ENVIRON

20 September 2007

Kalgoorlie Consolidated Gold Mines
Black Street
PMB 27
Kalgoorlie WA 6433

Attention: Michelle Berryman

Dear Michelle,

KCGM –FIMISTON OPEN PIT PARTICULATE MODELLING UPDATE

1 INTRODUCTION

ENVIRON Australia Pty Ltd (ENVIRON) was commissioned by Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) to assess the potential dust impacts associated with an extension of its existing Fimiston gold mine operations as part of the Public Environmental Review (PER) for the Project. The extension will include the mining of a westerly cutback (known as 'the Golden Pike Cutback') of the Fimiston Open Pit covering a surface extent of 30 hectares (ha).

As part of the study, air dispersion modelling of the dust emissions from the Fimiston Operations was undertaken using the AUSPLUME (Version 6.0) Gaussian air dispersion model. Emission factors were calculated for each major source using recommended emission factors, estimation of activity and controls employed at Fimiston. The modelling results were calibrated such that they were in agreement with the ambient monitoring data.

Recently KCGM has undertaken a more detailed assessment of the potential impacts resulting from metals contained in the particulates in the ambient environment. Part of this metals assessment involved a review of the modelling undertaken for the PER and an identification of the major contributors to the predicted ambient dust concentrations. This review found that the modelling completed for the PER predicted that the Fimiston Open Pit was the major contributor to the predicted ambient dust concentrations. However, in reality ENVIRON believes that the depth of the pit will mean that it should not be a significant contributor and that the waste rock dumps (WRD's), that receive the majority of the material mined at the Fimiston Operations, would be the major contributors to the predicted ambient particulate concentrations resulting from the Fimiston Operations. Also, the modelling conducted for the PER used an average emission factor and did not reflect changes in emissions that may occur under different conditions (e.g. wind speed).

As a result of this review, ENVIRON has re-assessed the emission factors used within the PER modelling and has also included condition dependent PM_{10} emission rates. This letter presents details of the re-assessment work.

2 MODELLING METHODOLOGY AND EMISSIONS FACTORS

2.1 Modelling

The air dispersion modelling of emissions from KCGM's Fimiston Operations completed for the PER used Ausplume (Version 6.0), a steady state Gaussian plume dispersion model. While ENVIRON had originally intended to use the Industrial Source Complex (ISCST3) model to take advantage of its in-pit retention algorithms, ISCST3 couldn't be used as the Fimiston Open Pit was too large for the model. Therefore, ENVIRON modelled the Fimiston Open Pit as an area source using Ausplume with a pit retention factor of 50% (EET Mining Manual, Version 2.3).

The PER model outputs were created such that the predicted concentration for each source, for each hour of the year, and for each grid point were retained. No additional air dispersion modelling was undertaken for this re-assessment which was completed by rescaling the PER modelling results for each source for each hour of the year. These rescaled concentrations were then summed to obtain the predicted ground level concentrations from the Fimiston Operations. Therefore, the reader is referred to the original air dispersion modelling report as presented in the PER for the detailed modelling methodology and approach used as presented in ENVIRON (2006).

2.2 Emission Factors and Rates

2.2.1 PER Emission Factors and Rates

The emission estimates used in the PER were made for each major source using recommended emission factors, estimation of activity and controls employed at Fimiston. The emission factors where expressed as a mass per unit area for each source.

The general equation for emission estimation used in the previous study was:

$$E = A \times EF \times (1 - ER/100) \qquad \text{Equation (1)}$$

where:
E = emissions,
A = activity rate,
EF = emission factor, and
ER= overall emission reduction efficiency, %.

Emission factors, activity information and emission estimates were determined from the following documents:

- National Pollutant Inventory, Emission Estimation Technique Manual for Mining, Version 3.2, December 2001.
- National Pollutant Inventory, Emission Estimation Technique Manual for Fugitive Emissions, December 1999.
- National Pollutant Inventory, Emission Estimation Technique Manual for Aggregated Emissions from Paved and Unpaved Roads, September 1999.
- SKM, 2005, Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques.
- PB 2005, KCGM National Pollutant Inventory Report 2004-2005. Draft (Revision A), October 2005.
- KCGM Supplied Information (*Pers. Comm.* KCGM, various).

A list of individual mining activities, and calculated emission estimates used in the assessment for both the existing and proposed operations, as used in the PER are presented in Tables 1 and 2.

Table 1: Summary of Emission Estimates used in the PER – Current Operations

Sources	Emission Estimate (Kg/yr)	
	TSP	PM10
1.Fimiston Open Pit		
Drilling	58,804	30,897
Blasting (1)	9,589	4,986
Loading	67,924	32,126
Wind Erosion	153,258	76,629
Haulage	3,337,943	668,271
Total Pit Emission	3,627,517	812,909
2. Processing Plant		
Crushing	2,275	227
Screening	910	682
Conveying	61,822	41,101
Carbon Kilns	23,769	15,846
Total Processing Plant Emissions	91,758	59,845
3. Waste Dumps		
Wind Erosion – Waste Dump-1	544	272
Wind Erosion – Waste Dump-2	6,340	3,170
Wind Erosion- Waste Dump-3	13,767	6,883
Wind Erosion- Waste Dump-4	9,955	4,977
Total Waste Dumps	30,606	15,302
4. Haulage (Pit to waste dumps and processing plant		
Dump trucks- Small	219,128	48,179
Dump trucks – Medium	87,999	18,503
Dump trucks- Large	1,705,766	344,324
Heavy Goods Vehicle	861	574
Wheeled Loader	438	292
Wheeled Tractor	273	182
Total Haulage	2,014,465	412,054
5. TSF – Wind Erosion		
Fimiston-I	511	255
Fimiston-II	1,625	813
Total TSF	2,136	1,068
6. Wind Erosion (Other)		
Service Corridors	4,086	2,043
Stockpiles	2,563	1,281
Total Wind Erosion	6,649	3,324

Notes:

1. A pit retention control of 50% was employed to the total emissions calculated above, therefore emissions used in the model (for the open pit) will be half of that displayed in the table above. This applies for both PM10 and TSP. The EET Mining Manual (V2.3) specifies a pit retention factor of 5% for PM10 however based on model validation studies, a 50% retention factor was used in the modelling as it provided better correlation with observations.
2. A high control efficiency has been applied for blasting emissions as KCGM employ a control strategy to ensure blasting is not undertaken during unfavorable winds. Therefore emissions from blasting are lower than other process emissions.

Table 2: Summary of Emission Estimates – Used in the PER – Pit Extension

Sources	Emission Estimate (Kg/yr)	
	TSP	PM10
1.Fimiston Open Pit		
Drilling	58,804	30,897
Blasting	9,691	5,039
Loading	199,887	94,541
Haulage	3,628,519	739,784
Wind Erosion	171,056	85,528
Total Pit Emission	4,067,957	955,790
2. Processing Plant		
Crushing	2,600	260
Screening	1,040	780
Conveying	61,920	41,150
Carbon Kilns	23,769	15,846
Total Processing Plant Emissions	89,329	58,036
3. Waste Dumps		
Wind Erosion – Waste Dump-1	544	272
Wind Erosion – Waste Dump-2	6,340	3,170
Wind Erosion- Waste Dump-3	13,767	6,883
Wind Erosion- Waste Dump-4	9,955	4,977
Wind Erosion - Waste Dump-5	3,560	1,780
Total Waste Dumps	34,166	17,082
4. Haulage (Pit to waste dumps and processing plant		
Dump trucks- Small	243,232	53,478
Dump trucks – medium	97,678	20,539
Dump trucks- Large	1,893,401	382,200
Heavy Goods Vehicle	861	574
Wheeled Loader	438	292
Wheeled Tractor	273	182
Total Haulage	2,235,883	457,265
5. TSF – Wind Erosion		
Fimiston-I	511	255
Fimiston-II	1,625	813
Kaltails	5,804	2,902
Total TSF's	7940	3970
6. Wind Erosion (Other)		
Service Corridors	4,535	2,268
Stockpiles	2,845	1,422
Total Wind Erosion (other)	7380	3690

Notes

1. A pit retention control of 50% was employed to the total emissions calculated above, therefore emissions used in the model (for the open pit) will be half of that displayed in the table above. This applies for both PM10 and TSP. The EET Mining Manual (V2.3) specifies a pit retention factor of 5% for PM10 however based on model validation studies, a 50% retention factor was used in the modelling as it provided better correlation with observations.
2. A high control efficiency has been applied for blasting emissions as KCGM employ a control strategy to ensure blasting is not undertaken during unfavorable winds. Therefore emissions from blasting are lower than other process emissions.

2.2.2 Updated Emission Factors and Rates

A more detailed analysis of the PER modelling results conducted as part of a particulate metal study found that the Fimiston Open Pit was the predicted to be the dominant contributor to ground level concentrations of dust in the Kalgoorlie township.

The lack of sensitivity of the PER modelling results to the other sources including the WRDs, indicated that impacts from the Fimiston Open Pit were likely to be over estimated with the emissions from the WRD's being under predicted. Therefore, the methods used to develop the PER emissions estimates were reviewed with the aim of producing more representative emissions estimates from the WRD's and the Fimiston Open Pit.

A method developed by the USEPA was obtained from the AP-42 Fifth Edition, Volume I Chapter 13.2.5: Miscellaneous Sources. This method, titled "*Industrial Wind Erosion*" focuses on wind speed dependent erosion from various sources including the WRD's and was applied for this study.

The equation used in the determination of the emission factor was

$$\text{Emission Factor} = K * N * P_i$$

Where:

K = Particle size Multiplier (1 for TSP and 0.5 for PM_{10})
N = The number of disturbances per year (for this study it was assumed there was an average of 4 disturbances per year)
P_i = The erosion potential corresponding to the observed gust of wind for a given period, g/m^2

As per the USEPA method, the erosion potential was calculated using the following formula:

$$P_i = 58\,(u^* - u_t^*)^2 + 25\,(u^* - u_t^*)$$
$$P_i = 0 \text{ for } u^* \leq u_t^*$$

Where:

u^* = Friction Velocity (m/s)
u_t^* = Threshold Friction Velocity (m/s)

The Friction Velocity (u^*) was calculated using the following formula

$$u^* = \text{Wind Speed (m/s)} * (u_s/u_r)$$

Where:

u_s/u_r = the ratio of surface wind speed to approach speed.

For this study, a u_s/u_r ratio of 0.5 was used as an indicative ratio for elevated stockpiles as outlined in the USEPA methodology.

The threshold friction Velocity (u_t^*) is a constant that can be determined based on field studies or chosen from values that have been determined in studies conducted by the USEPA on several different surface types. The value used in this study was 0.5 (m/s) and was based on the typical threshold friction velocity of a ground coal pile.

The hourly wind speeds used in the dispersion modelling were also used to determine the emission factor (g/m^2) for each hour of the modelling period. The hourly emission factor was converted to an emission per unit area per second (g/s/m^2). The emission rate calculated for each hour was then used to create a variable emissions file that was used to rescale the modelling PER modelling outputs.

Due to the dominance of the Fimiston Open Pit emissions in the PER modelling results, the methodology used in the determination of the emissions rates used in the modelling was reviewed. Previous work undertaken by CSIRO for KCGM found that for pit depths of beyond 100 m, nearly all of the pit generated dust is predicted to be retained in the pit. Therefore, the previously derived Fimiston Open Pit emissions were reduced by a factor of 90% to account for the in-pit retention.

This reassessment has only considered the changes to the emission factors for the Fimiston Open Pit and the WRDs. All of the other emissions identified in Tables 1 and 2 remained the same. The revised Fimiston Open Pit and the WRDs emissions are presented in Tables 3 and 4.

Table 3: Summary of Updated Emission Estimates – Current Operations

Sources	Emission Estimate (Kg/yr)
	PM10
1.Fimiston Open Pit	
Drilling	3,089
Blasting	498
Loading	1,537
Wind Erosion	7,662
Haulage	157,446
Total Pit Emission	**172,191**
2. Waste Dumps	
Wind Erosion – Waste Dump-1	53,937
Wind Erosion – Waste Dump-2	628,745
Wind Erosion- Waste Dump-3	1,365,135
Wind Erosion- Waste Dump-4	3,216,040
Total Waste Dumps	**5,263,857**

Notes

1. Includes Pit retention factor of 90%

Table 4: Summary of Updated Emission Estimates – Pit Extension

Sources	Emission Estimate (Kg/yr)
	PM10
1.Fimiston Open Pit	
Drilling	3,090
Blasting	504
Loading	1,445
Haulage	8,553
Wind Erosion	172,353
Total Pit Emission	**194,066**
2. Waste Dumps	
Wind Erosion – Waste Dump-1	55,631
Wind Erosion – Waste Dump-2	628,745
Wind Erosion- Waste Dump-3	1,365,135
Wind Erosion- Waste Dump-4	3,216,040
Wind Erosion - Waste Dump-5	353,523
Total Waste Dumps	**5,619,074**

Notes

2. Includes Pit retention factor of 90%

3 RESULTS

3.1 Updated Results

Tables 5 and 6 present the predicted 24-hour maximum and annual concentrations of PM_{10} at various nominated receptors around and within the Fimiston Operations for both the existing and proposed scenarios.

The results indicate that that the proposed expansion will result in small increases in the predicted ground level concentrations at some receptors but decreases in other areas. The decrease at Hopkins Street is most likely attributable to the reduction in estimated emissions from the Fimiston Open Pit which is due to the deepening of the pit. Increases at the other receptors are likely due to the inclusion of additional sources particularly in the south of the operations.

Table 5: Predicted 24-Hour Maximum PM_{10} Concentrations for Current and Proposed Operations

Name	x	y	Current Operations Concentrations (µg/m^3)	Proposed Operations Concentrations (µg/m^3)
Hopkins St	356422	6592858	64	69
Boulder Shire Yard	355769	6593210	41	45
Clancy St	355681	6594118	39	38
Hewitt St	355270	6596193	77	61
Waste Dump-1	355630	6595824	49	40
Waste Dump-2	357473	6595668	77	75
Waste Dumps 3	357757	6592901	84	102
Fim-1	356703	6596929	75	64
Fim-2	361340	6595862	32	27
Kaltails	361728	6591329	51	46

Table 6: Predicted Annual Average PM_{10} Concentrations for Current and Proposed Operations

Name	x	y	Current Operations Concentrations (µg/m^3)	Proposed Operations Concentrations (µg/m^3)
Hopkins St	356422	6592858	12	14
Boulder Shire Yard	355769	6593210	8	9
Clancy St	355681	6594118	9	10
Hewitt St	355270	6596193	19	16
Waste Dump-1	355630	6595824	17	15
Waste Dump-2	357473	6595668	23	20
Waste Dumps 3	357757	6592901	31	48
Fim-1	356703	6596929	24	19
Fim-2	361340	6595862	4	3
Kaltails	361728	6591329	5	5

Figures 1, 2, 3 and 4 present plots of the predicted 24-hour maximum and annual average PM_{10} ground level concentrations for the updated existing and proposed scenarios.

Figure 1: Predicted 24-Hour Average Maximum PM_{10} Concentrations (µg/m³) Existing

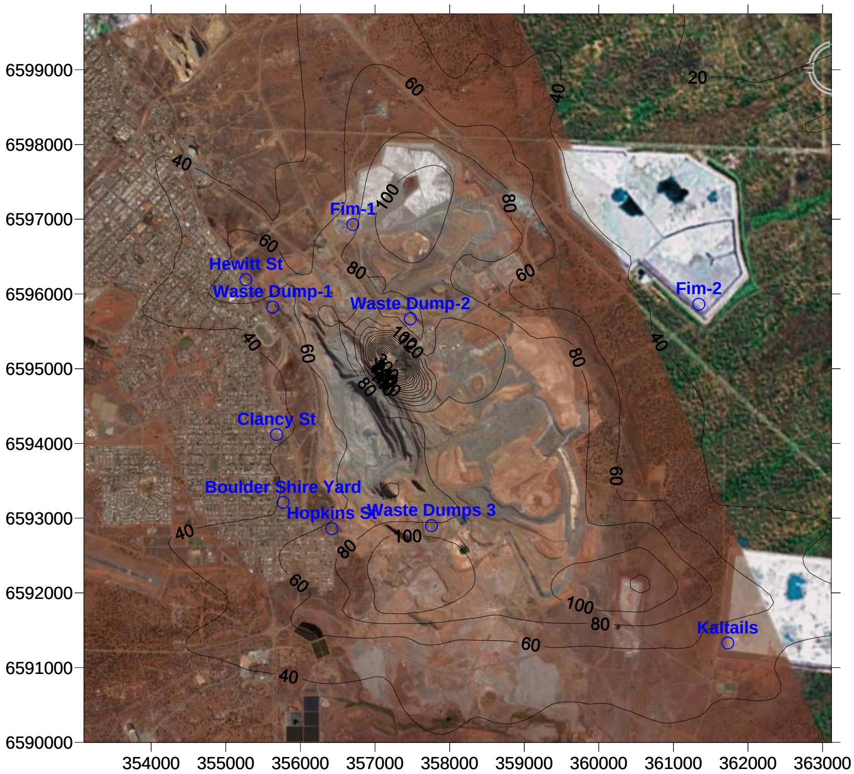


Figure 2: Predicted Annual Average PM_{10} Concentrations (µg/m³) Existing

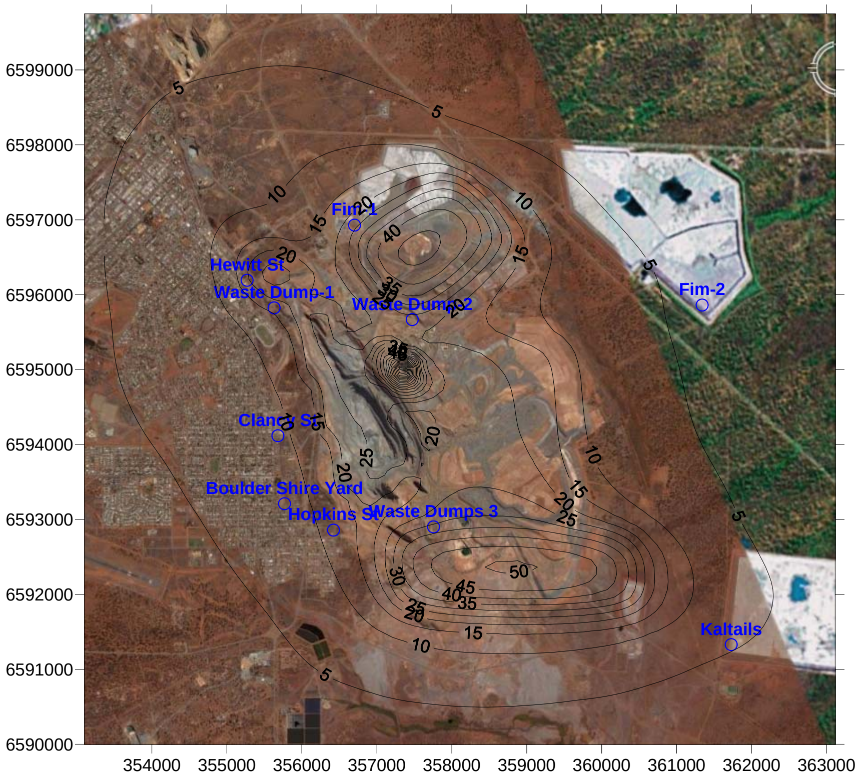


Figure 3: Predicted 24-Hour Average Maximum PM_{10} Concentrations (µg/m³) Proposed

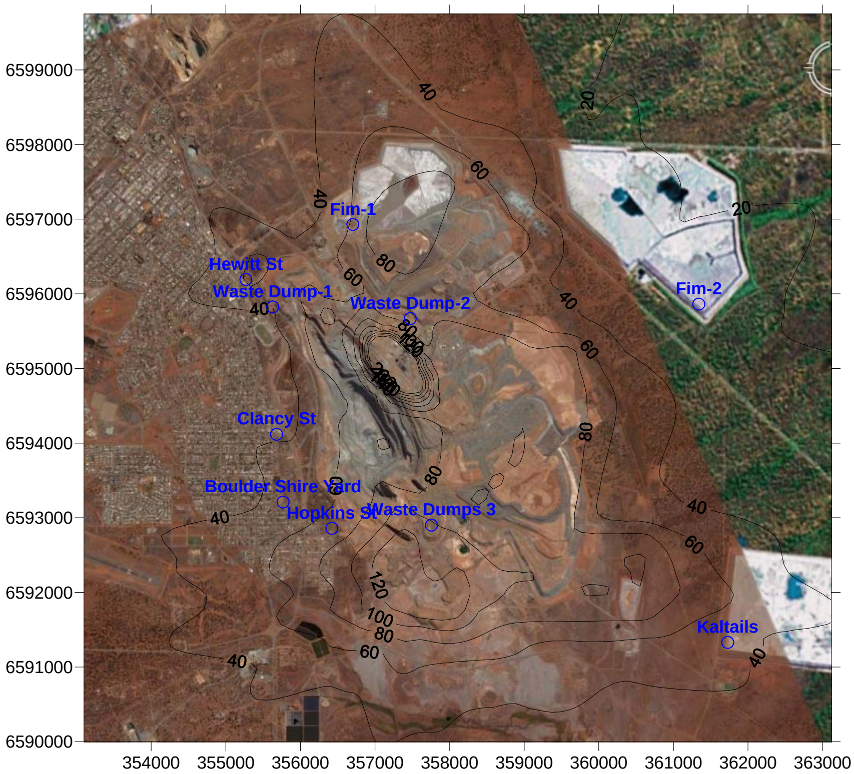
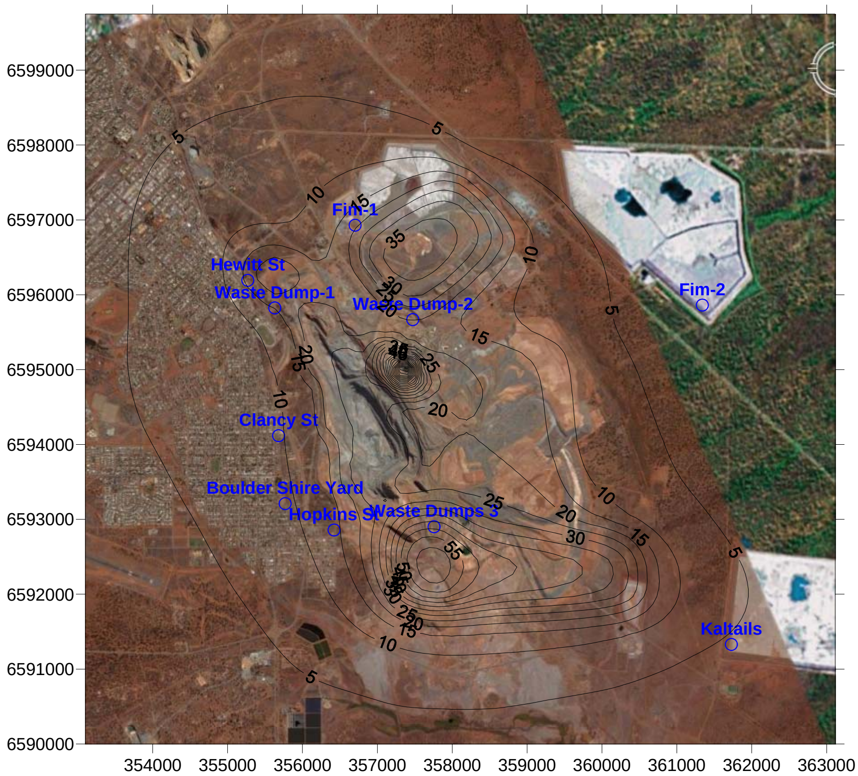


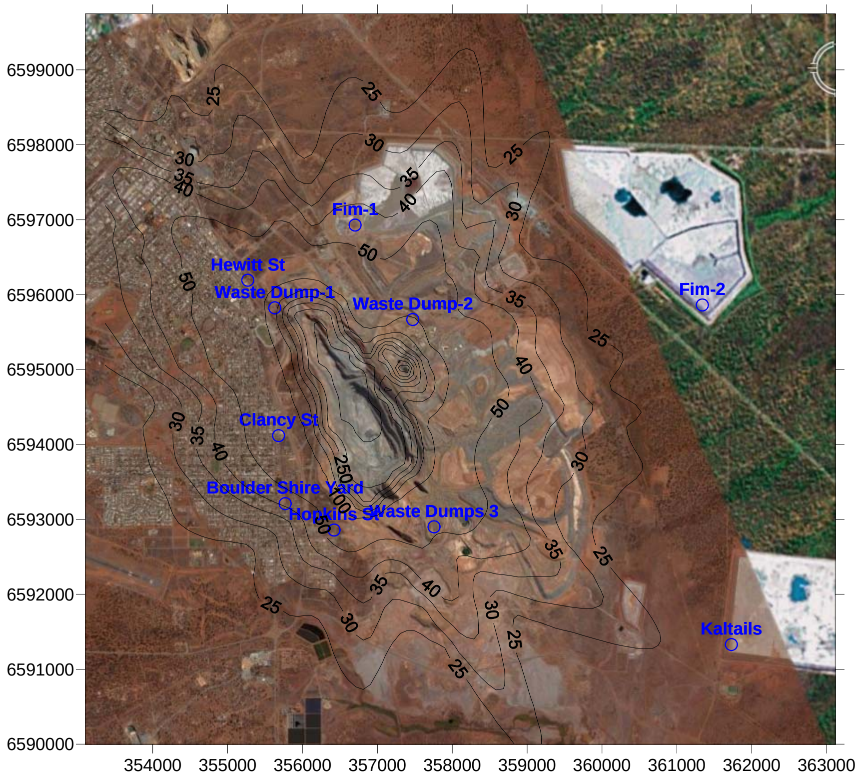
Figure 4: Predicted Annual Average PM_{10} Concentrations ($\mu g/m^3$) Proposed



3.2 Comparison with Previous Modelling

Figure 5 presents the maximum predicted 24-hour average PM_{10} concentrations as presented in the PER and shows the dominance of emissions from the Fimiston Open Pit. By comparing Figures 1 and 5, the differences between the PER model results and the current reanalysis are readily apparent and show the higher impacts predicted from the WRDs.

Figure 5: Predicted 24-Hour Maximum PM_{10} Concentrations (µg/m^3) Existing (Previous modelling)



3.3 Comparison of Updated Figures Against Monitoring Data

The air dispersion modelling report prepared for the PER assessed the model predictions against the PM_{10} measurements taken at the Boulder Shire Yard. This assessment found that for the existing situation the modelling results should result in a maximum predicted 24-hour concentration at Boulder Shire Yard should be in the order of 40 µg/m^3. The modelling results form the re-analysis (Table 5) are consistent with the PER model calibration.

4 CONCLUSIONS

This study involved the updating of emissions rates and factors for modelling undertaken as part of an assessment on the expansion of KCGM's operations at Kalgoorlie. Post analysis of the PER modelling indicated that there may been possible under prediction of the impacts associated with the WRD's and over prediction of impacts from the Fimiston Open Pit. The methodology used in the determination of emissions from the WRD's and Fimiston Open Pit was reviewed and subsequently a new methodology for the determination of emissions factors devised by the USEPA for the WRD's was determined and applied. For the Fimiston Open Pit, the pit retention factor used in the PER, based on studies undertaken by KCGM and CSIRO was assessed to have been too low and was therefore increased.

The modelling predicted little difference between the ground level concentrations between the existing operations and proposed expansion. Small increases in the ground level concentrations were predicted to the southwest of the operations but small decreases in the ground level concentrations were predicted to the northwest. The modelling results generated from the updated emission factors were checked against those previously predicted (and expected) for the Boulder Shire Yard monitoring site and found to be consistent.

ENVIRON believes that the reanalysis has resulted in a more realistic contribution of the WRDs to the predicted concentrations and a decrease in the predicted emissions from the Fimiston Open Pit. These modelling results will be evaluated against, and potentially further refined by, the ambient PM_{10} monitoring stations that have been established in the vicinity of the Fimiston Operations and documented in the Fimiston Air Quality Management Plan.

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Please contact the undersigned directly should you wish to discuss any aspects of this report.

Yours faithfully
ENVIRON AUSTRALIA PTY LTD

Brian Bell
Manager, Western Australia