would contribute very little to existing dust levels in the area.

5. ASSESSMENT CRITERIA

One of the main reasons for analysing monitoring data is to determine existing air quality so that the assessment criteria can be determined in accordance with the EPA's modelling guidelines (**NSW EPA, 2001**).

When monitoring data are not available it becomes difficult to quantify the existing air quality and to undertake a robust air quality assessment. In this study, no dust deposition or dust concentration data are available. There is an approximate relationship between annual dust deposition and annual TSP concentrations that applies in areas where particulate matter is dominated by mining/quarry dust. Areas experiencing 4 g/m^2/month typically experience annual TSP concentrations of 90 μg/m^3. Further, in mining areas, typically 40% of TSP will be in the PM_{10} size range. In the absence of dust concentration and deposition measurements a conservative estimate of dust deposition levels has been made for the purposes of this assessment. It has been assumed that the annual average dust deposition levels in the study area is 2 g/m^2/month. Thus in an area where measured annual average dust deposition rates are 2 g/m^2/month (from) the annual TSP concentration would be 45 μg/m^3 and annual average PM_{10} concentrations would be 18 μg/m^3.

Assuming the background concentrations and deposition levels are reasonable and conservative, then, using the EPA's modelling guidelines the following criteria would be applicable:

- Acceptable increase in annual average PM_{10} is **12** µg/m^3 (30 – 18 µg/m^3)
- Acceptable increase in annual average TSP is **45** µg/m^3 (90 – 45 µg/m^3)
- Acceptable increase in annual deposition (insoluble solids) **2** g/m^2/month

It will be seen later (**Section 8**) that the contribution of dust emissions from the proposed operations to the existing levels and that selection of more conservative estimates of background concentrations and deposition levels would not result in exceedances of relevant air quality goals.

In addition, the EPA guideline requires an assessment against 24-hour PM_{10} concentrations. The preferred approach is to add model predictions of predicted PM_{10} to measured PM_{10} concentrations for the same meteorological conditions. To do this requires contemporaneous monitoring and meteorological data so that the predicted concentrations for particular meteorological conditions can be matched to ambient concentrations that occur with those meteorological conditions.

The objective then is that the sum of the predicted concentration from the project being assessed and the background should not exceed the criterion. Alternatively the assessment criterion can be that the project should not cause additional exceedances.

The requirement to match ambient concentrations with corresponding meteorological conditions used for the model prediction is based on the assumption that meteorological conditions and background concentrations are correlated. In some cases this may be the case, but in the presence of bushfires or other unpredictable emissions this is not the case. A further requirement is that a database of continuous 24-hour PM_{10} concentrations is available along with the corresponding meteorological data. This is not the case for this study.

The above approach can be unworkable when background 24-hour concentrations occasionally exceed the 50 µg/m^3 concentration criterion. In this case, there is no way that the emission source can comply with the criteria, when added to the background. For example one exceedance in the pre-project background concentrations could lead to the conclusion that the air shed could not accept additional emissions. Frequent exceedances of the 24-hour criterion indicate a polluted environment and therefore additional emissions would be undesirable. However, a generally unpolluted air shed that occasionally experiences high PM_{10} concentrations, for example due to bushfires, would not require that a project should not be approved. Thus the assessment process needs to take these issues into account.

In view of the above the EPA also allows the assessment test to be that the predicted 24-hour average PM_{10} concentration from the development should be less than 50 µg/m^3. This is the approach that has been adopted here. This goal is only applicable when the mine is operating with best practice industry standards for dust control.

6. ESTIMATED DUST EMISSIONS

Estimated dust emission totals are presented in **Table 4**, and details of the calculations are presented in **Appendix B**. These estimates assume some control of dust emissions is achievable through the use of watering carts on all unsealed haul roads and by enclosing some of the processing areas.

For the air quality impact assessment, two stages of the mines operation have been considered. These two stages are identified as Stage 2 and Stage 5. Maximum production in any one year has been assumed to be 1.4 Mt.

Stage 2 has been modelled to represent the mining operations in its early development. During this stage there would be significant activities taking place in the pit but the total exposed working area of the pit would be small. Stage 5 operations represent the maximum exposed working areas and mining activities. The latter stage is considered to present the worst case in terms of air quality impacts associated with the proposal.

Table 4. Estimated dust emissions per year for kaolin mining operations

Mining Activities	***TSP emission rate (kg/y)***	
	Stage 2	Stage 5
Dozer ripping material in the pit	11,385	11,385
Loading ripped material to trucks	635	635
Hauling material to crushing station	37,333	74,667
Dumping loaded material to hopper	635	635
Primary crushing of material	6,300	6,300
Hauling topsoil material to stockpiles	613	1,664
Dumping material to stockpiles	10	47
Wind erosion from the exposed working area	9,110	38,544
Wind erosion from stockpiles	1,051	5,256
TOTAL	***67,072***	***139,133***

Dust emissions have been estimated by analysing the mining operations for each stage of development. The fraction of fine, inhalable and coarse particles for each activity has been taken into account for the dispersion modelling.

The operations which apply in each case have been combined with emission factors developed, both locally and by the US EPA, to estimate the amount of dust produced by each activity. These emission factors applied are considered to be the most up to date methods for determining dust generation rates.

7. APPROACH TO ASSESSMENT

The short-term industrial source complex model (ISC3-ST - Version 02035) 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 US. 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**). 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 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 also includes mechanisms for determining the effect of terrain on plume dispersion. The model works on an hourly time step which 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 steady state dispersion conditions are 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. 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 collection of volume sources. Each volume source may comprise dust emissions from a variety of activities. Estimates of emissions for each volume source 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 low dust generation (because wind erosion and other wind dependent emissions rates will be low) and poor dispersion. If these measures are not taken then the model has the potential to significantly overstate impacts.

The modelling has been based on the use of three particle-size categories (0 to 2.5 µm - referred to as FP ($PM_{2.5}$), 2.5 to 10 µm - referred to as CM (coarse matter) and 10 to 30 µm - referred to as the Rest). Mass emission rates in each of these size ranges have been determined using the factors derived from the **SPCC (1986)** study and TSP emission rates calculated using emission factors derived from **US EPA (1985)** and **NERDDC (1988)** work. The distribution of particles in each particle size range is as follows:

- $PM_{2.5}$ (FP) is 0.0468 of the TSP

- $PM_{2.5-10}$ (CM) is 0.3440 of TSP
- PM_{10-30} (Rest) is 0.6090 of TSP.

Modelling was done using three ISC source groups. Each group corresponded to a particle size category. Each source in the group was assumed to emit at the full TSP emission rate and to deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mean of the limits of the particle size range, except for the $PM_{2.5}$ group, which was assumed to have a particle size of 1 µm. The predicted concentration in the three plot output files for each group were then combined according to the weightings above to determine the concentration of PM_{10} and TSP. As an example the input file is provided in **Appendix C**. The mining activities have been assumed to be in operation for ten hours per day.

8. ASSESSMENT OF IMPACTS

8.1 Preamble

This section provides an interpretation of the predicted dust concentrations and deposition levels. The model runs were undertaken using the meteorological data described in **Section 4.1** (from Mount Piper) and the emissions data described in **Section 6**.

Simulations were undertaken for two stages in the life of the mine (Stage 2 and Stage 5). For each stage assessed, four isopleth diagrams have been produced showing the following:

1. Predicted maximum 24-hour average PM_{10} concentration;
2. Predicted annual average PM_{10} concentration;
3. Predicted annual average TSP concentration; and
4. Predicted annual average dust deposition.

The maximum 24-hour average contour plots do not represent the dispersion pattern at any particular instant in time, but show the highest predicted 24-hour average concentration that occurred at each location. The maxima are used to show concentrations which can possibly be reached under the modelled conditions.

Model predictions are presented in **Figures 7** to **14** and are discussed below. Dispersion modelling has also been undertaken using meteorological data generated by TAPM. Results from modelling using the TAPM data are presented in **Appendix D**. Analysis of the model results using both meteorological data sets indicate that a similar level of impact is predicted.

8.2 Stage 2 Operations

Figures 7 to **10** present predictions for PM_{10}, TSP and dust deposition levels due to the mining operations in Stage 2 of the proposal.

From **Figure 7** it can be seen that predicted maximum 24-hour concentrations do not exceed 50 µg/m^3 beyond the exploration lease boundary. Concentrations at the nearest residence are predicted to be below 20 µg/m^3 averaged over 24-hours. This is below to NSW EPA 50 µg/m^3 goal.

Predicted annual average PM_{10} concentrations due to the proposed mine are presented in **Figure 8**. This figure shows that the contribution to existing PM_{10} concentrations from the mining activities would be very low beyond the boundary of the exploration lease. The most affected residence is predicted to experience annual average PM_{10} concentrations less than 2 $\mu g/m^3$. It would be unlikely that the proposed Stage 2 mining operations would cause exceedances of the annual average PM_{10} goal of 30 $\mu g/m^3$ at any sensitive receptor.

Similarly, for TSP the annual average predictions (see **Figure 9**) at all sensitive receptors are expected to be low. No exceedances of the 90 $\mu g/m^3$ NHMRC goal would be expected. The predicted TSP concentration due to the mining operations in Stage 2 being around 2 to 3 $\mu g/m^3$ at the nearest residence (to the south-west of the site).

Figure 10 shows the predicted dust deposition levels due to the mine in Stage 2. Dust deposition levels at the nearest residence are predicted to be less than 0.2 g/m^2/month. This level is well below the maximum permissible increase allowed by EPA (2 g/m^2/month) and compliance with this goal in Stage 2 would be anticipated. Also, it is unlikely that the total deposited dust level would exceed 4 g/m^2/month due to Stage 2 mining operations.

Predicted concentrations and deposition levels at the nearest residences due to Stage 2 mining operations are summarised below.

- Predicted maximum 24-hour PM_{10} average concentration less than 20 $\mu g/m^3$
- Predicted annual average PM_{10} concentration less than 2 $\mu g/m^3$
- Predicted annual average TSP concentration less than 3 $\mu g/m^3$
- Predicted increase in annual average dust deposition less than 0.2 g/m^2/month

8.3 Stage 5 Operations

Modelling results for Stage 5 of the kaolin mining operations are presented in **Figures 11** to **14**. Predicted dust concentrations and deposition levels during Stage 5 operations are of similar magnitude to the Stage 2 predictions. The major difference between Stage 2 and Stage 5 being that maximum concentrations and deposition levels would shift further to the south-east. This would be expected with a shift in the activities to the south-east during Stage 5.

Examination of the predicted concentration and deposition levels due to the proposed operations during Stage 5 leads to similar conclusions to those drawn from Stage 2 predictions. That is, the maximum 24-hour PM_{10}, annual average PM_{10} and TSP and annual average dust deposition levels due to the proposed operations during this stage are unlikely to cause exceedances of their respective air quality goals. Predictions at the nearest residence are low and it is unlikely that the proposed operations would be the cause of exceedances of air quality goals.

Predicted concentrations and deposition levels at the nearest residences due to Stage 5 mining operations are summarised below.

- Predicted maximum 24-hour PM_{10} average concentration less than 30 $\mu g/m^3$
- Predicted annual average PM_{10} concentration 2 $\mu g/m^3$ or less
- Predicted annual average TSP concentration less than 5 $\mu g/m^3$
- Predicted increase in annual average dust deposition 0.2 g/m^2/month or less

9. GREENHOUSE ISSUES

Mining results in the emission of carbon dioxide (CO_2) during the combustion of diesel fuel (used primarily in diesel-powered equipment) and indirectly in the use of electricity to power mining equipment. These are the only significant sources of greenhouse gases involved in the Project. The electrical and fuel requirements for these sources have been used to estimate CO_2 emission rates for the proposed mining operations. In doing this it has been assumed that each MWh of electrical energy used results in the release of 1.06 t of CO_2 and that the cost of electricity is 13 cents per kWh.

Table 5 summarises the estimated CO_2 emissions from the Project for each year of operation. It is estimated that over the life of the mine $2.6 Million will be spent on electricity to power the conveyors, offices and signaling on site. This would equate to 21,200 t of CO_2, assuming the cost of electricity is 13 cents per kWh.

Table 5. Summary of estimated CO_2 emissions from Project

Year	Diesel equipment					CO_2 from electricity (t)	Total CO_2 emission (t)	CO_2 emission as % of 2000
	Diesel usage (t/y)	Carbon content (%)	Percent combusted (%)	Carbon left in fuel (%)	CO_2 emissions (t)			
1	99	86	99	1	308	1,010	1,318	0.00025
2	124	86	99	1	387	1,010	1,397	0.00026
3	151	86	99	1	472	1,010	1,482	0.00028
4	178	86	99	1	557	1,010	1,567	0.00029
5	261	86	99	1	815	1,010	1,825	0.00034
6	289	86	99	1	902	1,010	1,912	0.00036
7	318	86	99	1	992	1,010	2,002	0.00037
8	348	86	99	1	1,088	1,010	2,098	0.00039
9	380	86	99	1	1,186	1,010	2,196	0.00041
10	436	86	99	1	1,361	1,010	2,371	0.00044
11*	507	86	99	1	1,582	1,010	2,592	0.00048
12	507	86	99	1	1,582	1,010	2,592	0.00048
13	507	86	99	1	1,582	1,010	2,592	0.00048
14	507	86	99	1	1,582	1,010	2,592	0.00048
15	507	86	99	1	1,582	1,010	2,592	0.00048
16	507	86	99	1	1,582	1,010	2,592	0.00048
17	507	86	99	1	1,582	1,010	2,592	0.00048
18	507	86	99	1	1,582	1,010	2,592	0.00048
19	507	86	99	1	1,582	1,010	2,592	0.00048
20	507	86	99	1	1,582	1,010	2,592	0.00048
21	507	86	99	1	1,582	1,010	2,592	0.00048
Total	8,159	-	-	-	25,471	21,200	46,671	0.00872

** From Year 11 it has been assumed that peak production is maintained through until Year 21 and that the total diesel usage over life of mine is 9.6 million litres.*

These figures can be compared with the CO_2 equivalent emission estimates from Australia's National Greenhouse Gas Inventory (**Australian Greenhouse Office, 2002**). There are two widely accepted methods for estimating greenhouse gas emissions (1) the United Nations Framework Convention on Climate Change (UNFCCC) and (2) the Kyoto protocol method. The differences between the two methods relate to the way in which forest sinks are treated. The estimated CO_2-equivalent emission for the two methods for all sectors are:

- UNFCCC – 535.3 Mt
- Kyoto – 503.3 Mt

For the purposes of this discussion we will only reference the UNFCCC figure. The 1990 emission using the UNFCCC methodology is 503.3 Mt.

There are no practical alternative fuels for a mining project of this type. However, alternative mining methods can lead to greater efficiency in the use of fuels and electricity. These include:

- Minimising haul distances for waste and ore
- Minimising double handling of materials
- Using the most practical and efficient machinery

10. CONCLUSIONS

This study has assessed air quality impacts due to the proposed kaolin mine at Newnes Junction. Potential air quality impacts examined are those due to emissions of PM_{10}, TSP and deposition of insoluble solids. Dispersion modelling has been used for assessment purposes.

Two stages of the mine's life have been assessed. These stages have been chosen to cover a range of dust emission conditions due to the proposed operations.

Results from the dispersion modelling have indicated that off-site dust impacts would be minimal. Although site specific air quality monitoring has not been carried out for this project, the dispersion modelling study has indicated that the proposed operations would contribute very little to existing dust levels in the area. Compliance with air quality goals would be expected during all stages of the proposed mining operations.

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APPENDIX A
JOINT WIND SPEED, WIND DIRECTION AND STABILITY CLASS FREQUENCY TABLES

FROM 97. 1. 3   TO 97.12.31

PASQUILL STABILITY CLASS "A"

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.002869	.003142	.000820	.000000	.000000	.000000	.000000	.000000	.006831	1.91
NE	.001503	.003279	.000956	.000000	.000000	.000000	.000000	.000000	.005738	2.20
ENE	.001230	.001503	.001230	.000000	.000000	.000000	.000000	.000000	.003962	2.30
E	.001230	.002732	.000410	.000000	.000000	.000000	.000000	.000000	.004372	1.95
ESE	.001366	.001913	.000956	.000000	.000000	.000000	.000000	.000000	.004235	2.15
SE	.000410	.003415	.001776	.000000	.000000	.000000	.000000	.000000	.005601	2.53
SSE	.000683	.004645	.000956	.000000	.000000	.000000	.000000	.000000	.006284	2.35
S	.002596	.003689	.001093	.000000	.000000	.000000	.000000	.000000	.007377	2.11
SSW	.001913	.003415	.002186	.000000	.000000	.000000	.000000	.000000	.007514	2.36
SW	.000820	.003825	.001639	.000137	.000000	.000000	.000000	.000000	.006421	2.51
WSW	.001093	.002869	.002459	.000273	.000000	.000000	.000000	.000000	.006694	2.79
W	.001503	.004645	.003142	.000546	.000000	.000000	.000000	.000000	.009836	2.79
WNW	.000546	.004645	.002322	.000410	.000000	.000000	.000000	.000000	.007923	2.68
NW	.002732	.005328	.001639	.000000	.000000	.000000	.000000	.000000	.009699	2.13
NNW	.003689	.011612	.002869	.000000	.000000	.000000	.000000	.000000	.018169	2.24
N	.003142	.005738	.001639	.000000	.000000	.000000	.000000	.000000	.010519	2.10
CALM									.011749	
TOTAL	.027322	.066393	.026093	.001366	.000000	.000000	.000000	.000000	.132923	2.14

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 7320

PASQUILL STABILITY CLASS "B"

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.000683	.002596	.002186	.000000	.000000	.000000	.000000	.000000	.005464	2.66
NE	.000273	.001503	.001230	.000000	.000000	.000000	.000000	.000000	.003005	2.96
ENE	.000273	.000820	.001093	.000137	.000000	.000000	.000000	.000000	.002322	2.91
E	.000137	.000410	.000683	.000137	.000000	.000000	.000000	.000000	.001366	3.08
ESE	.000000	.001366	.001776	.000137	.000000	.000000	.000000	.000000	.003279	3.16
SE	.000137	.001503	.001093	.000000	.000000	.000000	.000000	.000000	.002732	2.90
SSE	.000137	.001776	.000956	.000137	.000000	.000000	.000000	.000000	.003005	2.95
S	.000137	.001093	.001913	.000000	.000000	.000000	.000000	.000000	.003142	3.00
SSW	.000137	.000546	.001230	.000273	.000000	.000000	.000000	.000000	.002186	3.30
SW	.000000	.001503	.002459	.000956	.000000	.000000	.000000	.000000	.004918	3.76
WSW	.000000	.000956	.003142	.001503	.000000	.000000	.000000	.000000	.005601	3.90
W	.000000	.001093	.002596	.001913	.000000	.000000	.000000	.000000	.005601	4.10
WNW	.000137	.001776	.004235	.001913	.000000	.000000	.000000	.000000	.008060	3.87
NW	.000410	.001366	.002732	.000410	.000000	.000000	.000000	.000000	.004918	3.18
NNW	.000273	.005328	.002732	.000137	.000000	.000000	.000000	.000000	.008470	2.81
N	.000956	.002869	.002049	.000000	.000000	.000000	.000000	.000000	.005874	2.57
CALM									.001366	
TOTAL	.003689	.026503	.032104	.007650	.000000	.000000	.000000	.000000	.071311	3.19

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 7320

PASQUILL STABILITY CLASS "C"

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.001093	.001230	.004098	.000546	.000000	.000000	.000000	.000000	.006967	3.18
NE	.000273	.000273	.001503	.000000	.000000	.000000	.000000	.000000	.002049	3.19
ENE	.000000	.000546	.000956	.000137	.000000	.000000	.000000	.000000	.001639	3.44
E	.000546	.001230	.002186	.000820	.000000	.000000	.000000	.000000	.004781	3.32
ESE	.000137	.001503	.003689	.001230	.000000	.000000	.000000	.000000	.006557	3.72
SE	.000000	.001913	.005874	.001230	.000000	.000000	.000000	.000000	.009016	3.68
SSE	.000000	.002869	.004372	.000410	.000000	.000000	.000000	.000000	.007650	3.42
S	.000000	.001366	.001230	.000137	.000000	.000000	.000000	.000000	.002732	3.08
SSW	.000137	.001503	.001913	.001503	.000000	.000000	.000000	.000000	.005055	3.59
SW	.000546	.001503	.005464	.004508	.000000	.000000	.000000	.000000	.012022	4.09
WSW	.000000	.000956	.003552	.005055	.000000	.000000	.000000	.000000	.009563	4.45
W	.000273	.000820	.004645	.005328	.000000	.000000	.000000	.000000	.011066	4.41
WNW	.000273	.001639	.003279	.005328	.000000	.000000	.000000	.000000	.010519	4.17
NW	.000137	.003279	.003825	.001776	.000000	.000000	.000000	.000000	.009016	3.60
NNW	.000273	.006421	.004235	.001230	.000000	.000000	.000000	.000000	.012158	3.07
N	.000546	.001913	.000410	.000137	.000000	.000000	.000000	.000000	.003005	2.45
CALM									.001639	
TOTAL	.004235	.028962	.051230	.029372	.000000	.000000	.000000	.000000	.115437	3.66

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 7320

PASQUILL STABILITY CLASS "D"

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.001776	.006557	.007514	.000273	.000000	.000000	.000000	.000000	.016120	2.95
NE	.000410	.002322	.001913	.000000	.000137	.000000	.000000	.000000	.004781	3.01
ENE	.000000	.001366	.001366	.000410	.000000	.000000	.000000	.000000	.003142	3.43
E	.000273	.005738	.008607	.004645	.000273	.000000	.000000	.000000	.019536	3.69
ESE	.000137	.004645	.017760	.009290	.000410	.000000	.000000	.000000	.032240	4.05
SE	.000000	.011066	.014754	.001913	.000137	.000000	.000000	.000000	.027869	3.32
SSE	.000273	.014071	.010109	.004918	.001366	.000410	.000000	.000000	.031148	3.51
S	.000410	.008470	.003415	.001093	.001639	.000000	.000000	.000000	.015027	3.33
SSW	.001776	.009563	.004508	.003279	.001503	.000000	.000000	.000000	.020628	3.27
SW	.019126	.015164	.006831	.007377	.002869	.000820	.000000	.000000	.052186	2.81
WSW	.015984	.008880	.012158	.007514	.004918	.001776	.000137	.000000	.051366	3.39
W	.000820	.005464	.005328	.003005	.004781	.000546	.000000	.000000	.019945	4.40
WNW	.000820	.004781	.004781	.001230	.001366	.000000	.000000	.000000	.012978	3.48
NW	.000683	.009016	.005464	.001230	.000683	.000000	.000000	.000000	.017077	3.08
NNW	.001366	.010383	.002869	.001230	.000956	.000273	.000000	.000000	.017077	3.00
N	.000683	.002049	.000956	.000273	.000137	.000000	.000000	.000000	.004098	2.82
CALM									.002869	
TOTAL	.044536	.119536	.108333	.047678	.021175	.003825	.000137	.000000	.348087	3.34

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 7320

PASQUILL STABILITY CLASS "E"

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.000410	.003279	.000820	.000000	.000000	.000000	.000000	.000000	.004508	2.46
NE	.000000	.001776	.000683	.000000	.000000	.000000	.000000	.000000	.002459	2.83
ENE	.000137	.002186	.000546	.000000	.000000	.000000	.000000	.000000	.002869	2.53
E	.000137	.000683	.000546	.000137	.000000	.000000	.000000	.000000	.001503	2.73
ESE	.000410	.001366	.000820	.000000	.000000	.000000	.000000	.000000	.002596	2.46
SE	.000410	.002596	.000683	.000000	.000000	.000000	.000000	.000000	.003689	2.53
SSE	.000410	.004645	.000273	.000000	.000000	.000000	.000000	.000000	.005328	2.28
S	.000546	.005464	.001093	.000273	.000000	.000000	.000000	.000000	.007377	2.46
SSW	.002596	.005328	.001230	.000000	.000000	.000000	.000000	.000000	.009153	2.07
SW	.018579	.011202	.002732	.000683	.000000	.000000	.000000	.000000	.033197	1.70
WSW	.017486	.006557	.000820	.000137	.000000	.000000	.000000	.000000	.025000	1.49
W	.003142	.002049	.000820	.000000	.000000	.000000	.000000	.000000	.006011	1.81
WNW	.001366	.001639	.000546	.000000	.000000	.000000	.000000	.000000	.003552	1.92
NW	.001366	.004372	.000000	.000000	.000000	.000000	.000000	.000000	.005738	1.85
NNW	.002596	.007377	.000137	.000000	.000000	.000000	.000000	.000000	.010109	1.82
N	.001913	.002186	.000137	.000000	.000000	.000000	.000000	.000000	.004235	1.73
CALM									.002322	
TOTAL	.051503	.062705	.011885	.001230	.000000	.000000	.000000	.000000	.129645	1.87

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 7320

PASQUILL STABILITY CLASS "F"

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.002596	.001503	.000000	.000000	.000000	.000000	.000000	.000000	.004098	1.42
NE	.001913	.001366	.000000	.000000	.000000	.000000	.000000	.000000	.003279	1.53
ENE	.002186	.001503	.000000	.000000	.000000	.000000	.000000	.000000	.003689	1.47
E	.000683	.000820	.000000	.000000	.000000	.000000	.000000	.000000	.001503	1.53
ESE	.003415	.000683	.000000	.000000	.000000	.000000	.000000	.000000	.004098	1.19
SE	.002869	.000820	.000000	.000000	.000000	.000000	.000000	.000000	.003689	1.21
SSE	.004645	.001913	.000000	.000000	.000000	.000000	.000000	.000000	.006557	1.32
S	.004098	.002869	.000000	.000000	.000000	.000000	.000000	.000000	.006967	1.44
SSW	.005874	.002322	.000000	.000000	.000000	.000000	.000000	.000000	.008197	1.30
SW	.020082	.002049	.000000	.000000	.000000	.000000	.000000	.000000	.022131	1.10
WSW	.025956	.002459	.000000	.000000	.000000	.000000	.000000	.000000	.028415	.99
W	.011339	.001639	.000000	.000000	.000000	.000000	.000000	.000000	.012978	1.01
WNW	.004508	.002049	.000000	.000000	.000000	.000000	.000000	.000000	.006557	1.36
NW	.006011	.002186	.000000	.000000	.000000	.000000	.000000	.000000	.008197	1.29
NNW	.008060	.004508	.000000	.000000	.000000	.000000	.000000	.000000	.012568	1.39
N	.007240	.003825	.000000	.000000	.000000	.000000	.000000	.000000	.011066	1.38
CALM									.058607	
TOTAL	.111475	.032514	.000000	.000000	.000000	.000000	.000000	.000000	.202596	.94

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 7320

ALL PASQUILL STABILITY CLASSES

WIND SPEED CLASS (MPS)

WIND SECTOR	.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	MEAN SPEED
NNE	.009426	.018306	.015437	.000820	.000000	.000000	.000000	.000000	.043989	2.59
NE	.004372	.010519	.006284	.000000	.000137	.000000	.000000	.000000	.021311	2.55
ENE	.003825	.007923	.005191	.000683	.000000	.000000	.000000	.000000	.017623	2.55
E	.003005	.011612	.012432	.005738	.000273	.000000	.000000	.000000	.033060	3.24
ESE	.005464	.011475	.025000	.010656	.000410	.000000	.000000	.000000	.053005	3.50
SE	.003825	.021311	.024180	.003142	.000137	.000000	.000000	.000000	.052596	3.07
SSE	.006148	.029918	.016667	.005464	.001366	.000410	.000000	.000000	.059973	3.00
S	.007787	.022951	.008743	.001503	.001639	.000000	.000000	.000000	.042623	2.62
SSW	.012432	.022678	.011066	.005055	.001503	.000000	.000000	.000000	.052732	2.66
SW	.059153	.035246	.019126	.013661	.002869	.000820	.000000	.000000	.130874	2.38
WSW	.060519	.022678	.022131	.014481	.004918	.001776	.000137	.000000	.126639	2.55
W	.017077	.015710	.016530	.010792	.004781	.000546	.000000	.000000	.065437	3.22
WNW	.007650	.016530	.015164	.008880	.001366	.000000	.000000	.000000	.049590	3.17
NW	.011339	.025546	.013661	.003415	.000683	.000000	.000000	.000000	.054645	2.61
NNW	.016257	.045628	.012842	.002596	.000956	.000273	.000000	.000000	.078552	2.41
N	.014481	.018579	.005191	.000410	.000137	.000000	.000000	.000000	.038798	2.03
CALM									.078552	
TOTAL	.242760	.336612	.229645	.087295	.021175	.003825	.000137	.000000	1.000000	2.53

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID OBSERVATIONS = 7320

APPENDIX B
ESTIMATED DUST EMISSIONS FROM KAOLIN MINE

STAGE 2 OPERATION DUST EMISSIONS
KAOLIN MINE - NEWNES JUNCTION

Introduction

The dust emission inventory has been estimated using the emission factors and the mine plan information provided. Emission factors have been developed using emission factor equations provided in the **US EPA (1985)** (and subsequent updates) publication referred to as AP-42 and from factors determined by **NERDDC (1988)**.

Estimated emissions are presented for all significant dust generating activities associated with the development of the mine.

It has been assumed (as a worst case assessment) that mining activities occur 10 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.

Dozer ripping material in pit

In normal operation two dozers will be working in the pit. The rate at which dust will be generated by a dozer working is calculated using Equation 1.

Equation 1

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

where,

s = silt content (%), and

M = moisture content (%)

Taking M to be 10% and s to be 10%, the emission factor is estimated to be approximately 2.07 kg/hour. Assuming that each dozer is working for approximately 2,750 hours/y, the total dust emissions would be approximately 11,385 kg/y [2 dozers x 2,750 h/y x 2.07 kg/h].

Loading ripped material to trucks

In a typical year of operation, approximately 1,400,000 t/y of material will be loaded into trucks through the use of a front end loader (FEL) for haulage to the crusher station. Each tonne of material loaded will generate a certain amount of dust, depending on the wind speed and the moisture content. Equation 2 (**US EPA, 1995B, 13.2.4-3**) shows the relationship between these variables.

Equation 2

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

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

Assuming a moisture content of 4.8% (maximum that Equation 2 has been tested for), the total emission for a typical year is therefore given by;

$$E_{TSP} = 1{,}400{,}000 \times 0.00035 \times \left(\frac{U}{2.2}\right)^{1.3}$$

A "wind speed factor", [that is the $(U/2.2)^{1.3}$ part of Equation 2], will vary from hour to hour. This factor has been calculated for each hour in the meteorological data file and an annual average determined to be approximately 1.295. The total emissions from loading ripped material to trucks will therefore be approximately 635 kg/y [1,400,000 x 0.00035 x 1.295].

Hauling material to crushing station

Approximately 1,400,000 t/y of material will be hauled using 75 t trucks. Assuming a return travel distance of 1 km, dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road, the total dust generated is expected to be 37,333 kg/y [(1,400,000 t / 75 t) x 1 km x 4 kg/km x 50/100].

Dumping material to hopper

Approximately 1,400,000 t of material will be unloaded from trucks to the hopper. Each tonne dumped will generate dust at the rate determined by Equation 2.

The total emission is therefore given by;

$$E_{TSP} = 1{,}400{,}000 \times 0.00035 \times \left(\frac{U}{2.2}\right)^{1.3}$$

The emissions from this process will vary from hour to hour depending on the wind speed and in the model this is how the emission is represented. However, the annual emission is also of interest. Using the annual average "wind speed factor" of 1.295 (as determined previously), the total emissions from unloading the material from trucks will be approximately 635 kg/y [1,400,000 x 0.00035 x 1.295].

Primary crushing of material

It has been assumed that all material passes through primary crushing, generating dust at the rate of 0.009 kg/t (**US EPA, 1985**). Partial enclosure can reduce this emission by 50%. The total dust generated from crushing is therefore approximately, 6,300 kg/y [1,400,000 t/y x 0.009 kg/t x 50/100].

Hauling topsoil material to stockpiles

Approximately 23,000 t/y of topsoil will be hauled using 75 t trucks. Assuming a return travel distance of 1 km to the stockpiles, dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road, the total dust generated is expected to be 613 kg/y [(23,000 t / 75 t) x 1 km x 4 kg/km x 50/100].

Dumping material to stockpiles

Approximately 23,000 t of topsoil will be unloaded from trucks to the stockpiles in the early mining stages. Each tonne dumped will generate dust at the rate determined by Equation 2.

The total emission for is therefore given by;

$$E_{TSP} = 23{,}000 \times 0.00035 \times \left(\frac{U}{2.2}\right)^{1.3}$$

Using the annual average "wind speed factor" of 1.295 (as determined previously), the total emissions from unloading the material from trucks will be approximately 10 kg/y [23,000 x .000035 x 1.295].

Wind Erosion

Wind erosion from the exposed working area

Assuming that the exposed working area is approximately 2.6 ha, the annual dust emission will be approximately 9,110 kg/y [2.6 ha x 0.4 kg/ha/h x 24 h/day x 365 day/y].

Wind erosion from stockpiles

Emissions from stockpiles can be controlled by 50% with the use of water sprays. Assuming that the stockpile area is approximately 0.6 ha and 50% control applies, the annual dust emission will be approximately 1,051 kg/y [0.6 ha x 0.4 kg/ha/h x 24 h/day x 365 day/y x 50/100].

STAGE 5 OPERATIONS DUST EMISSIONS
KAOLIN MINE - NEWNES JUNCTION

Introduction

Estimated emissions for the proposed Stage 5 mining operations are presented below for all significant dust generating activities associated with this stage.

Dozer ripping material in pit

Assuming that each dozer is working for approximately 2,750 hours/y, the total dust emissions would be approximately 11,385 kg/y [2 dozers x 2,750 h/y x 2.07 kg/h].

Loading ripped material to trucks

The total emissions from loading ripped material to trucks will therefore be approximately 635 kg/y [1,400,000 x 0.00035 x 1.295].

Hauling material to crushing station

Approximately 1,400,000 t/y of material will be hauled using 75 t trucks. Assuming a return travel distance of 2 km, dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road, the total dust generated is expected to be 74,667 kg/y [(1,400,000 t / 75 t) x 2 km x 4 kg/km x 50/100].

Dumping material to hopper

The total emissions from unloading the material from trucks will be approximately 635 kg/y [1,400,000 x 0.00035 x 1.295].

Primary crushing of material

The total dust generated from crushing is therefore approximately, 6,300 kg/y [1,400,000 t/y x 0.009 kg/t x 50/100].

Hauling topsoil material to stockpiles

Approximately 104,000 t/y of topsoil will be hauled using 75 t trucks. Assuming a return travel distance of 0.6 km, dust generation rate of 4 kg/VKT and 50% control of dust by watering of the haul road, the total dust generated is expected to be 1,664 kg/y [(104,000 t / 75 t) x 0.6 km x 4 kg/km x 50/100].

Dumping material to stockpiles

Approximately 104,000 t of topsoil will be unloaded from trucks to the stockpiles. Each tonne dumped will generate dust at the rate determined by Equation 2.

The total emission for is therefore given by;

$$E_{TSP} = 104{,}000 \times 0.00035 \times \left(\frac{U}{2.2}\right)^{1.3}$$

Using the annual average "wind speed factor" of 1.295 (as determined previously), the total emissions from unloading the material from trucks will be approximately 47 kg/y [104,000 x 0.00035 x 1.295].

Wind Erosion

Wind erosion from the exposed working area

Assuming that the exposed working area is approximately 11 ha (including completed areas that have not been fully rehabilitated), the annual dust emission will be approximately 38,544 kg/y [11 ha x 0.4 kg/ha/h x 24 h/day x 365 day/y].

Wind erosion from stockpiles

Emissions from stockpiles can be controlled by 50% with the use of water sprays. Assuming that the stockpile area is approximately 3 ha and 50% control applies, the annual dust emission will be approximately 5,256 kg/y [3 ha x 0.4 kg/ha/h x 24 h/day x 365 day/y x 50/100].

Stage 2 operations	Dozers ripping	Loading to trucks	Hauling material to crusher station	Dumping material to hopper	Crushing of material	Hauling topsoil to stockpiles	Dumping topsoil to stockpiles	Wind erosion from exposed working area	Wind erosion from stockpiles	Total emission rate g/s
Emission rate kg/y	11,385	635	37,333	635	6,300	613	10	9,110	1,051	
Number of sources	2	1	5	1	1	3	1	4	1	
Source ID										
1	1	0	0	0	0	0	0	0	0	**0.1805**
2	1	0	0	0	0	0	0	0	0	**0.1805**
3	0	1	0	0	0	0	0	0	0	**0.0201**
4	0	0	1	0	0	0	0	0	0	**0.2368**
5	0	0	1	0	0	0	0	0	0	**0.2368**
6	0	0	1	0	0	0	0	0	0	**0.2368**
7	0	0	1	0	0	0	0	0	0	**0.2368**
8	0	0	1	0	0	0	0	0	0	**0.2368**
9	0	0	0	0	1	0	0	0	0	**0.1998**
10	0	0	0	0	0	1	0	0	0	**0.0065**
11	0	0	0	0	0	1	0	0	0	**0.0065**
12	0	0	0	0	0	1	0	0	0	**0.0065**
13	0	0	0	0	0	0	1	0	0	**0.0003**
14	0	0	0	0	0	0	0	1	0	**0.0722**
15	0	0	0	0	0	0	0	1	0	**0.0722**
16	0	0	0	0	0	0	0	1	0	**0.0722**
17	0	0	0	0	0	0	0	1	0	**0.0722**
18	0	0	0	0	0	0	0	0	1	**0.0333**
19	0	0	0	1	0	0	0	0	0	**0.0201**

Stage 5 operations	Dozers ripping	Loading to trucks	Hauling material to crusher station	Dumping material to hopper	Crushing of material	Hauling topsoil to stockpiles	Dumping topsoil to stockpiles	Wind erosion from exposed working area	Wind erosion from stockpiles	Total emission rate g/s
Emission rate kg/y	11,385	635	74,667	635	6,300	1,664	47	38,544	5,256	
Number of sources	2	1	6	1	1	3	1	4	2	
Source ID										
1	1	0	0	0	0	0	0	0	0	**0.1805**
2	1	0	0	0	0	0	0	0	0	**0.1805**
3	0	1	0	0	0	0	0	0	0	**0.0201**
4	0	0	1	0	0	0	0	0	0	**0.3946**
5	0	0	1	0	0	0	0	0	0	**0.3946**
6	0	0	1	0	0	0	0	0	0	**0.3946**
7	0	0	1	0	0	0	0	0	0	**0.3946**
8	0	0	1	0	0	0	0	0	0	**0.3946**
9	0	0	1	0	0	0	0	0	0	**0.3946**
10	0	0	0	0	1	0	0	0	0	**0.1998**
11	0	0	0	0	0	1	0	0	0	**0.0176**
12	0	0	0	0	0	1	0	0	0	**0.0176**
13	0	0	0	0	0	1	0	0	0	**0.0176**
14	0	0	0	0	0	0	1	0	0	**0.0015**
15	0	0	0	0	0	0	0	1	0	**0.3056**
16	0	0	0	0	0	0	0	1	0	**0.3056**
17	0	0	0	0	0	0	0	1	0	**0.3056**
18	0	0	0	0	0	0	0	1	0	**0.3056**
19	0	0	0	0	0	0	0	0	1	**0.0833**
20	0	0	0	0	0	0	0	0	1	**0.0833**
21	0	0	0	1	0	0	0	0	0	**0.0201**

APPENDIX C
ISCST3 INPUT FILE

ISCST3 INPUT FILE:

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

SO STARTING
   LOCATION  POINT1  VOLUME  244694 6292839 1006.5
   LOCATION  POINT2  VOLUME  244768 6292835 1006.6
   LOCATION  POINT3  VOLUME  244726 6292874 1007
   LOCATION  POINT4  VOLUME  244758 6292894 1006.8
   LOCATION  POINT5  VOLUME  244794 6292986 1007.1
   LOCATION  POINT6  VOLUME  244809 6293097 1006.4
   LOCATION  POINT7  VOLUME  244819 6293200 1007
   LOCATION  POINT8  VOLUME  244823 6293334 1007.1
   LOCATION  POINT9  VOLUME  244862 6293371 1009.1
   LOCATION  POINT10  VOLUME  244889 6293365 1004.7
   LOCATION  POINT11  VOLUME  244792 6292836 1008.6
   LOCATION  POINT12  VOLUME  244793 6292756 1010.6
   LOCATION  POINT13  VOLUME  244808 6292666 1022.9
   LOCATION  POINT14  VOLUME  244852 6292719 1029
   LOCATION  POINT15  VOLUME  244559 6293011 1006
   LOCATION  POINT16  VOLUME  244730 6293014 1007
   LOCATION  POINT17  VOLUME  244655 6292880 1005.6
   LOCATION  POINT18  VOLUME  244765 6292873 1007
   LOCATION  POINT19  VOLUME  244856 6292760 1025.4
   LOCATION  POINT20  VOLUME  244852 6292654 1035.6
   LOCATION  POINT21  VOLUME  244889 6293365 1004.7
   LOCATION  POINT22  VOLUME  244694 6292839 1006.5
   LOCATION  POINT23  VOLUME  244768 6292835 1006.6
   LOCATION  POINT24  VOLUME  244726 6292874 1007
   LOCATION  POINT25  VOLUME  244758 6292894 1006.8
   LOCATION  POINT26  VOLUME  244794 6292986 1007.1
   LOCATION  POINT27  VOLUME  244809 6293097 1006.4
   LOCATION  POINT28  VOLUME  244819 6293200 1007
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   LOCATION  POINT32  VOLUME  244792 6292836 1008.6
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   LOCATION  POINT35  VOLUME  244852 6292719 1029
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   LOCATION  POINT37  VOLUME  244730 6293014 1007
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   LOCATION  POINT55  VOLUME  244808 6292666 1022.9
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   LOCATION  POINT57  VOLUME  244559 6293011 1006
   LOCATION  POINT58  VOLUME  244730 6293014 1007
   LOCATION  POINT59  VOLUME  244655 6292880 1005.6
   LOCATION  POINT60  VOLUME  244765 6292873 1007
   LOCATION  POINT61  VOLUME  244856 6292760 1025.4
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RE DISCCART 245686 6293673 921
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RE DISCCART 246181 6293179 930
RE DISCCART 246223 6292775 958
RE DISCCART 246223 6291786 1036
RE DISCCART 245888 6291716 980
RE DISCCART 245735 6291201 1048
RE DISCCART 245219 6291145 1088
RE DISCCART 244760 6291173 1042
RE DISCCART 244272 6291201 1029
RE DISCCART 243631 6291228 1070
RE DISCCART 243381 6291228 1121
RE DISCCART 242670 6291618 1110
RE DISCCART 242684 6291257 1135
RE DISCCART 243283 6290755 1072
RE DISCCART 243673 6290727 1076
RE DISCCART 244300 6290727 971
RE DISCCART 244773 6290727 1066
RE DISCCART 245248 6290755 1096
RE DISCCART 245846 6290755 1102
RE DISCCART 246181 6290755 1071
RE DISCCART 246264 6291173 1061
RE DISCCART 246654 6291758 987
RE DISCCART 246683 6292218 938
RE DISCCART 246724 6292761 938
RE DISCCART 246766 6293360 944
RE DISCCART 246766 6293792 901
RE DISCCART 246181 6294447 944
RE DISCCART 245679 6294767 982
```
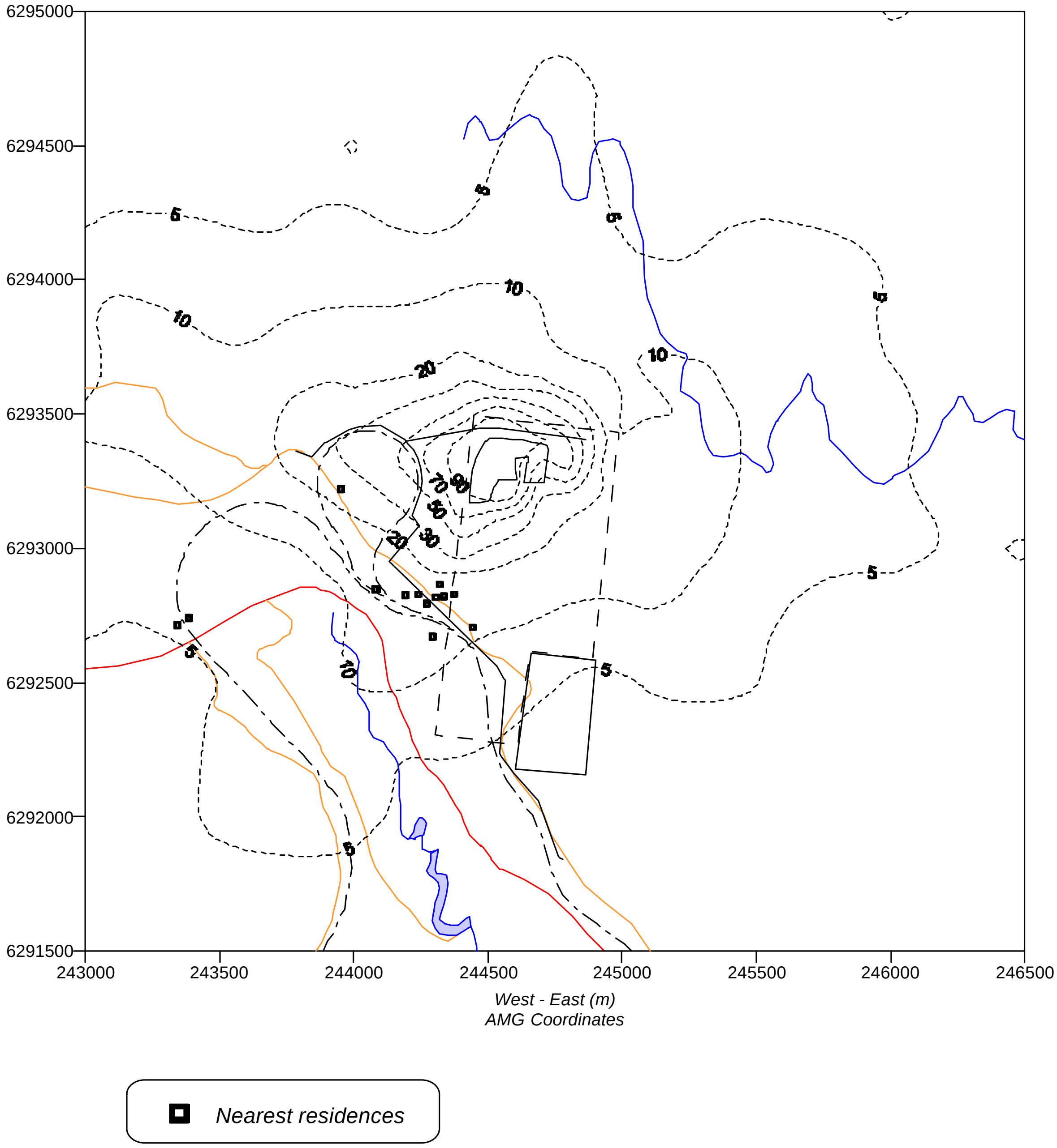
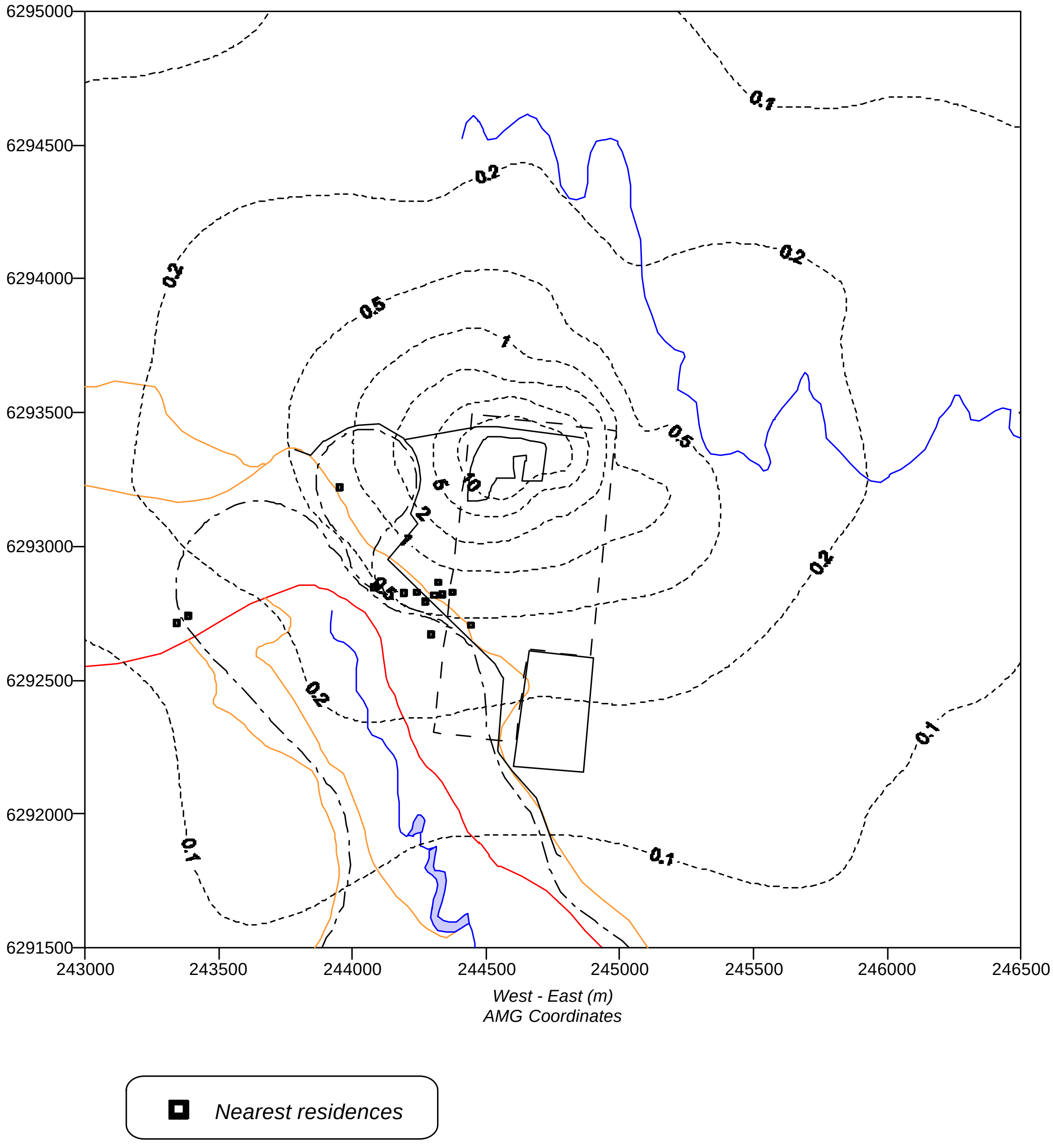

```
RE FINISHED

ME STARTING
   INPUTFIL  C:\kaolin\metdata\mtp97.isc
   ANEMHGHT  10  METERS
   SURFDATA  99999  1997
   UAIRDATA  66666  1997
ME FINISHED

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

APPENDIX D
DISPERSION MODEL RESULTS USING TAPM METEOROLOGICAL DATA



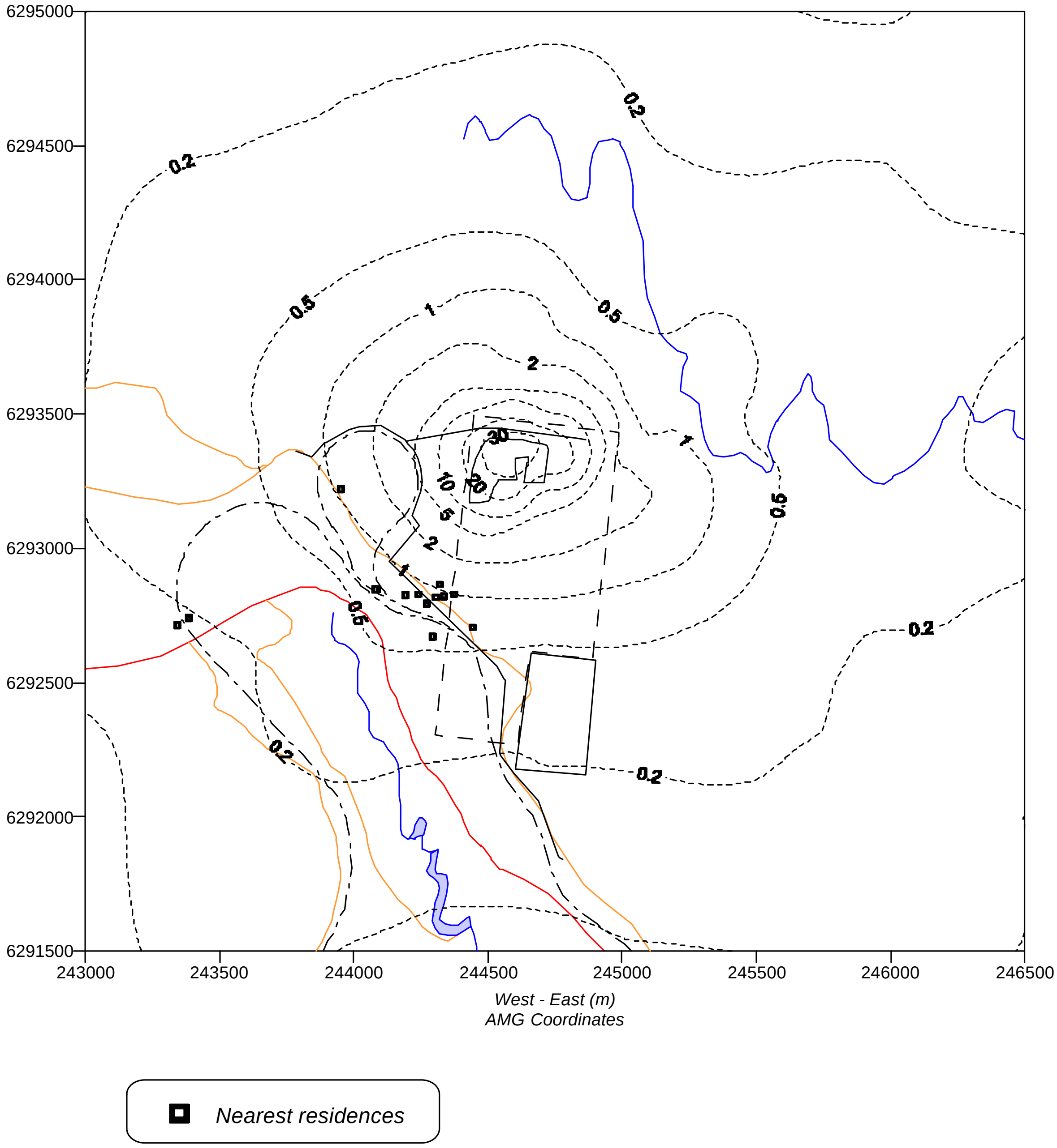
Predicted maximum 24-hour average PM_{10} concentration at ground-level for Stage 2 operations (µg/m^3)

FIGURE D1



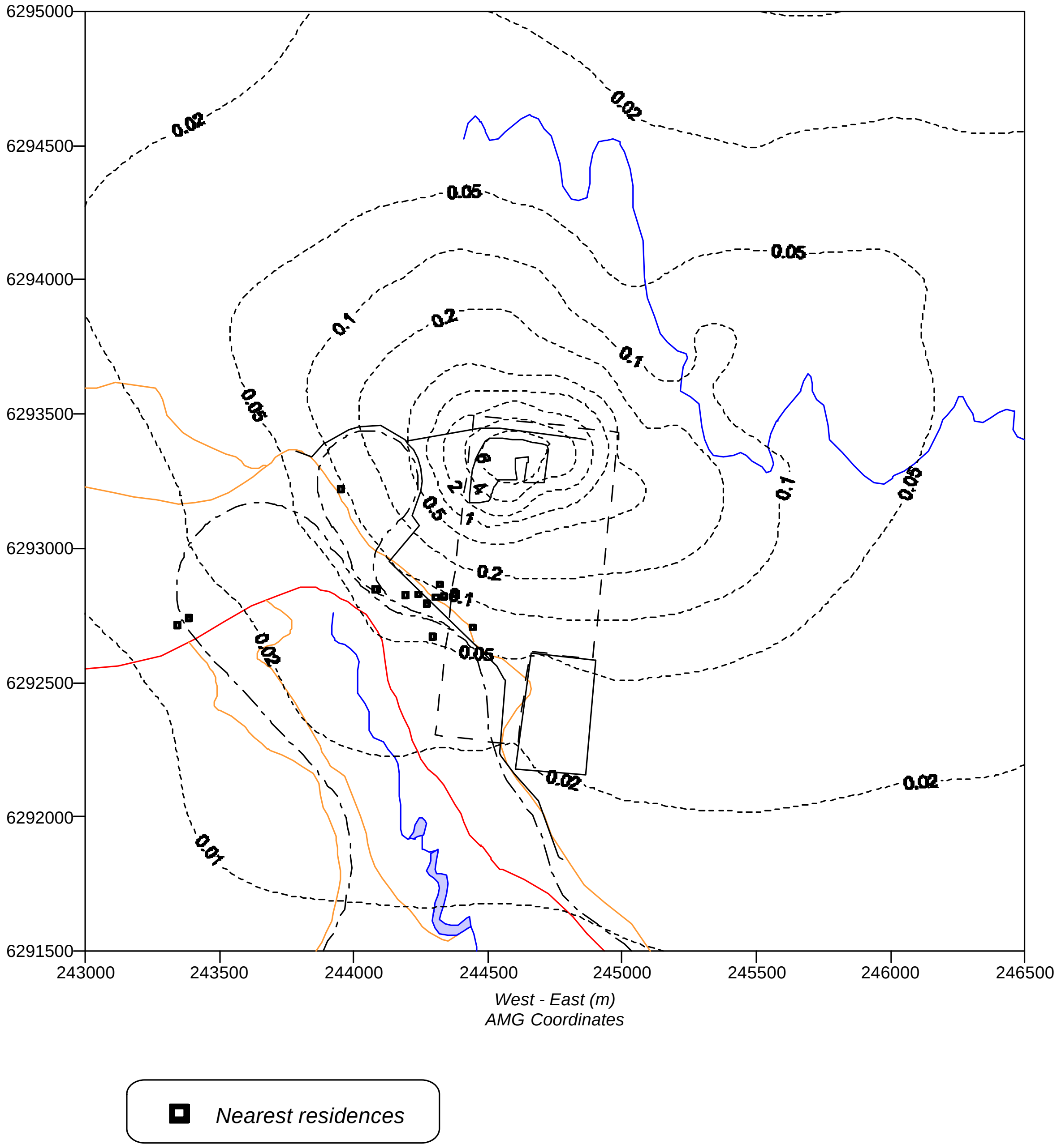
Predicted annual average PM_{10} concentration at ground-level for Stage 2 operations (µg/m^3)

FIGURE D2



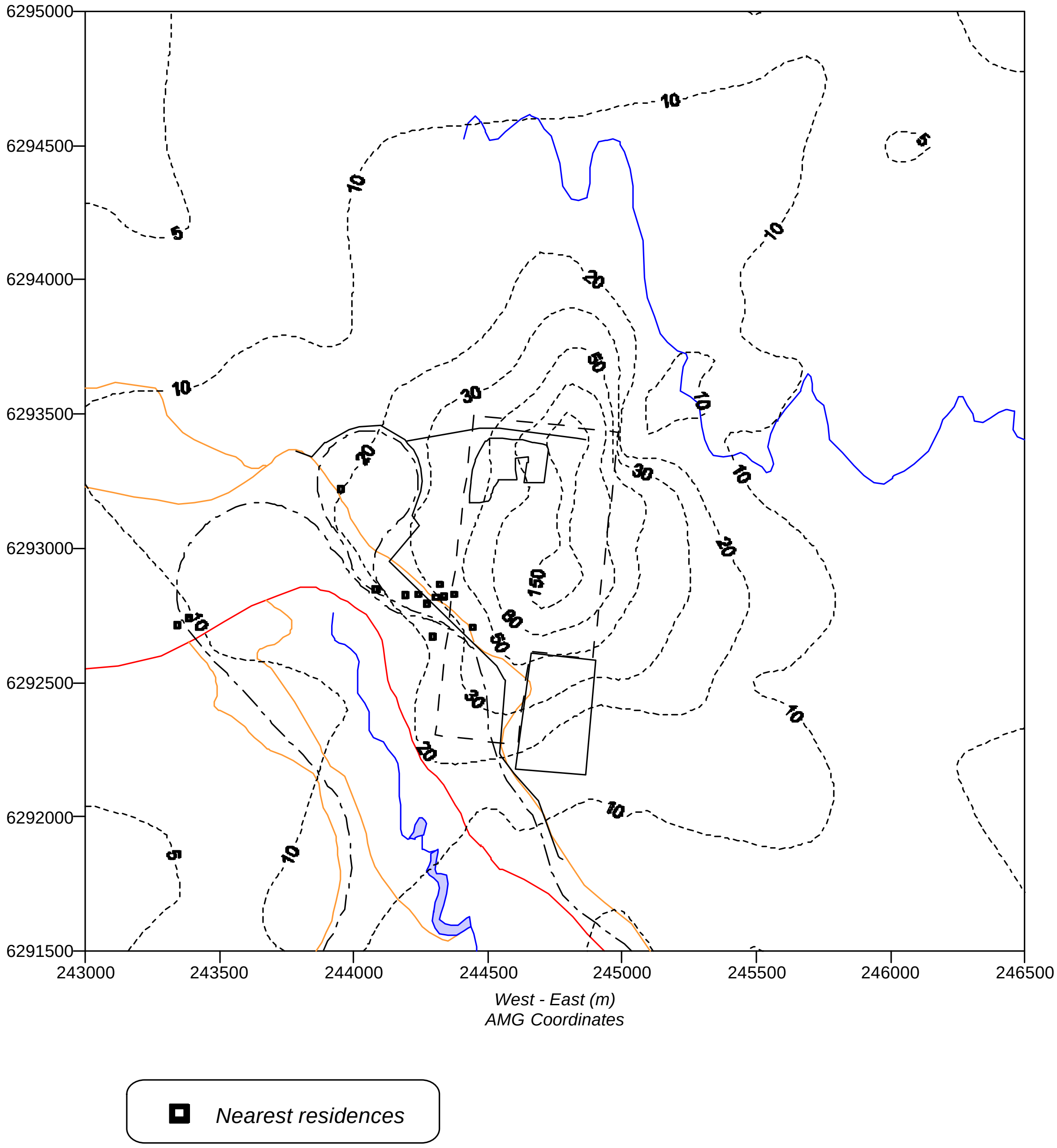
Predicted annual average TSP concentration at ground-level for Stage 2 operations (µg/m^3)

FIGURE D3



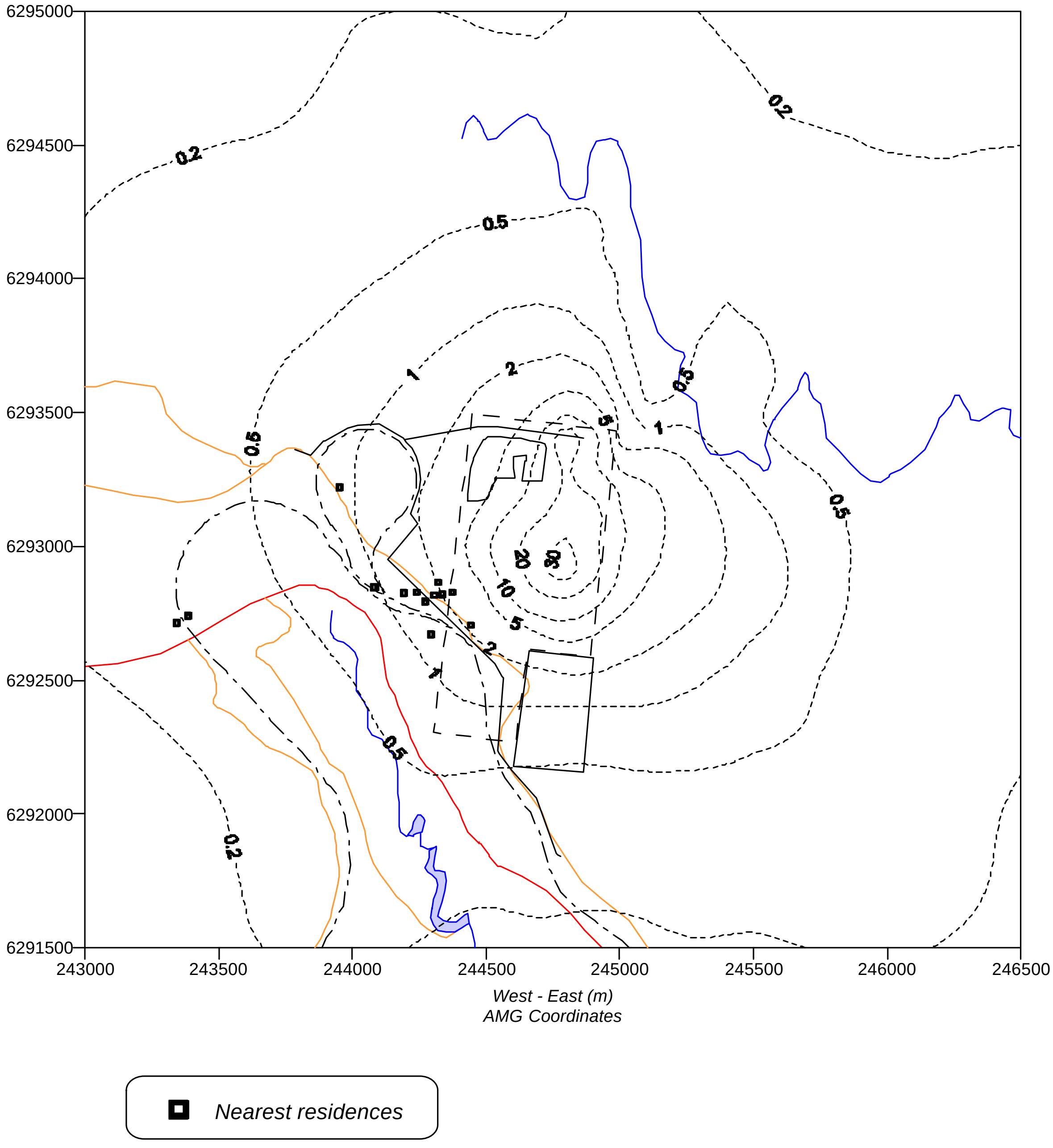
Predicted annual average dust deposition at ground-level for Stage 2 operations (g/m²/month)

FIGURE D4



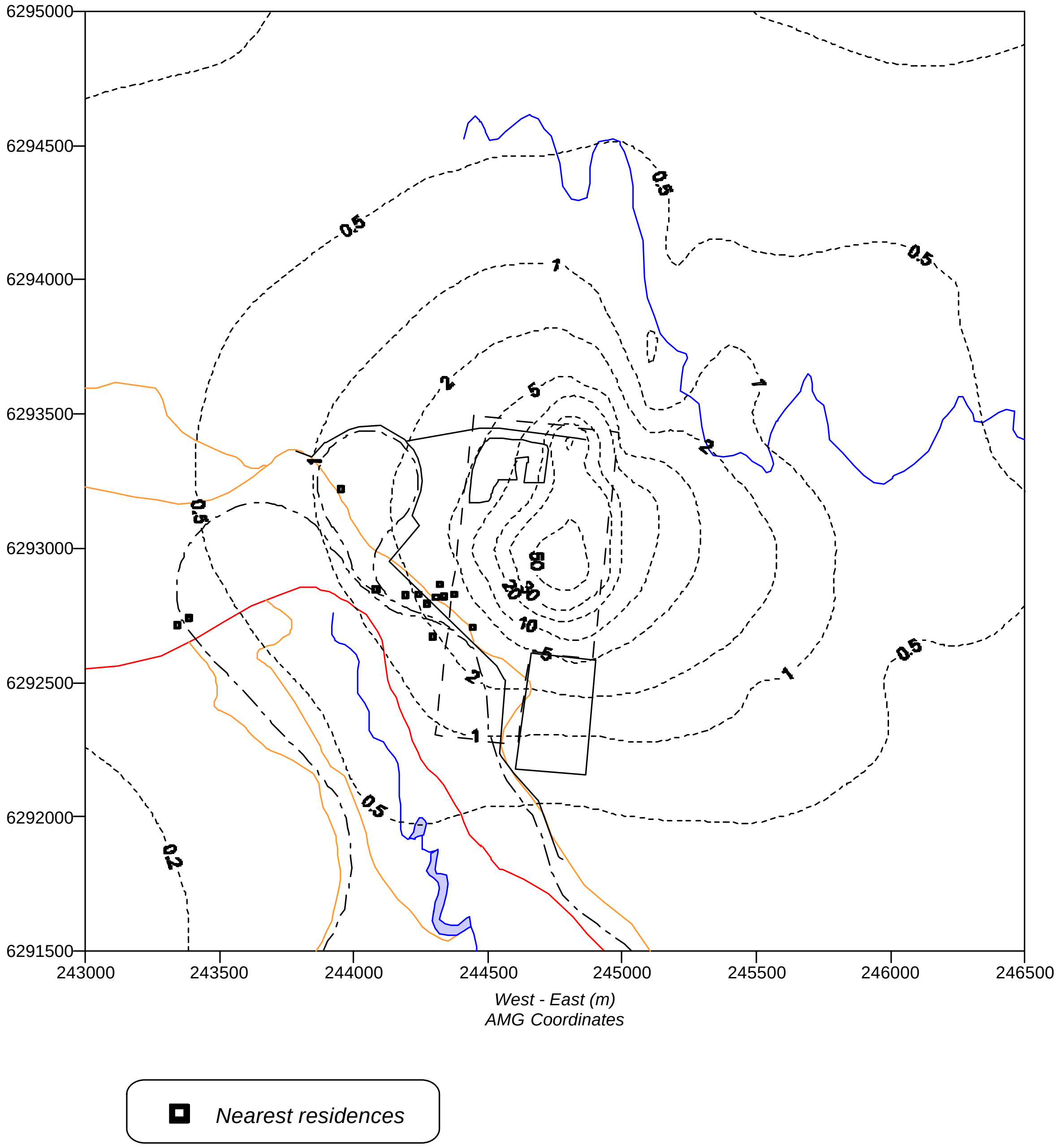
Predicted maximum 24-hour average PM_{10} concentration at ground-level for Stage 5 operations (µg/m^3)

FIGURE D5



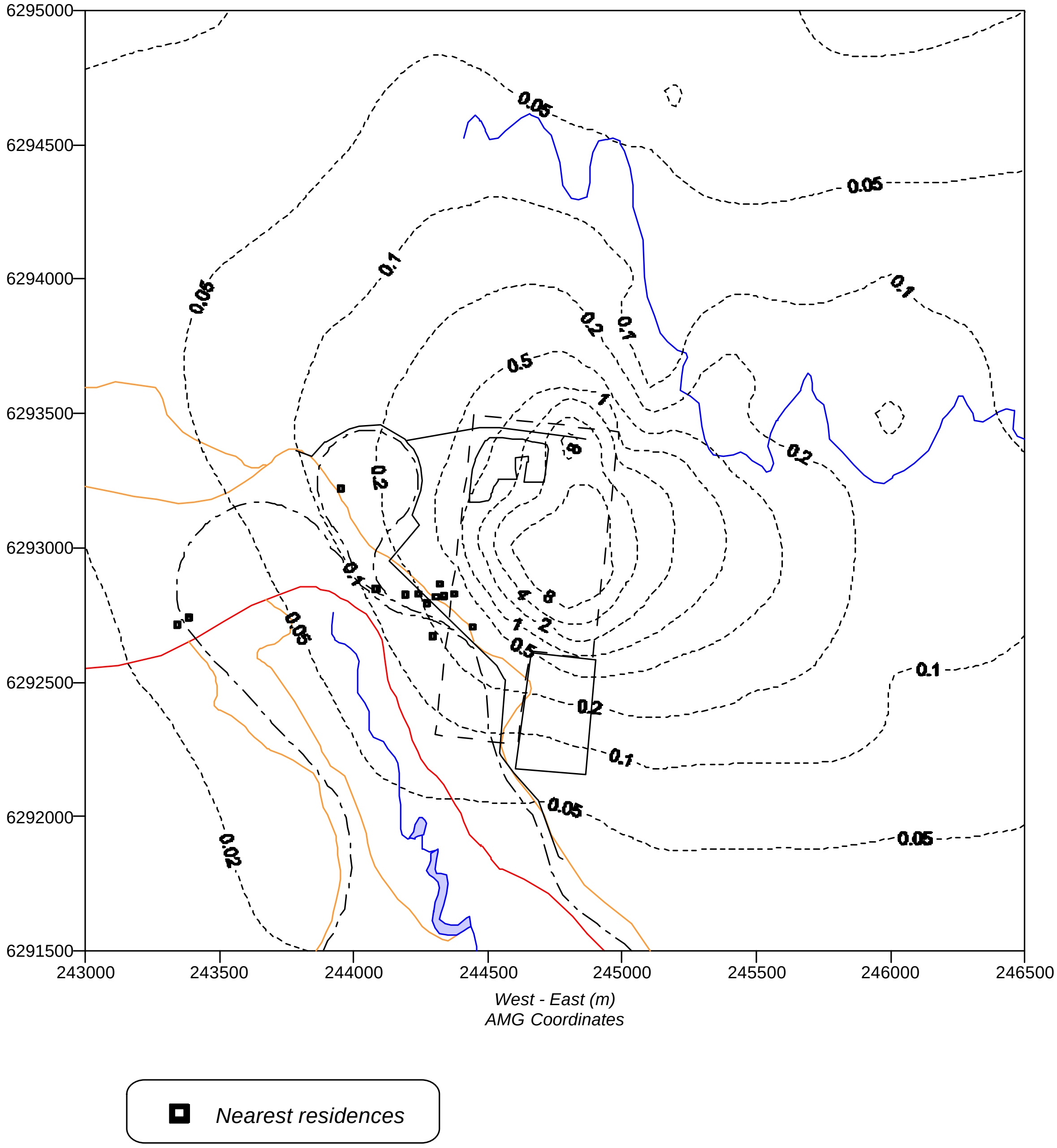
Predicted annual average PM_{10} concentration at ground-level for Stage 5 operations ($\mu g/m^3$)

FIGURE D6



Predicted annual average TSP concentration at ground-level for Stage 5 operations (µg/m³)

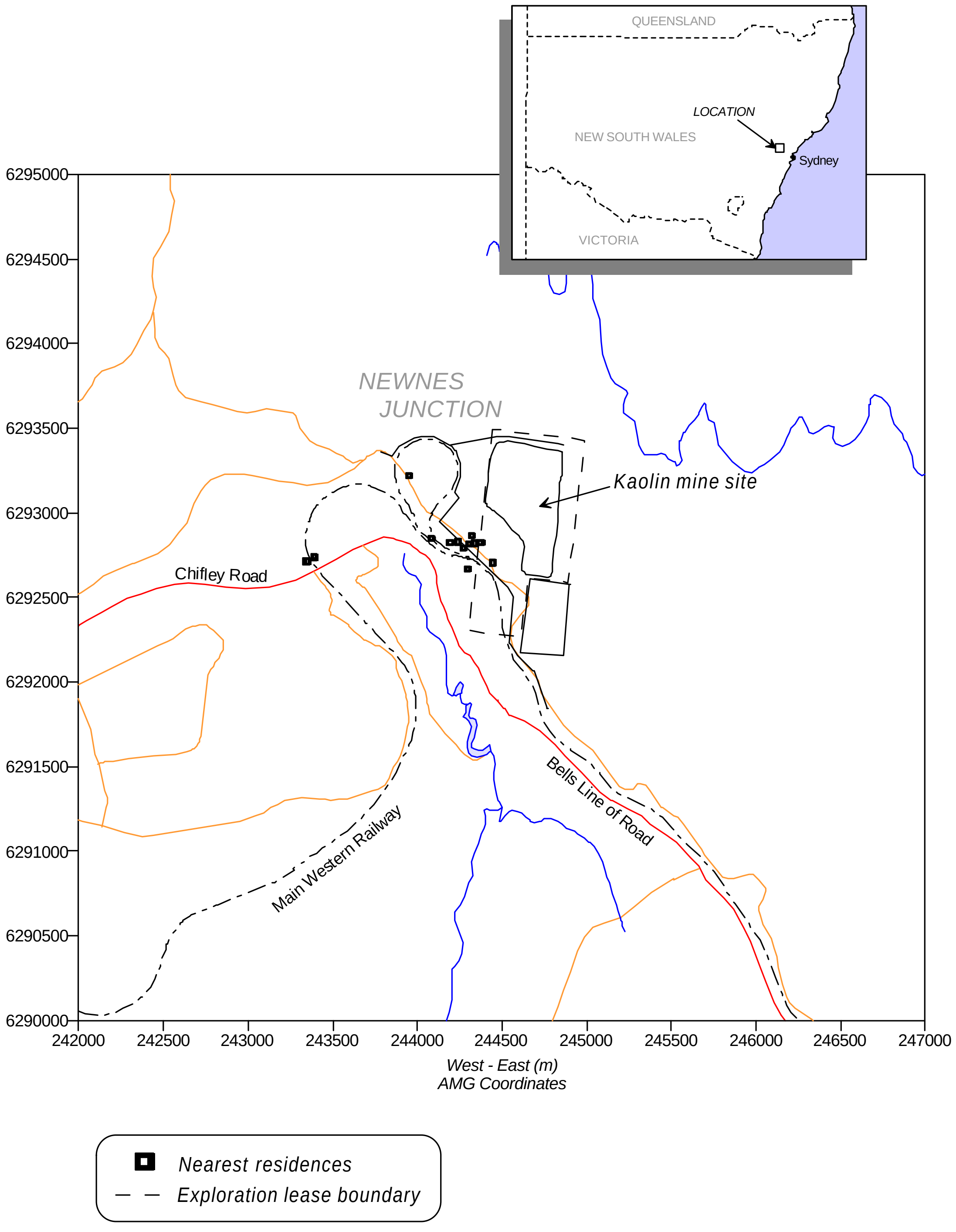
FIGURE D7



Predicted annual average dust deposition at ground-level for Stage 5 operations (g/m^2/month)

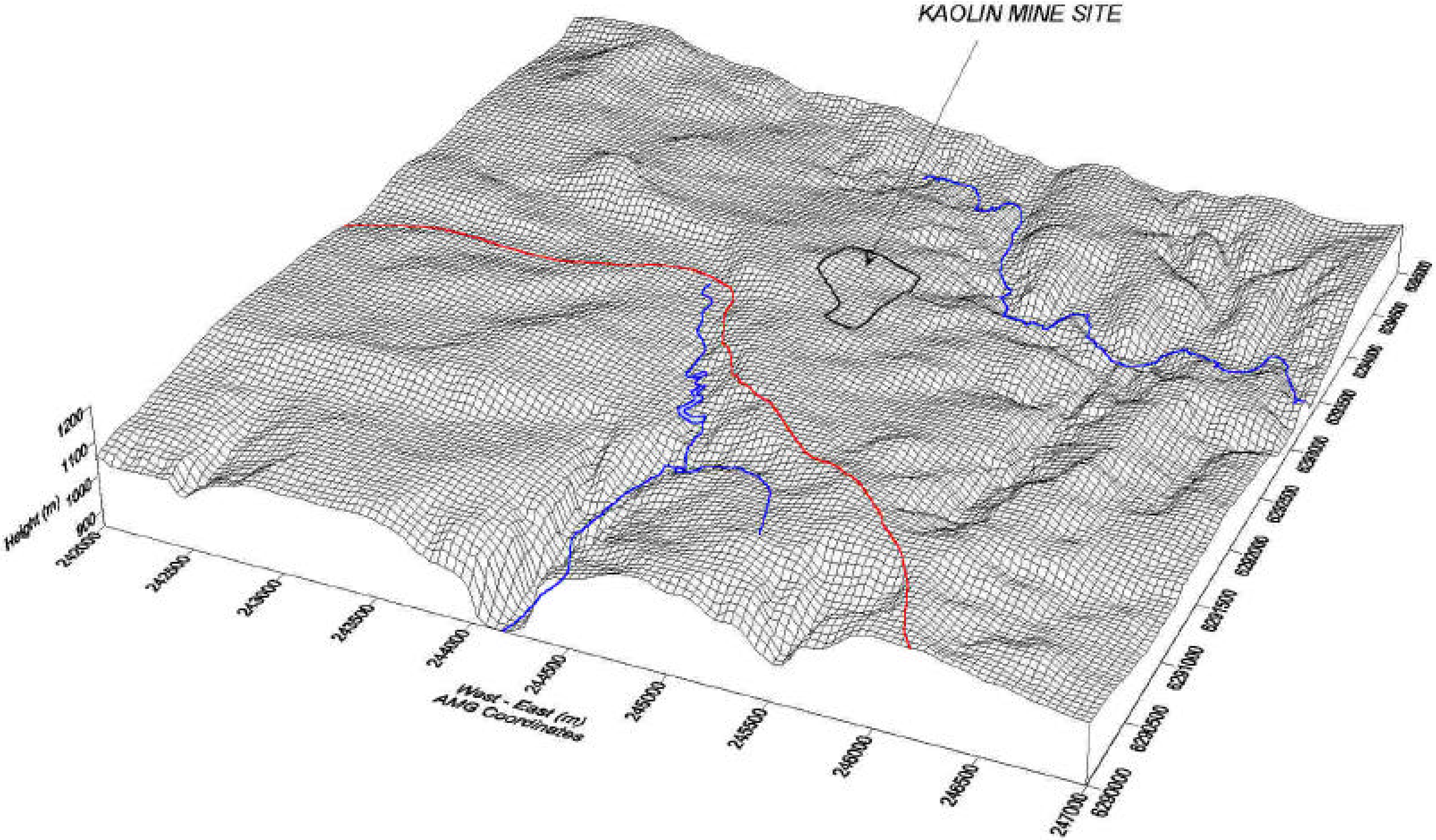
FIGURE D8

FIGURES



Location of Proposed Kaolin Mine

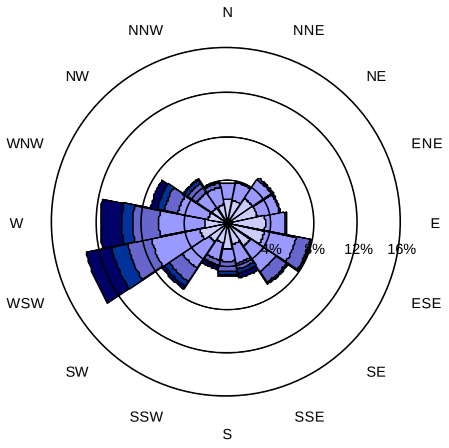
FIGURE 1



Pseudo 3-dimensional representation of local area

FIGURE 2

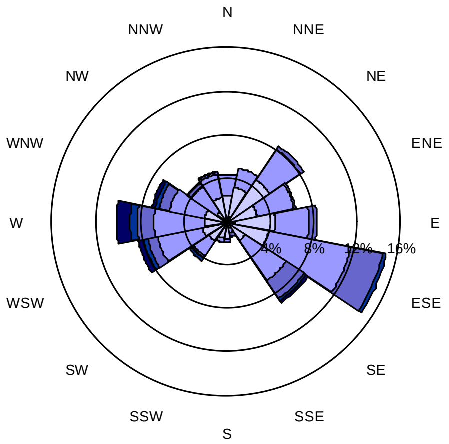
Annual and Seasonal Windroses for Newnes Junction (TAPM) 2001



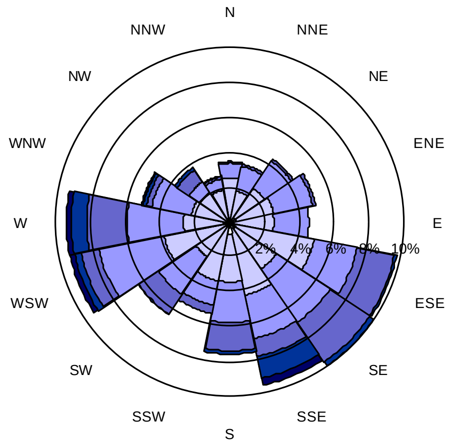
Annual
Calms = 0.4%

Wind speed (m/s)

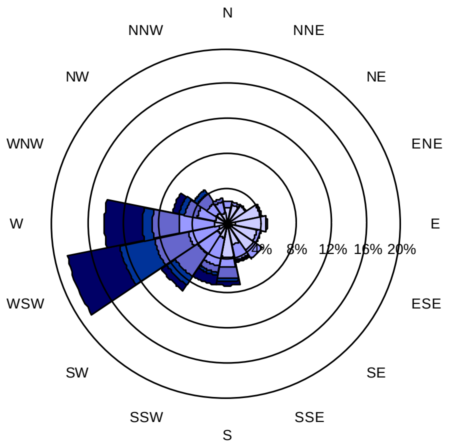
- >0.5 - 1.5
- >1.5 - 3
- >3 - 4.5
- >4.5 - 6
- >6 - 7.5
- >7.5



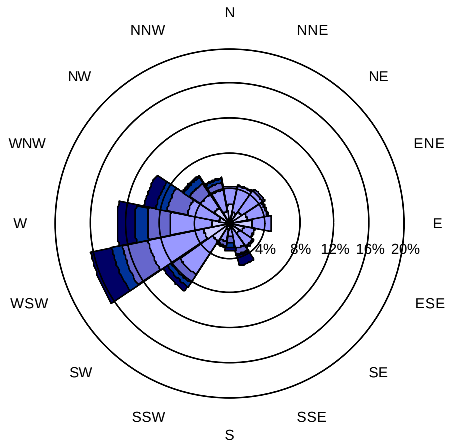
Summer
Calms = 0.1%



Autumn
Calms = 0.7%

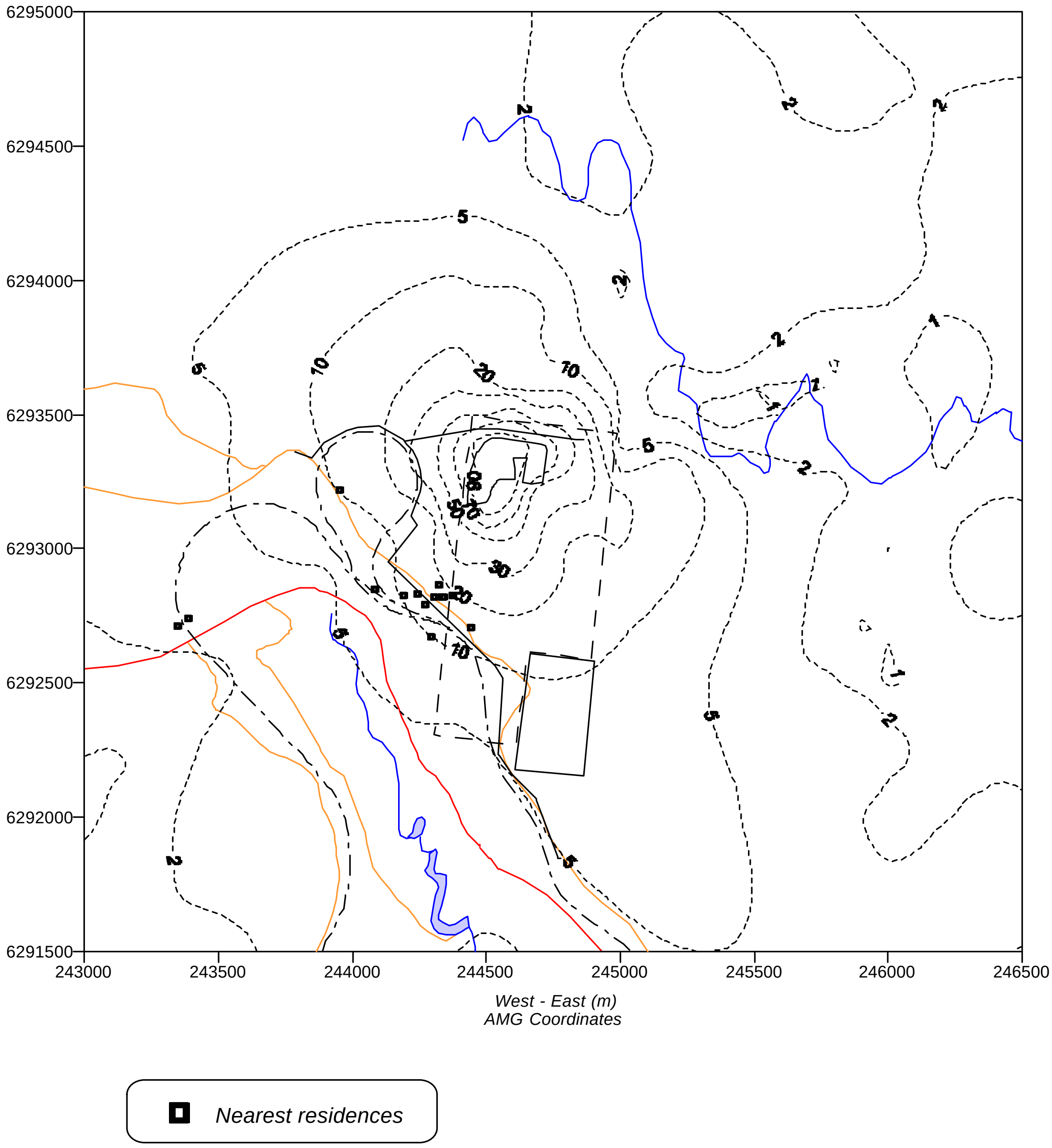


Winter
Calms = 0.5%



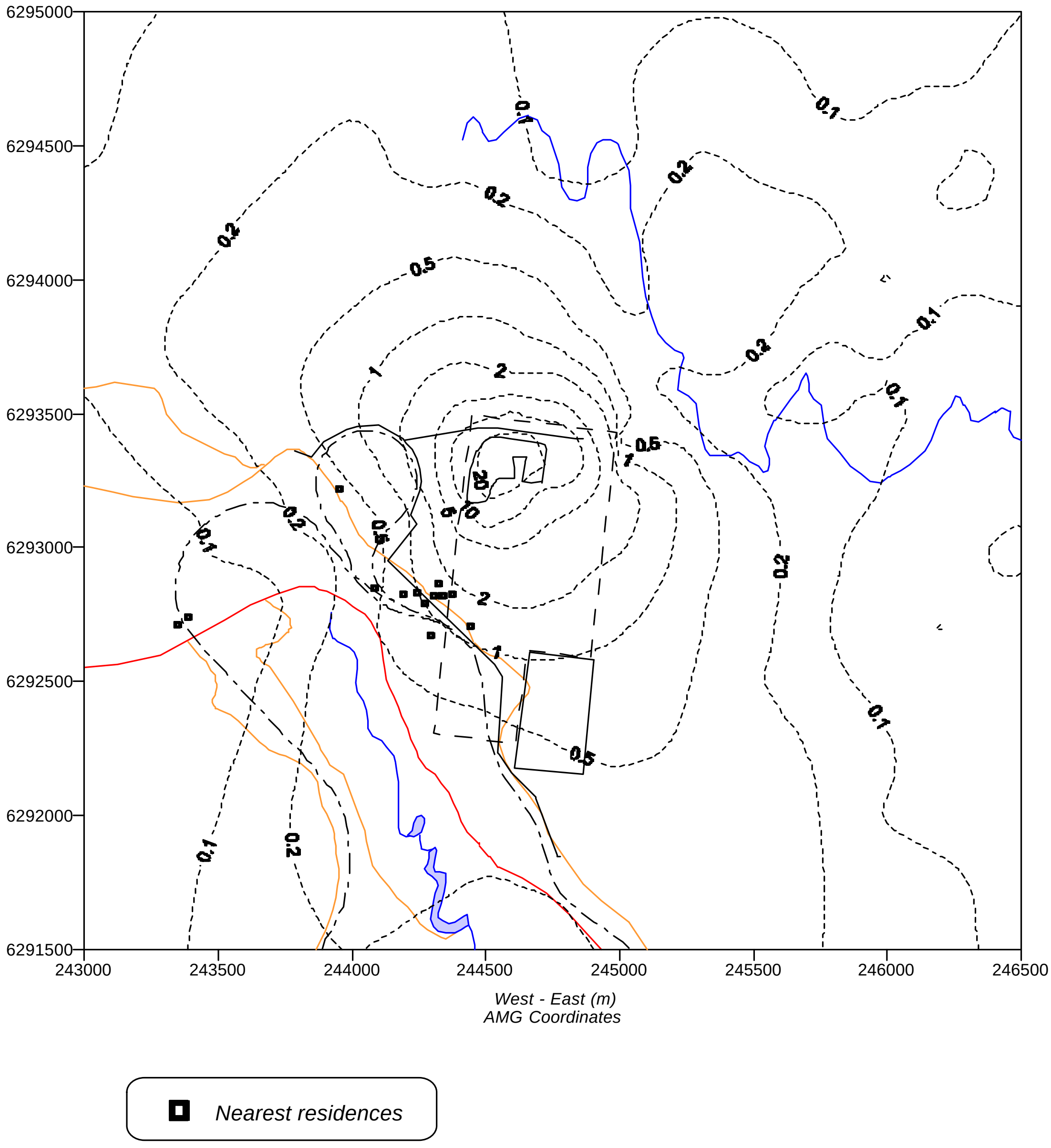
Spring
Calms = 0.0%

FIGURE 6



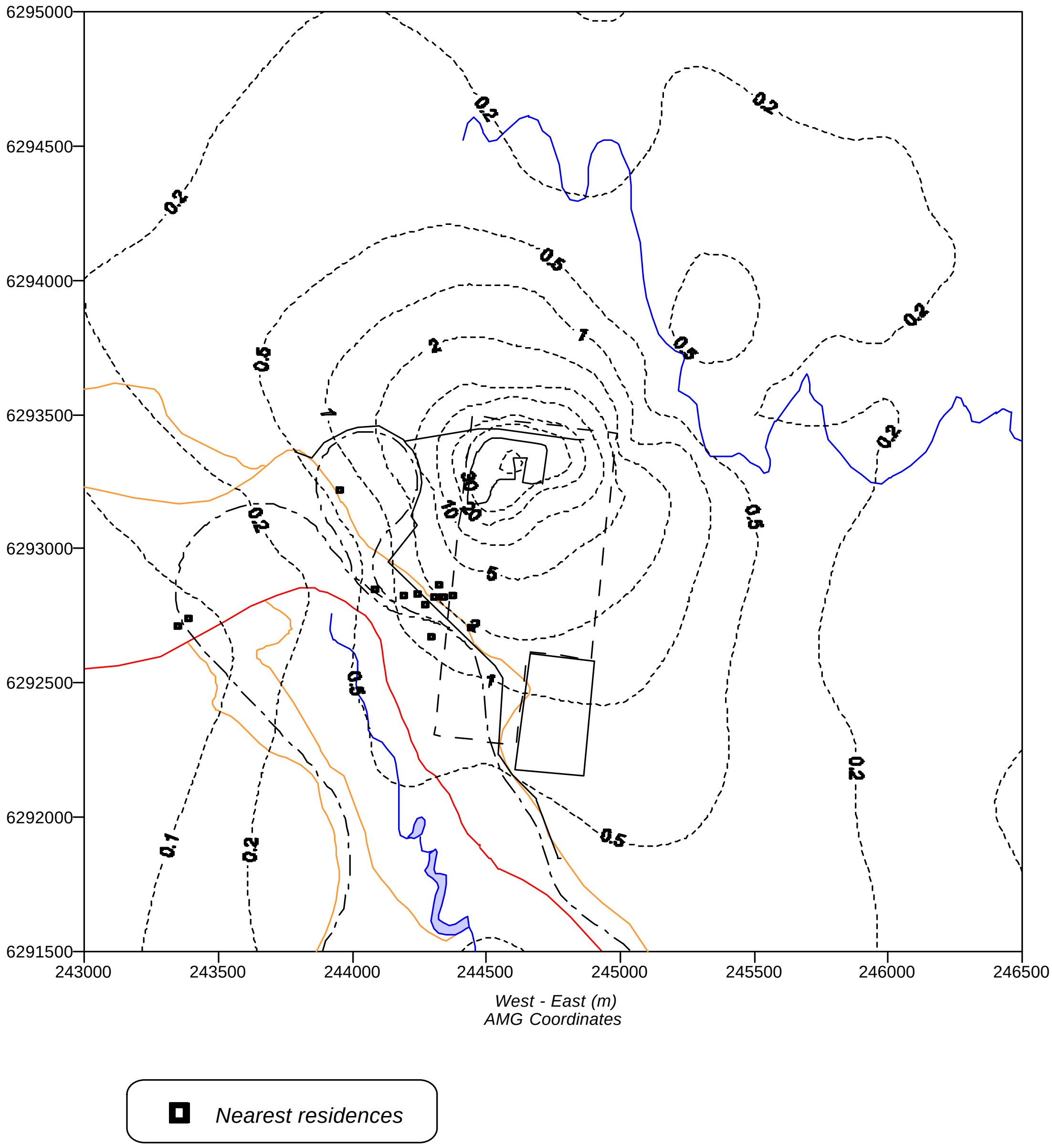
Predicted maximum 24-hour average PM_{10} concentration at ground-level for Stage 2 operations (µg/m^3)

FIGURE 7



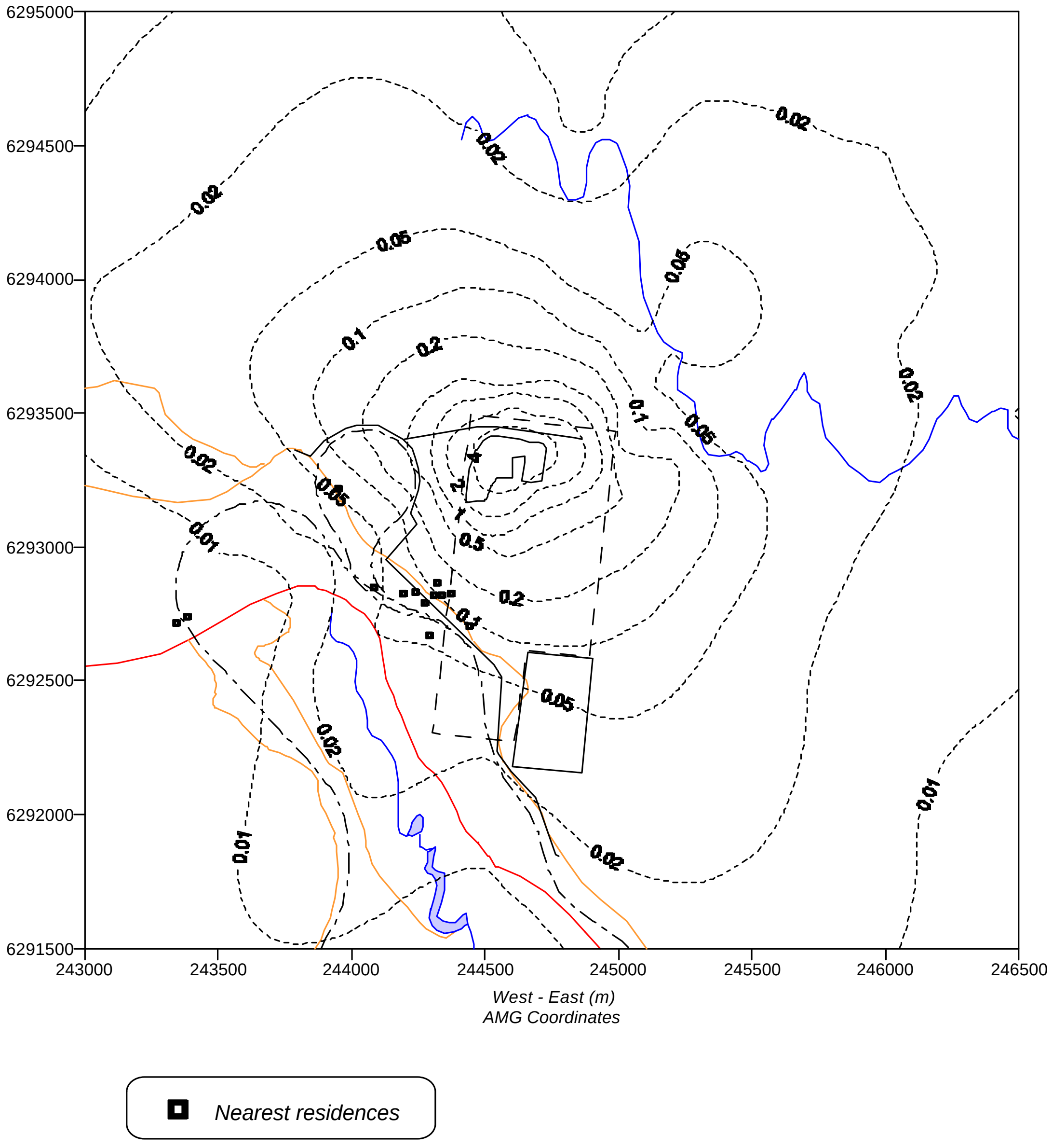
Predicted annual average PM_{10} concentration at ground-level for Stage 2 operations (μg/m^3)

FIGURE 8



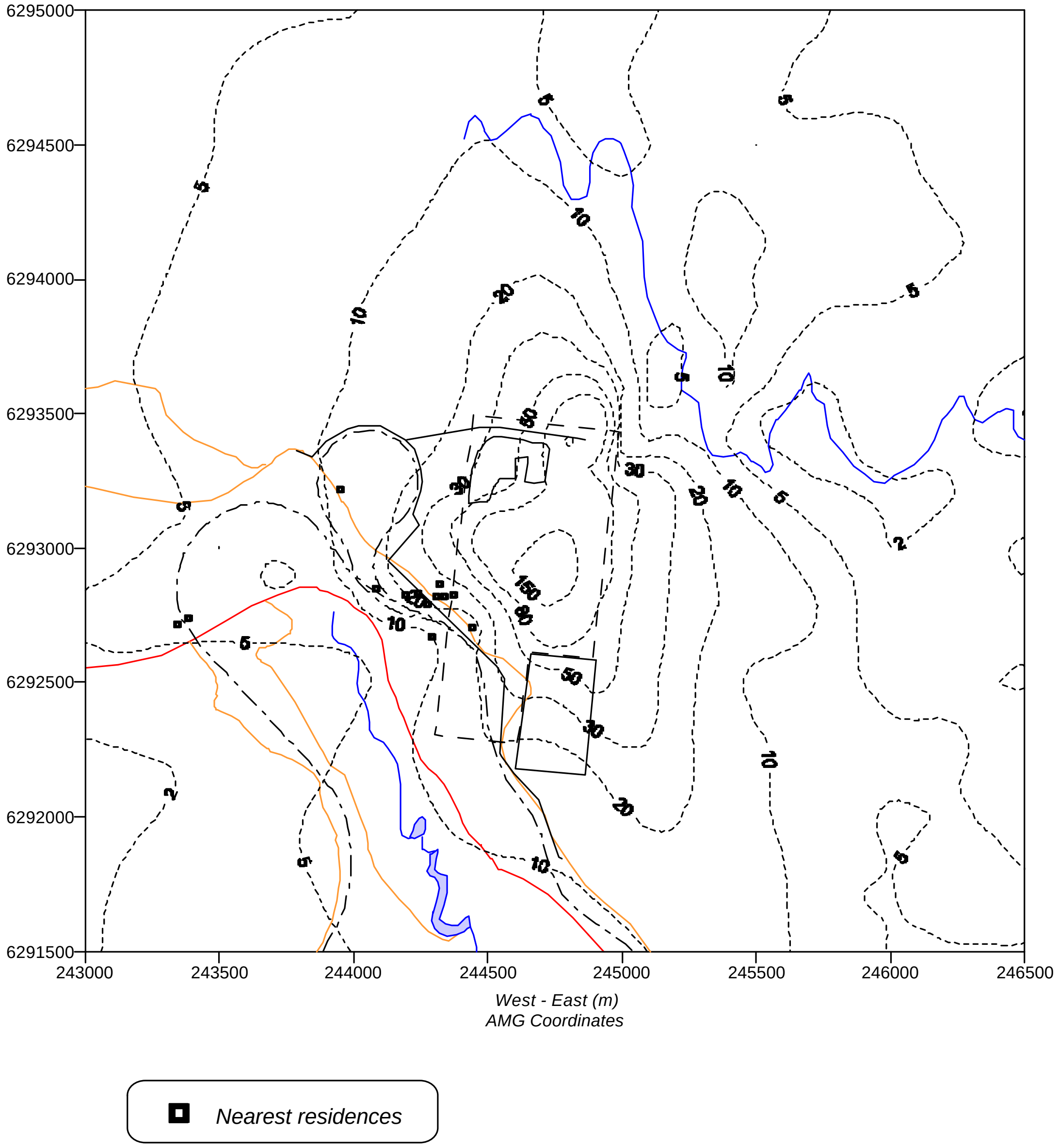
Predicted annual average TSP concentration at ground-level for Stage 2 operations (µg/m^3)

FIGURE 9



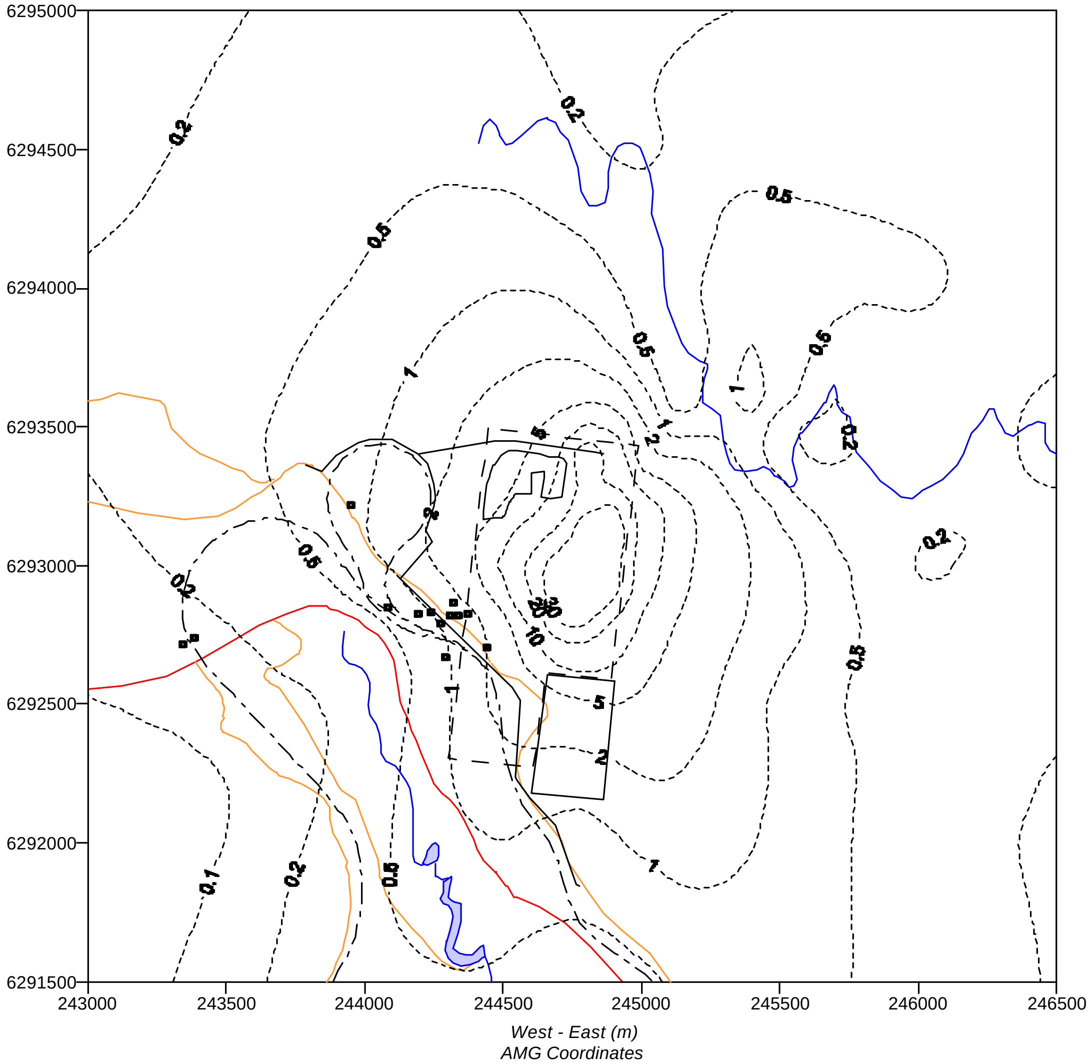
Predicted annual average dust deposition at ground-level for Stage 2 operations ($g/m^2/month$)

FIGURE 10



Predicted maximum 24-hour average PM_{10} concentration at ground-level for Stage 5 operations ($\mu g/m^3$)

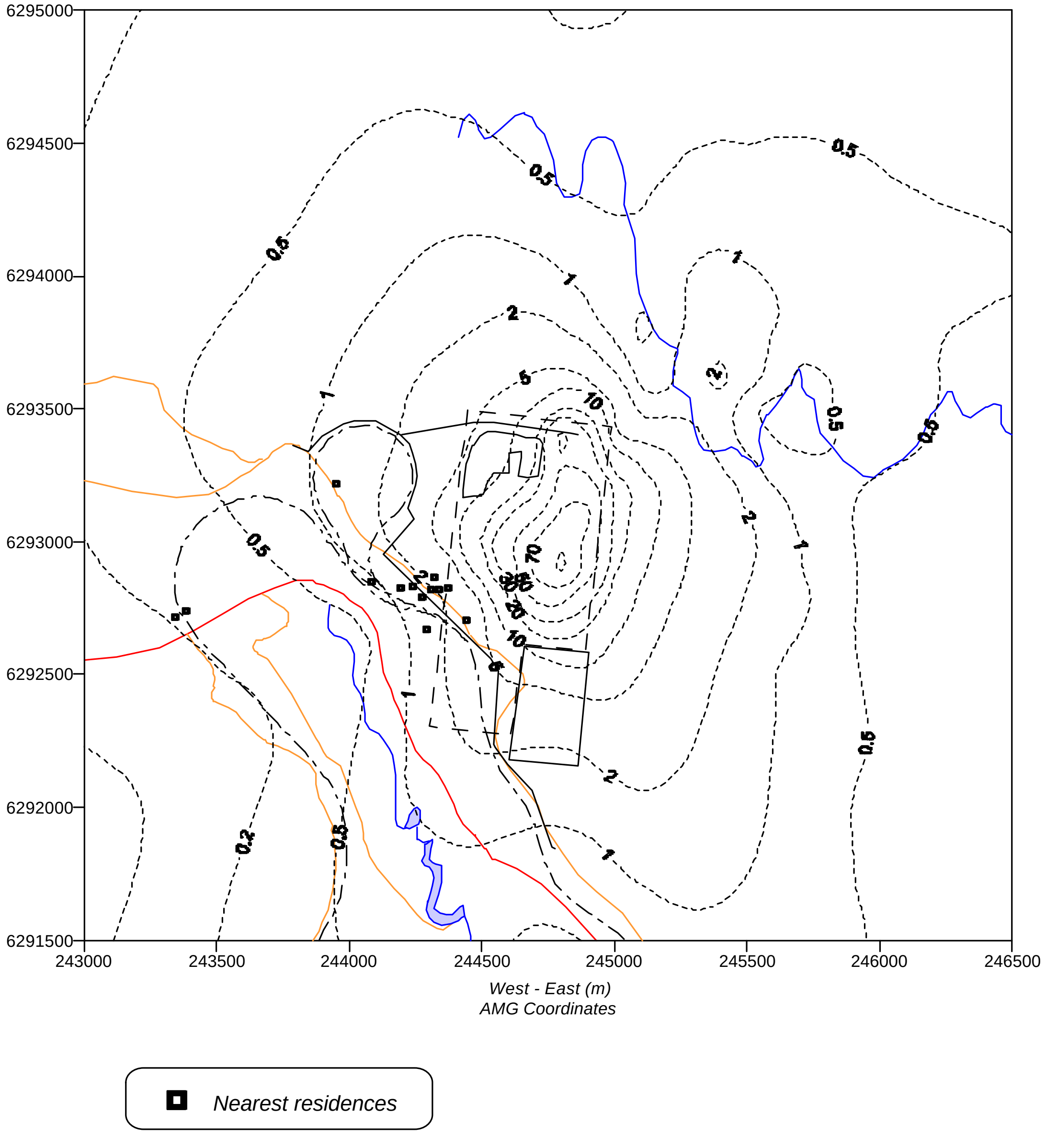
FIGURE 11



Nearest residences

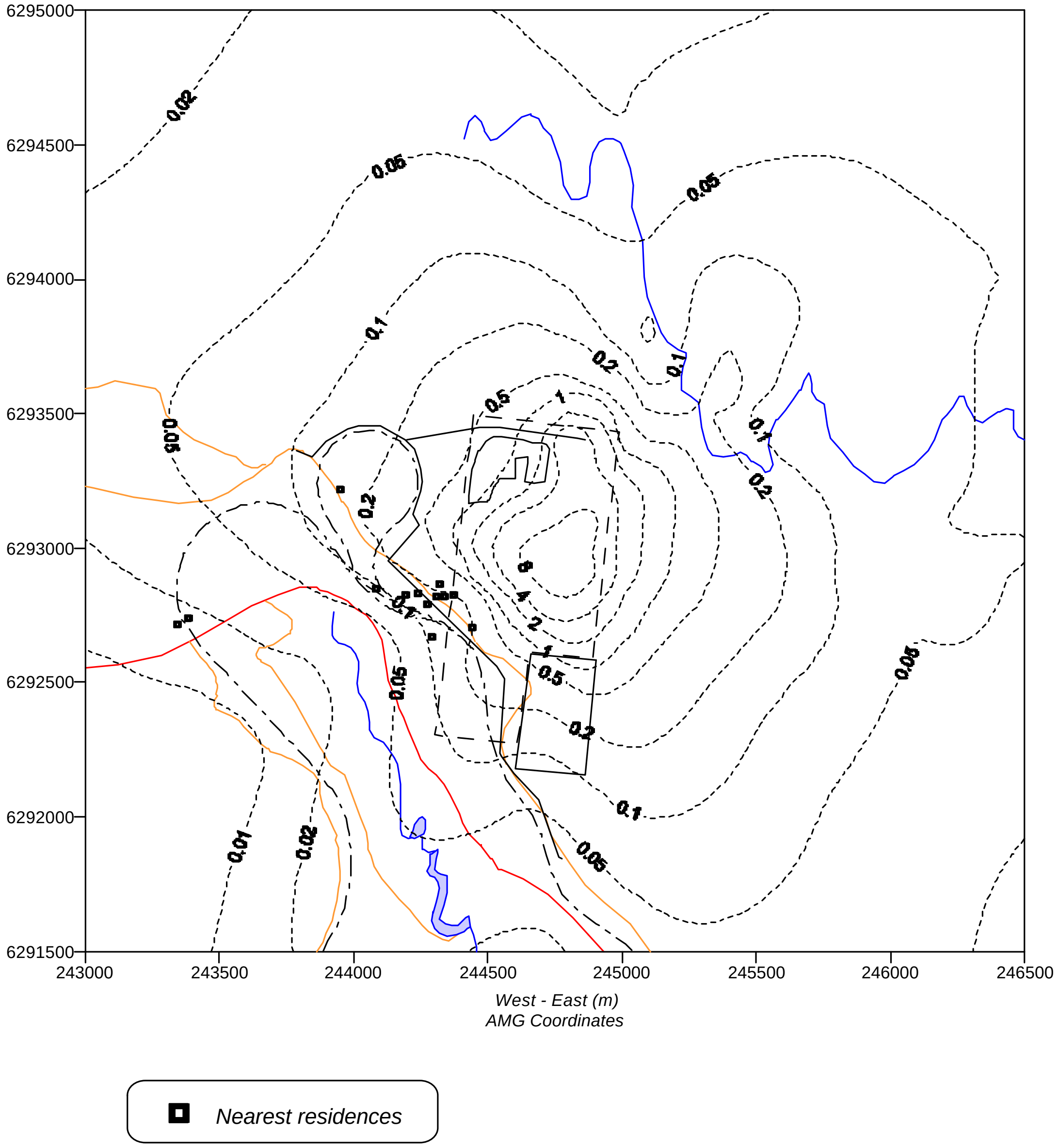
Predicted annual average PM_{10} concentration at ground-level for Stage 5 operations (µg/m^3)

FIGURE 12



Predicted annual average TSP concentration at ground-level for Stage 5 operations (μg/m^3)

FIGURE 13



Predicted annual average dust deposition at ground-level for Stage 5 operations (g/m^2/month)

FIGURE 14