16. Air Quality

This chapter addresses the air quality aspects of the Project. It describes the existing air quality environment including the surrounding land use and local climatic conditions. Potential impacts to air quality based on the worst case dust generation conditions are assessed, and measures for the mitigation of any impacts are proposed.

A detailed air quality assessment is provided in Appendix T. The potential impacts and associated mitigation measures identified in this chapter form the basis of the air quality component of the project risk assessment undertaken in Chapter 5. The project risk assessment includes consequence, likelihood and residual risk ratings for air quality impact after management measures are implemented.

16.1 Existing Environment

The area surrounding the mine site is rural and sparsely populated. The Werenbun community is the closest residential area located approximately 6.5km from the site. The community consists of 10 houses, 30 people and an open undercover area used as a school by the Northern Territory School of the Air.

The Stuart Highway, the main arterial road in the region, is located west of the mine site.

The mine site is located within an area that supports a population of the Gouldian finch, a species protected under the EPBC Act. This species has the potential to be affected by dust from the Project (Chapter 14).

16.1.1 Local Meteorology

The Project is located in a remote region of the Northern Territory and no locally representative meteorological information was available for use in the air quality study. Consequently, meteorology representative of the mine site and surrounding region was simulated using the CSIRO's Air Pollution Model meteorological model for use in the air dispersion modelling study. The model simulates local meteorology based on synoptic-scale information used in weather prediction models and incorporates the effects of local terrain, land use features, surface roughness, vegetation type, soil type and the monthly deep soil moisture content.

The period modelled was September 2007 to August 2008. This period was selected to capture a full Wet Season, rather than modelling a calendar year and separating the Wet Season into two non-sequential periods at either end of the year. The September 2007 to August 2008 period was selected as it experienced a changing El Nino Southern Oscillation pattern over the Wet Season which led to a break in drought conditions in eastern and southern Australia over the preceding years and generated near average rainfall in the project region. The approach taken in air quality studies is to assess impacts associated with climatic conditions that are representative of (or average for) the region. This is important for meteorological parameters such as rainfall, temperature, wind speed and wind direction as excessively high or low rainfall or temperature may suppress or exacerbate dust generation, or alter wind patterns to skew the distribution of impacts in a particular sensitive area. Consequently, average rainfall in the region is an important consideration in the selection of a meteorological year for assessment.

The performance of the Air Pollution Model to simulate regional meteorology was evaluated against Bureau of Meteorology observations at the Tindal Royal Australian Air Force Base and Pine Creek monitoring stations. The comparison found that modelled wind conditions are generally in agreement with the Bureau of Meteorology observations. Hourly surface winds, temperatures and atmospheric stability were then extracted for the mine site for use in the air dispersion model.

16.1.2 Wind Climate and Atmospheric Stability

The Air Pollution Model modelled annual and seasonal distributions of wind for the mine site are presented in Figure 16-1. The distributions illustrate distinct seasonality, with the Dry Season dominated by south-easterly winds and the Wet Season dominated by north-westerlies. Winds from the south east comprise 20% of annual winds, followed in frequency by winds from the east-southeast (19%). This pattern reflects the dominance of the easterly trade winds experienced at this latitude during the Dry Season and the effect of the Australian Monsoon on Wet Season wind conditions. The incidence of light winds, which give rise to poor dispersion of emissions released at ground level, is also highest from the south east. These winds comprise 19.5% of winds in the 0.5 to 2.1m/s category. The average modelled wind speed was 2.46m/s.

Annual **Wet Season** **Dry Season**

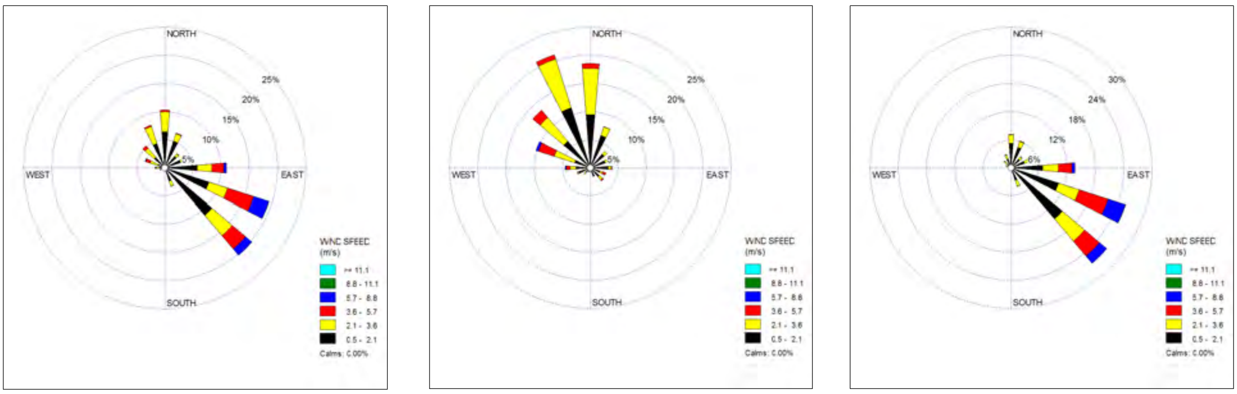


Figure 16-1 Annual and Seasonal Wind Distributions for the Mine Site – Sept 2007 to Aug 2008

Atmospheric stability dictates how effectively and efficiently a plume will disperse. The Pasquill / Gifford scale consists of six stability classes. A, B and C represent strongly, moderately and slightly unstable atmospheres respectively where dispersion of ground level emissions is efficient due to convective turbulent vertical mixing. Category D classifies a neutral atmosphere and E and F slightly and moderately stable atmospheres respectively. Stable conditions will generally develop at night, under clear skies and weak gradient winds and such conditions are often coupled with ground based, radiation forced temperature inversions, sometimes with fog, mist or frost. In a stable atmosphere (categories E and F), dispersion is poorest as vertical mixing of air is suppressed. This can result in a downwind plume detectable to a greater distance compared to similar emissions under unstable conditions.

The annual stability rose for the data set is depicted in Figure 16-2. The following features are portrayed:

- stability class D (neutral) is the most common atmospheric condition, present 38% of the time;
- stable classes E and F combined comprise 34% of atmospheric condition; and
- the highest incidence of E and F conditions are seen from the southeast.

When season is taken into account, the highest incidence of stable conditions corresponds to the change in prevailing wind (Figure 16-2).

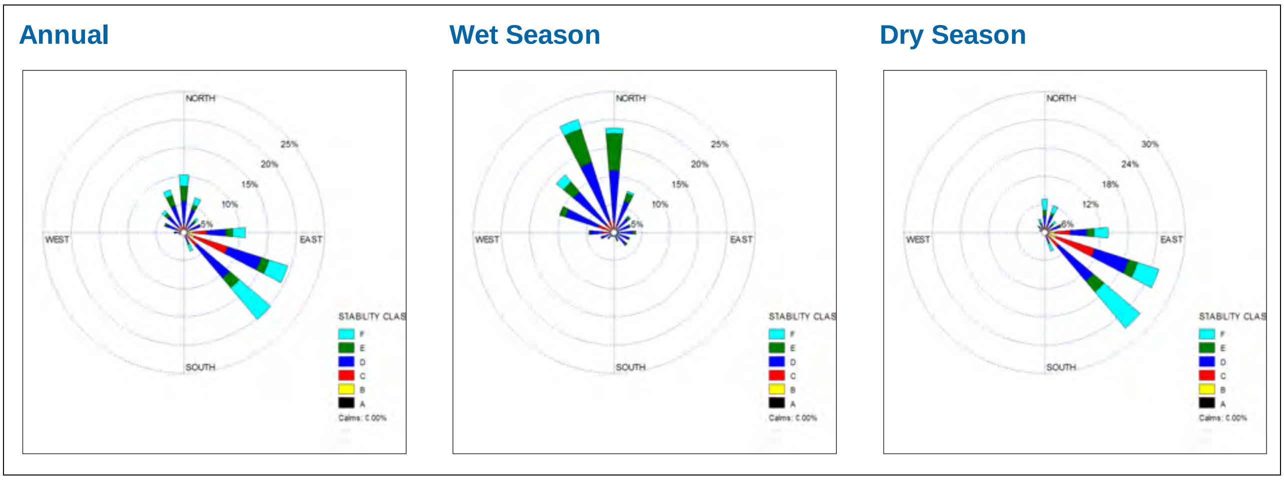


Figure 16-2 Distribution of Atmospheric Stability Classes by Wind Direction for the Mine Site

16.1.3 Background Air Quality

The pollutant of most concern associated with the construction and operation of open-cut mining projects is particulate matter (as dust). Dust, in this case, refers to the crustal material generated by the transfer, processing, handling and storage of extracted material such as soil, overburden, ore and waste rock. The residual minor component of the total particulate matter load is associated with diesel emissions from stationary and mobile plant and earthmoving equipment.

The assessment of criteria air pollutants, such as dust, is made by comparison of ground level concentrations of emissions associated with the Project combined with existing pollutant background concentrations against the air quality standards. Consequently, it is important to understand the background air quality at the mine and the location of sensitive receptors.

The Project is situated in a sparsely populated rural area primarily consisting of scrubby vegetation. The main naturally occurring sources of dust in the region are smoke from bush fires, wind erosion of large areas of sparsely vegetated exposed ground, and sealed and unsealed roads. Other dust sources in the project area include the wind erosion of existing non-operational facilities such as the HLP, WRD and TSFs developed for the mine's previous operations. As there is little urbanisation in the region and towns are located greater than 50km from the mine site, fine particulate matter ($PM_{2.5}$) and dust from anthropogenic sources such as vehicle movement and engine combustion is expected to make a negligible contribution to background air quality. Regional ambient dust concentrations are expected to be variable throughout the year due to various factors including rainfall totals during the Wet and Dry Seasons, wind conditions and disturbances associated with people movements.

Particulates are commonly monitored and assessed in three size ranges:

- less than 2.5 micron fraction ($PM_{2.5}$);
- less than 10 micron fraction (PM_{10}); and
- Total Suspended Particulates (TSP) – defined as particles less than 50µm.

The concentration of PM_{10} is a subset of the TSP concentration, while the concentration of $PM_{2.5}$ is a subset of the TSP and PM_{10} concentration.

All particle sizes are capable of being suspended in ambient wind. Larger particles contribute most to potential nuisance, while the finer particles, PM_{10} (the inspirable fraction) and $PM_{2.5}$ (the respirable fraction) can present a health issue. The most important size fraction of the particulate load generated in both the ambient environment and by the Project is considered to be PM_{10} due to the source and type of the dust generated by the Project, i.e. crustal matter in a rural setting rather than combustion sources in an urban airshed.

Installation of a power plant comprising a gas turbine and two gas-fired reciprocating engines is also proposed. Emissions from the plant will consist of NO_2, CO and trace quantities of fine particles, primarily in the $PM_{2.5}$ size fraction, and volatile organic compounds (VOCs). These pollutants are generally associated with urban development, motor vehicles and industry and are generated by the combustion of carbon-based fuels. The location of the Project is remote and well separated from other similar sources of these pollutants and existing ambient concentrations are expected to be very low.

Background Dust Levels used in the Cumulative Impact Assessment

The *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM) (NEPM 2003) does not provide guidance on the determination of background air quality where no site-specific data are available. However, the Victorian Government's *State Environment Protection Policy (Air Quality Management)* 2001 (SEPP 2001) does provide such guidance. It states that the 70th percentile of one year of observed hourly concentrations may be used as a constant value to represent background concentrations in numerical modelling. For pollutants that are assessed on a 24-hour average basis, the 70th percentile of one year of 24-hour averages must be used.

PM_{10} and $PM_{2.5}$ levels at Casuarina, Northern Territory are monitored annually. The average of the 75th percentile concentrations for the period 2004 to 2009, as reported at Casuarina, is presented in Table 16-1.

Table 16-1 Ambient Background Concentrations

TSP	PM_{10}	$PM_{2.5}$
42µg/m^3	20.8µg/m^3	11.2µg/m^3

This level is considered to be a conservative estimate of ambient concentrations in the Project and surrounding areas to represent background levels in the dispersion modelling assessment. The Casuarina site is situated nearer to the urbanised airshed of Darwin and a 75th percentile concentration of PM_{10} of 20.8µg/m^3 is in reasonable agreement with similar percentiles for other industrialised and urban airsheds in Australia.

The annual average concentration of $PM_{2.5}$ of 11.2µg/m^3 is considered to be very conservative. The late Dry Season scrub burning is considered to be the dominant influence on particle pollution in the northern regions of the Northern Territory, but this will affect specific local areas as it is a mobile source, be intermittent and of variable duration due to meteorological influences and fuel supply, and take place late in the Dry Season. During the Wet Season, the ambient dust load can be expected to be relatively low.

In the absence of TSP monitoring data at Casuarina, a value of 42µg/m^3 has been adopted. This concentration is based on measurements in other Australian air sheds where PM_{10} concentrations typically represent half of the total airborne dust load.

16.2 Air Quality Criteria

The Northern Territory Government has not published any guidance or objectives for the assessment of air quality in the Northern Territory. In the absence of state or territory-specific environmental protection regulations, suitable air quality assessment criteria and guidance have been sought from other national and state legislation. A review of national and state air quality standards and objectives considered for use in the assessment is presented in Table 16-2.

Table 16-2 Air Quality Standards and Impact Assessment Criteria used in the Assessment

Indicator	Air Quality Standard[a]	Impact Assessment Criterion[b]	Intervention Level[c]	Averaging Time
PM_{10}	50 µg/m³	50 µg/m³	60 µg/m³	24-hour
$PM_{2.5}$	25 µg/m³		36 µg/m³	24-hour
TSP	N/A	90 µg/m³	N/A	Annual
Deposited dust	N/A	Total: 4 g/m²/month Incremental: 2 g/m²/month	N/A	Annual
NO_2	226 µg/m³ 56 µg/m³	N/A	N/A	1-hour Annual
CO	10,260 µg/m³	N/A	N/A	8-hour

Notes: [a] Ambient Air Quality NEPM, [b] NSW DECCW criterion, [c] EPA Vic. Mining PEM, N/A: Not applicable

In accordance with the Commonwealth *National Environment Protection Measures (Implementation) Act 1998*, the Air NEPM is based on a regional air monitoring protocol and the average for the monitoring network across an urban airshed is assessed against the Air NEPM standards, rather than an assessment at individual receptor locations. While the Air NEPM standards are designed to be used for the assessment and management of air quality in urban areas with a population greater than 25,000 people, where the Air NEPM (2003) is designed to protect humans from pollution primarily generated from the combustion of fossil fuels (i.e. NO_2, CO, PM_{10} and $PM_{2.5}$[1]), they have been adopted in some state environmental air policies as air quality objectives or impact assessment criteria (namely Queensland and New South Wales).

In the case of the Project, the mine site is situated in a remote location with negligible levels of NO_2 and CO and a variable natural background dust load. The mine is not located in a densely populated urban environment affected by industry and motor vehicle pollution. The nearest sensitive human receptors are situated 6.5km away. Consequently, it is recommended that these objectives are used to manage air quality to meet project-specific goals in a similar way to the application of the Victorian Government's *State Environment Protection Policy (Air Quality Management) 2001* (SEPP 2001) and the EPA Victoria *Mining and Extractive Industries Protocol for Environmental Management 2007* (EPA 2007) assessment criteria for PM_{10} and $PM_{2.5}$. This policy prescribes an interactive management process and the use of a 24-hour average intervention level for PM_{10} of 60µg/m³, where dust management and mitigation measures are intrinsically linked to the monitoring objective of PM_{10} at sensitive receptors. It is recommended that dust levels at sensitive places are monitored against a pre-determined trigger level

[1] It should be noted that $PM_{2.5}$ is an advisory standard only.

that allows the mine operators to monitor conditions, adjust activity rates and apply mitigation measures to meet air quality objectives.

The Air NEPM standards have been used to assess the potential for impacts of NO_2 and CO in the air quality modelling assessment, as well as PM_{10} and $PM_{2.5}$ in conjunction with further guidance from the Victorian Government's SEPP 2001. This assessment procedure has been used to identify potential air quality impacts and is based on a series of conservative modelling assumptions to assess compliance of the Project under worst case conditions. The modelling assumptions and methods are detailed in Section 16.3 and Appendix T. This assessment allows for the identification of problematical dust emission sources and potential mitigation measures to reduce dust impacts.

Worst case conditions with the potential to cause air quality impacts are projected to occur over approximately two days during maximum material extraction rates in the year in which the greatest amount of material is to be mined, and are due to the coincidence of worst case meteorological conditions. As dust emission generation is a function of material moved, this leads to a very conservative estimate of the Project's potential to affect regional air quality. As a consequence of this, an environmental risk assessment has also been undertaken as part of the assessment criteria to investigate the cause, frequency and likelihood of the worst case dust impacts.

In addition to the lack of state and territory-specific air quality criteria, where the Air NEPM has not published air quality assessment criteria for a substance, assessment criterion may be adopted from another national or international jurisdiction. For this assessment, the NSW Office of Environment and Heritage impact assessment criteria for TSP and deposited dust have been used.

The air quality assessment criteria considered for use in the impact assessment have been selected to protect human health and well-being, minimise the loss of amenity and the causation of nuisance affects and to manage environmental impacts. Specific objectives for protecting terrestrial flora and fauna and aquatic environments have not been derived and published. Consequently, the air quality criteria identified for use in this impact assessment apply specifically to the protection of human receptors.

16.3 Methodology

16.3.1 Air Dispersion Modelling

The impact assessment was conducted using EPA Victoria's AUSPLUME (Version 6.0) dispersion model to simulate plume transport and predict ground level pollutant concentrations and dust deposition rates for the estimated worst case conditions. Emissions modelled included fugitive dust from the mine site and stack emissions of fuel combustion products from the power plant.

The following sections provide a description of the inputs to the modelling and assumptions made in order to model pollutant concentrations and dust deposition rates.

Model, Source and Emission Characterisation

Emission rates for area and volume sources are detailed in Appendix B to the Technical Report (Appendix T). All initial source dispersion characteristics were modelled based on AUSPLUME model guidance. A variable emissions file was created to model blasting once per day, wind erosion during the Dry Season and no wind erosion during the Wet Season (1 December to 31 March) for the year 2007-08.

For the initial air quality modelling assessment, plume depletion was not modelled. Plume depletion can be parameterised for both dry and wet removal of particles. Plume depletion refers to the removal of particles from the suspended plume during travel through dry settling processes or wet scavenging of the plume by rain. Without depletion processes included in the model, plume concentrations are not diminished through particle deposition and particles continue to travel with the plume as it disperses and spreads out. The exclusion of plume depletion in the modelling process is considered to be more conservative than its inclusion and consequently its initial exclusion from the modelling is usually assessed in order to predict worst case maximum impacts. However, this conservative approach can lead to unrealistic and overly conservative estimates of ground level concentrations, particularly at significant distances from the source. For this study, further air quality modelling was undertaken as part of the environmental risk assessment process to investigate predicted high ground level concentrations in sensitive places and to assess the sensitivity of the model to certain assumptions such as dry and wet depletion.

Dust Particle Size Distribution

To model dust deposition, which is based on the settling rates of the different size fractions of TSP, a particle size distribution needs to be specified. Fall velocities are then simulated, with the coarser particles settling out from the dust plume at shorter distances than the finer fractions. There are nominally three sources of dust from the site: unprocessed / stockpiled ore, process ores and wind erosion from exposed surfaces.

To give a representative pattern of dust deposition from the site, particle size distributions for TSP were applied across the three sources (Table 16-3). TSP was modelled up to a particle size (or diameter) of 50µm. This is based on large particles falling out close to the source and therefore being unlikely to cause an off-site impact. TSP is defined in the Queensland *Environmental Protection (Air) Policy 2008* as particles with a mean equivalent aerodynamic diameter of "*not more than 50 microns*".

Table 16-3 Modelled TSP Particle Size Distributions

Range (µm)	Mean Size (µm)	Unprocessed Ore (a) Mass Fraction	Processed Ore (b) Mass Fraction	Wind Erosion (c) Mass Fraction
0 to 2.5	1.25	0.15	0.16	0.08
2.5 to 6.0	4.25	0.19	0.21	0.27*
6.0 to 10	8.0	0.17	0.25	0.16*
10 to 50	30	0.49	0.38	0.50
Total		**1.00**	**1.00**	**1.00**

(a) US EPA Document EPA-450/4-86-013 (July 1986), Table 3-2, p.22.

(b) US EPA Document EPA-450/4-86-013 (July 1986), p.A-7.

(c) US EPA AP-42 Industrial Wind Erosion, Chapter 13.2.5, Equation 2 (2006).

***** Distribution derived from unprocessed ore distribution.

16.3.2 Development of an Emissions Inventory

An air emissions inventory of dust and other gaseous constituents for the Mt Todd mine and power plant was developed for the first 10 years of production. Emission factors were sourced from:

- NPI Emission Estimation Technique Manual for Mining Version 3.1 (NPI EETM) (Jan 2012);
- NPI EETM for Gold Ore Processing Version 2.0 (Dec 2006);
- US EPA AP-42 (1995), Heavy Construction Operation Guideline (Section 13.2.3, AP-42); and
- NPI EETM for Combustion Engines Version 3.0 (June 2008).

$PM_{2.5}$ emissions were not calculated from the EETM NPI directly, but were calculated using the particle size distribution ratios for the three identified distinct dust generation sources.

Construction Dust Emissions

Activities which will create emissions during construction include:

- excavating and levelling of disturbed surfaces;
- handling and localised stockpiling of spoil and overburden;
- localised welding, cutting and grinding (includes fumes);
- vehicles driving on unsealed roads and unconsolidated soil surfaces;
- blasting; and
- wind erosion of exposed unstable soil and stockpiles;

It is anticipated that dust (PM_{10}, $PM_{2.5}$ and TSP) will be the most pertinent air pollutant during construction.

The impact from vehicle exhaust, mobile and fixed plant emissions, such as NO_X, CO and trace quantities of VOCs, during construction is likely to be negligible given the short-term construction period at any one location, distances involved to the site boundary, a paucity of regional sensitive receptors and the low background concentrations for gaseous pollutants.

Mining Operation Dust Emissions

Operations at Mt Todd will result in generation of dust from many different processes including:

- wind erosion of unconsolidated, exposed and open surfaces, including stockpiles;
- overburden removal;
- loading ore onto haul trucks;
- wheel generated dust from vehicles on unpaved haul roads;
- wheel generated dust from vehicles on paved roads (access roads and ore processing area);
- dumping of ore at the ROM pad stockpile and WRD;
- primary and secondary crushing;
- screening;
- conveyor transfer points between different process stages;
- motor vehicle exhaust; and
- power generation.

Estimated dust emissions are directly proportional to the total amount of material extracted and moved through the process. The proposed mine plan was evaluated to determine the key dust generating sources and the worst case dust emissions due to the quantity of material to be excavated, transferred, processed and stored on the site. Year 3 of the mine plan is the year of maximum production and worst case potential for dust emission generation. The volumes of material used to develop the dust emissions inventory were 102.169Mtpa of material extracted and 17.8Mtpa of ore processed during Year 3 (Table 16-4). Indicative total annual emissions of PM_{10}, including application of dust emission controls, was highest in year three (2,569tpa) and at least 7% higher than the second highest year (2,376tpa in year 4).

Table 16-4 Year 3 Mining Schedule

Material Component	Year 3 (Mtpa)
Total earth moved	102.169
Total ore mined	23.971
Total to processing plant	17.750
Total To ore stockpile	6.191
Total to waste dump or construction	78.227

Assumptions made in Dust Emission Estimation

A number of assumptions were used in the calculation of dust emission rates. Key assumptions include:

- construction of temporary facilities, permanent workshops, offices and pipelines were omitted due to their relatively small impact when compared to the mining operations;
- drilling emissions were not calculated as the high level of dust mitigation which is standard practice in the industry renders the emissions negligible;
- loading of the HPGR does not result in a dust emission as the belt ‘feeds directly’ into the HPGR as opposed to entering via a transfer point;
- dust generated from paved roads was not considered as the amount generated is negligible compared to other mining operations;
- wind erosion of exposed areas and stockpiles was only considered for the Dry Season;
- blasts occurring everyday covering an area of 2,000m^2 and a depth of 10m;
- an ore moisture content of at least 10%. The moisture content of the Mt Todd ore entering the primary crusher was considered to be relatively high at approximately 10%. It is assumed that this will be achieved in the process by the application of water sprays should the ore moisture at any particular time fall below this level. During the Wet Season, it is expected that the ore moisture content would be higher than during Dry Season periods;
- haul road dust emissions were calculated using the default surface silt content of 10% and surface moisture content 2% (NPI 2012). These assumptions, particularly during the Wet Season, are considered to be conservative and overestimate haul road dust emissions;
- TSF1 and TSF2 have negligible dust emissions while in operation as the tailings will be wet;
- pit retention factors of 5% for PM_{10} and 50% for TSP were applied to all processes which will occur in the mine pit as per the NPI (2012) guidance. The NPI (2012) equations do not have variable pit

retention factors based on pit depth. It is conservatively assumed that pits of 5 or 500m depth will have the same retained amount of dust; and

- no dust controls were applied to the unloading of haul tracks at the WRD. As this area is large, it is unreasonable that water sprays can be applied to every variable location that a truck unloads.

Control Measure Assumptions Applied in Dust Emission Estimation

The following dust control measures and their control efficiencies were applied in the dust emission estimation calculations:

- water spray controls were applied to the loading, unloading and wind erosion of stockpiles. A control factor of 50% was applied to the uncontrolled emissions of these sources as per the NPI Mining EET (2012, p.21) guidance;
- a dust emission control efficiency of 70% was applied to the primary and secondary crushing, screening and conveyor transfer operations;
- a maximum dust emission control efficiency factor of 90% for unpaved haul roads. This is based on the work of Kinsey and Cowherd (Buonicore and Davis 1992, p.144) that showed that dust emissions from unpaved roads can be reduced by greater than 90% by using chemical stabilisation; and
- loading of the re-claim stockpile will be undertaken with the application of water spray controls to provide a nominal 50% dust emission control efficiency.

16.3.3 Results – An Emissions Inventory

Mining and Processing

An air emissions inventory of dust and other gaseous constituents for the Mt Todd mine and power plant was developed for the first 10 years of production with the year of maximum production and worst case potential for dust generation determined to be year 3 of the mine plan. Appendix T details the calculation formulae applied to each of the identified sources.

The inventory predicts that during peak production periods, wheel generated dust comprises approximately 50% of the total annual emitted PM_{10}. The only other single source to exceed 10% of the total inventory was unloading waste rock to the waste rock dump (11%).

Modelling assumes that a TSF1 lift will occur during year 3. Emissions from the continuous operation of a bulldozer and the corresponding unloading of waste rock from the pit for its construction have been modelled. Unpaved haul road emissions associated with the movement of haul trucks transferring waste rock from the pit to TSF1 for construction have also been modelled.

Modelling assumed that the TSF1 operational area would remain wet and exposed soil stabilised as quickly as practicable.

Construction of TSF2 is scheduled to commence in year 5 of operations and dust emissions are not modelled in year 3.

Power Generation

Emissions from the Rolls-Royce Trent 60 Wet Low Emissions single gas turbine generator and two MAN 20V35/44 gas-fired reciprocating engines were calculated from vendor supplied data provided by Vista Gold and assumed that all equipment was operating at full capacity, 24 hours per day, 365 days per year. The turbine is designed to meet emission standards at varying operating capacities and ambient temperature conditions.

Nominal flue gas stack exit conditions are summarised in Table 16-6.

Modelled power plant emission rates of NO_2 and CO are presented in Table 16-7. Emissions of fine particles ($PM_{2.5}$) and VOCs are expected to be negligible. Consequently the assessment of potential air quality impacts associated with the power station has focussed on emission of NO_2 and CO.

Table 16-5 Estimated Maximum Annual Controlled Dust Emissions

Location of dust source	Dust emitting process	Estimated Emissions (tonnes/year)		
		$PM_{2.5}$	PM_{10}	TSP
Mine pit	Blasting	1.0	3.5	3.6
	Loading mined material to trucks	19.9	62.5	69.9
	Wind erosion from pit	22.4	149.1	157.0
ROM pad	Loading stockpile (50% water sprays)	16.0	37.3	106.5
	Wind erosion of stockpile (50% reduction)	0.7	4.9	9.9
LGO Stockpile	Loading stockpile (50% water sprays)	5.6	13.0	37.1
	Wind erosion of stockpile (50% reduction)	3.8	25.5	51.0
Waste Rock Dump	Wind erosion of WRD (30% reduction, rock armour)	26.1	174.3	348.5
	Loading WRD	120.5	281.2	803.5
Haul roads	Wheel generated dust (90% reduction, chemical stabilisation)	649.3	1,277.7	2,706.9
	Wind erosion of haul roads (50% reduction)	0.4	2.8	5.6
Processing plant	Loading primary crusher (70% reduction as enclosed)	1.1	3.4	7.3
	Conveyor transfer points (70% reduction as enclosed)	7.5	20.4	47.1
	Primary crusher (75% reduction due to scrubbers)	7.1	17.8	44.4
	Secondary crusher (75% reduction due to scrubbers)	25.6	63.9	159.8
	Screening (75% reduction due to scrubbers)	70.9	332.3	443.0
	Wind erosion of coarse ore stockpile	0.2	1.2	2.3
	HPGR (99% reduction as enclosed)	40.9	33.2	255.6
Tailings Storage Facility 1	Bulldozer operation	11.2	17.9	74.5
	Waste rock unloading for construction	20.3	47.3	135.3
Total		**1,030**	**2,569**	**5,469**

Table 16-6 Power Station Stack Source Characteristics used in the Assessment

Parameter	Gas turbine	Reciprocating engines
Model	Rolls-Royce Trent 60	MAN 20V35/44
Number of units assessed	1	2
Number of discharge points	1	1
Stack height (m)	21.3	21.3
Stack exit plane diameter (m)	3.05	1.83
Stack exhaust exit plane velocity (m/s)	48.3	12.5
Stack exhaust temperature (^oC)	422	298
Mass flow rate (kg/s)	166	Not available
Emission controls	NO_X – Wet Low Emissions Technology	None

Table 16-7 Stack Emission Rates used in the Modelling Assessment

Pollutant	Gas turbine	Reciprocating engines
Nitrogen dioxide[a] (g/s)	1.84	2.32
Carbon monoxide (g/s)	6.69	4.66

Notes: [a] NO_2 was calculated from vendor supplied NO_x, assuming an NO_2 to NO_x ratio of 30% for a conservative approach.

16.4 Potential Impacts

16.4.1 Overview

The assessment of the potential impact to air quality has been based on emissions estimated under worst case dust generation conditions during the worst case meteorological conditions. While air quality criteria are designed to assess the maximum impact, it is important to understand the distribution of ground level concentrations at sensitive places, the frequency at which assessment criteria are predicted to be exceeded (if at all), the conditions under which impacts occur and the probability that the highest emission rates will coincide with the poorest dispersion conditions. This is particularly important in the assessment of fugitive dust as the rate of emission is intrinsically linked to ambient conditions including surface moisture, rainfall, humidity, temperature and wind speed. These factors will affect dust generation through evaporation rates and dust lift off capacity and also the rate of mining activity.

Worst-case dust generation and impact is most likely to occur under the following conditions:

- when rainfall is at a minimum (Dry Season);
- operational activities are at a peak; with
- additional particles from vegetation burning (regional higher background levels); and
- when winds are light and stable, leading to poor dispersion of fine dust from operational activities; or
- when winds are stronger and able to transport the larger particles for some distance before settling.

As the closest urban areas are over 50km from the site, the main threat to the human population is likely to be due to emissions of particulate matter associated with the Project causing an impact at Werenbun.

16.4.2 Predicted Maximum Off-site Dust Impacts

Predicted Maximum Dust Ground Level Concentrations

The results of the initial air dispersion modelling assessment without plume depletion, for year 3 of operations, are presented in Table 16-8.

Table 16-8 Summary of Predicted Maximum Ground Level Dust Concentrations for Operational Year 3

Air Quality Indicator	$PM_{2.5}$		PM_{10}	TSP
Averaging Period	24 hours	Annual	24 hours	Annual
EPA Victoria Mining Criterion (µg/m³)	36	-	60	-
NEPM Criterion (µg/m³)	25	8	50	90
Background (µg/m³)	11.2	11.2	20.8	42
Compliant at Site Boundary	N/A*	N/A	N/A	N/A
Incremental at Werenbun Community Ground Level Concentrations (µg/m³)	21.6	1.4	49.7	6.9
Total at Werenbun Community Ground Level Concentrations (µg/m³)	32.8	12.6	70.5	48.9
% of Criterion at Werenbun Community	131	157	141	54
Incremental at Katherine (µg/m³)	5.6	0.3	12.6	1.4
Incremental at Pine Creek (µg/m³)	7.4	0.8	17.4	3.9

*N/A – the Air NEPM standard for PM_{10} and $PM_{2.5}$ is expected to be met at sensitive places, not the site boundary. Further clarification on the application of the Air NEPM standards is required by the regulator in Northern Territory.

Note: Dry and wet plume depletion not modelled.

The initial air quality modelling assessment has found that the highest cumulative 24-hour average ground level concentrations of PM_{10} and $PM_{2.5}$ are predicted to exceed the air quality criteria of 50µg/m³ and 25µg/m³ respectively at Werenbun. The PM_{10} standard was predicted to be exceeded on seven days based on the conservative modelling assumptions including maximum mining activity rates, modelling maximum dust emissions for the highest production year, worst case meteorological conditions and the exclusion of dry and wet depletion processes.

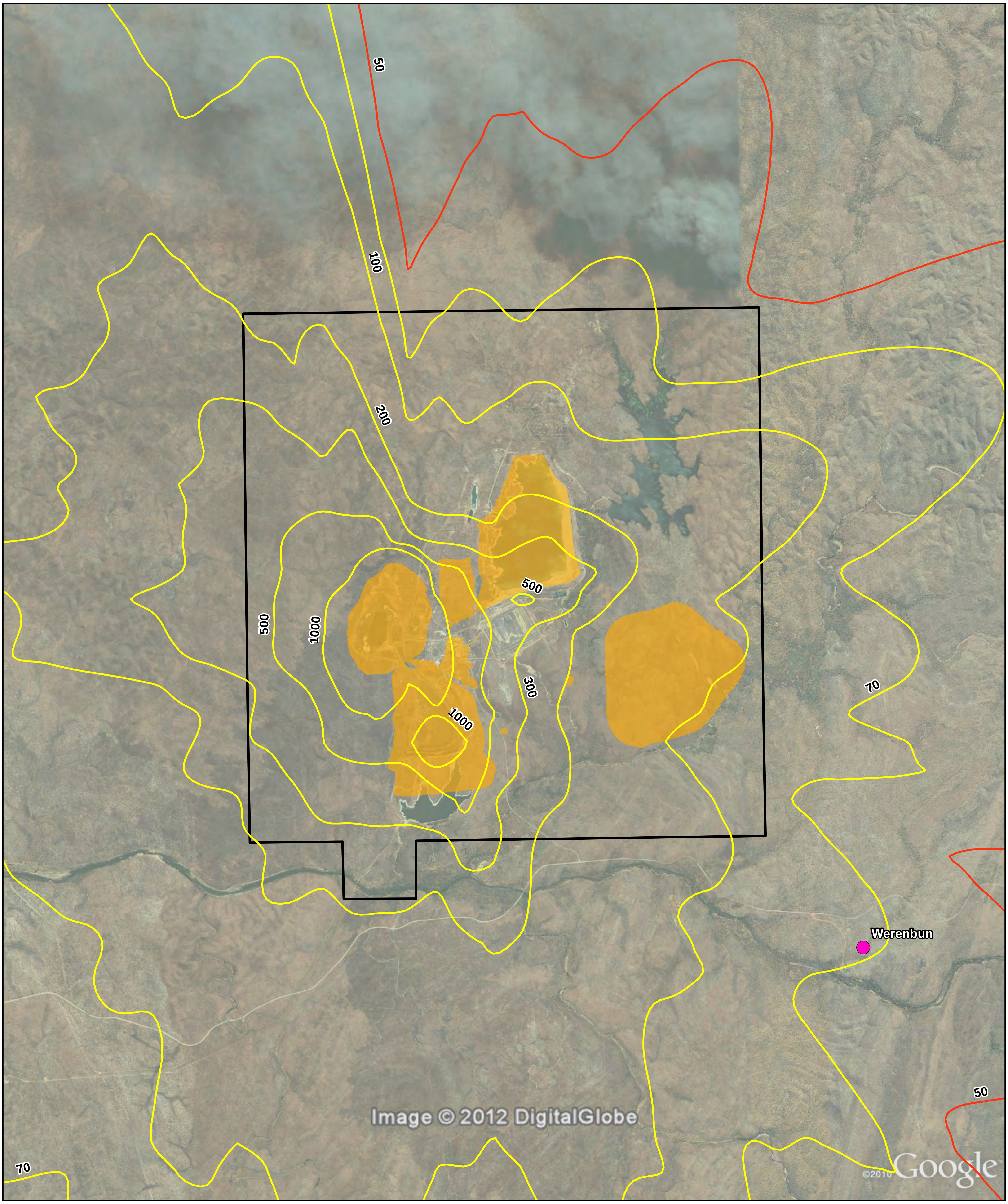
Notwithstanding the predicted exceedences of the PM_{10} and $PM_{2.5}$ standards, the annual average assessment criterion of TSP of 90µg/m³ is predicted to be met at Werenbun. The highest cumulative ground level concentration of TSP at Werenbun is predicted to be about 54% of impact assessment criteria, while the incremental impact is predicted to be very low at 16% of the assumed background concentration and less than 8% of the criterion.

Predicted maximum 24-hour average ground level concentrations of PM_{10} across the local area are illustrated in Figure 16-3. This figure indicates that the predicted highest concentrations of PM_{10} occur to the northwest of the emission sources at the mine site due to the dominant southeast trade winds. While there are no human receptors identified in the Yinberrie Hills area to the west of the Batman Pit, the assessment predicts that the area, including Gouldian finch habitat, has the potential to be exposed to a maximum 24-hour average ground level concentration of PM_{10} of greater than 200µg/m^3, when combined with a background concentration of 20.8µg/m^3. Air quality impacts associated with the health of the Gouldian finch are addressed further in Chapter 5 and Chapter 14. Further consultation with the environmental regulator will be undertaken to determine an appropriate assessment criteria for the protection and management of the Gouldian finch population and habitat.

The annual average ground level concentration of $PM_{2.5}$ at Werenbun is predicted to exceed the Air NEPM advisory standard due to a very high background concentration of 11.2µg/m^3, which is 140% of the standard of 8µg/m^3. This concentration has been used due to a lack of site representative data and is considered to be very conservative. Notwithstanding the total cumulative impact and background, the incremental increase in annual average ground level concentrations of $PM_{2.5}$ at Werenbun, associated with emissions from the mine site, is predicted to be very low at 1.4µg/m^3.

An Environmental Risk Assessment was conducted to investigate the cause and frequency of the potential exceedences of the Air NEPM standard of PM_{10} at Werenbun. Additional modelling was undertaken to better understand this potential impact. AUSPLUME modelling was carried out to include dry particle depletion (dust settling or fallout) at the Werenbun receptor. When dry depletion is considered in the model, the maximum incremental ground level concentration at Werenbun is predicted to be reduced by 5.5µg/m^3, thereby reducing the number of predicted exceedences of the Air NEPM standard from seven days to five days.

Further investigation found that the 12 highest ranked 24-hour average ground level concentrations at Werebun are predicted to occur during the Wet Season, i.e. December, January or February, when the Dry Season prevailing southeast wind changes to the northwest due to the Wet Season monsoon. This wind shift results in the dust plume being directed toward the Werenbun community. Notwithstanding this, these months are also associated with a significant amount of rainfall. Rainfall was not accounted for in the initial modelling assessment except in the removal of dust emissions associated with wind erosion of exposed surfaces during the Wet Season months. Consequently, when rainfall is taken into account it is reasonable to expect that the wet depletion (or scavenging) processes will remove at least an equivalent amount of dust (i.e. 5.5µg/m^3). If this takes place, the number of predicted exceedences of the Air NEPM standard of PM_{10} is expected to be two days. This is likely to be well within the requirements of the Air NEPM standard of PM_{10} as the predicted highest incremental ground level concentrations of PM_{10} at Werenbun occur during the Wet Season when background dust levels are likely to be relatively low due to moist soil conditions and no seasonal vegetative burning. Further, if consideration is given to the adoption of the EPA Victoria's *Mining and Extractive Industries Protocol for Environmental Management* (EPA 2007) guidance, and an interactive dust management plan is instigated, the Victorian Government's SEPP 2001 air quality intervention level of 60µg/m^3 for the 24-hour average is predicted to be met at Werenbun.



LEGEND

- Sensitive Receptors
- Concentration ug/mg^3 (Criterion 50 ug/m^3
- Criterion 50 ug/m^3
- Mineral Lease
- Emission Sources

0 0.5 1 1.5 2
Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

N

Vista Gold Australia Pty Ltd
Mt Todd Gold Project

Job Number	43-21801
Revision	1
Date	21 Jun 2013

Predicted 24-hour PM_{10} Concentrations

Figure 16-3

G:\43\21801\GIS\Maps 30000 TPA\EIS\Air\4321801_1101E.mxd

66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com.au

Data source: NRETAS - Mineral Lease (2011). Tetra Tech - Emission Sources (2013). Google Earth Pro - Imagery (Date extracted: 11/05/2012). GHD - Ground Level Concentration (2012). Created by: CM

Predicted Maximum Dust Deposition Rates

In the absence of measured regional dust deposition rate information, the assessment of deposited dust has been made against the incremental annual average impact assessment criterion of 2g/m^2/month. The incremental dust deposition rate was predicted to meet the impact assessment criterion at Werenbun (Figure 16-4). The incremental deposition rate was predicted to be 0.4g/m^2/month at Werenbun, without the inclusion of dry and wet depletion. This value is expected to be a conservative upper limit as dust depletion through wet removal mechanisms is expected to be large during the Wet Season.

The Yinberrie Hills area to the west of the Batman Pit is predicted to have the highest deposition rates due to the prevailing south east winds.

In a similar manner to the assessment of ground level concentrations, the modelling of dust deposition has been conducted without plume particle depletion and is therefore considered to be a conservative estimate. Actual particle depletion from the plume is expected to reduce predicted deposition rates beyond the lease boundary.

16.4.3 Power Station Emission Impacts

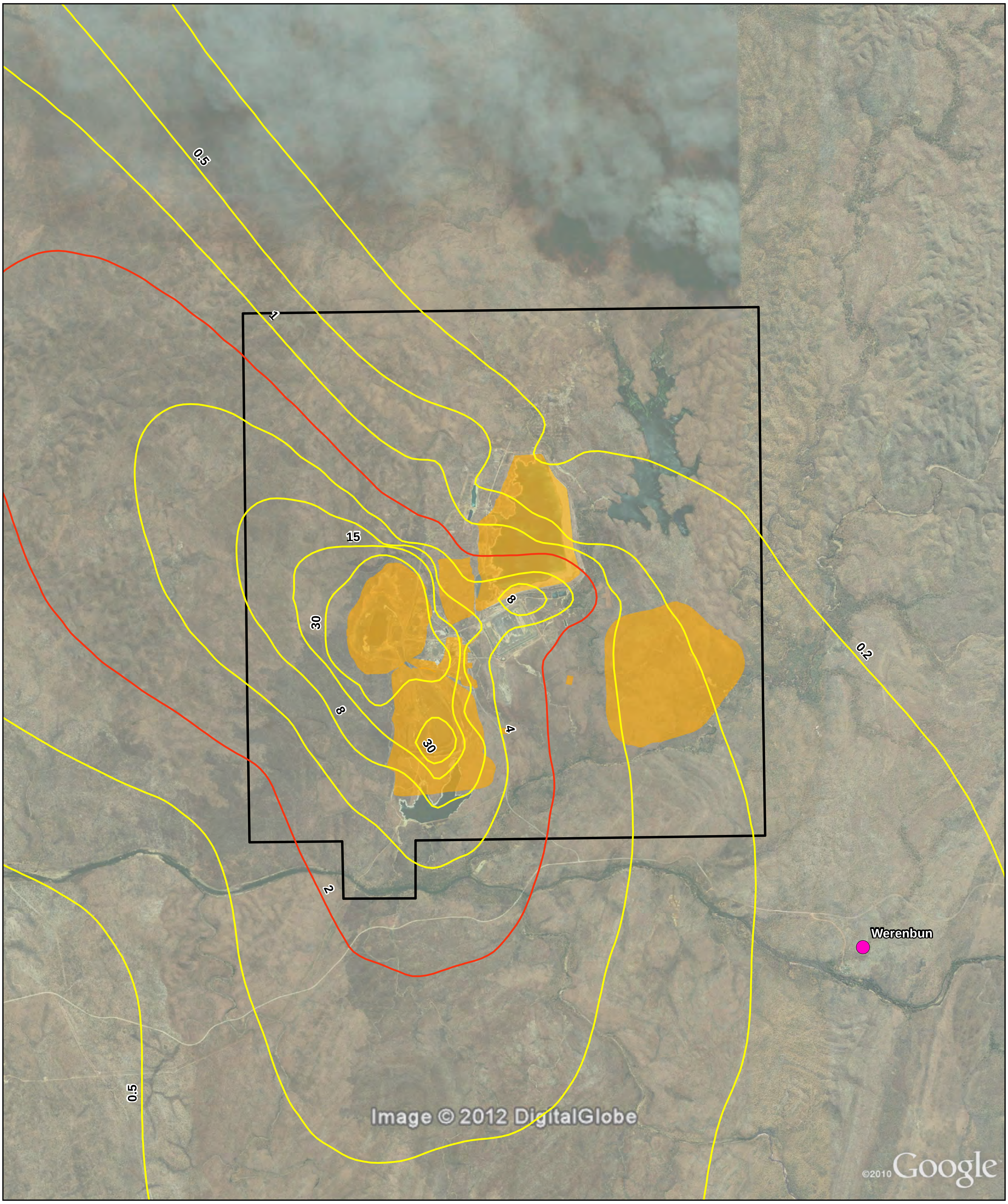
Assessment of CO and NO_2 from the Power Station was undertaken with the proposed stack emitting at a constant rate of 100% engine load. The predicted maximum 1-hour and annual average ground level concentrations of NO_2 and 8-hour average ground level concentrations of CO at any location beyond the mine site boundary are presented in Table 16-9.

The most influential constituent is NO_2, assessed as a 1-hour average ground level concentration. The assessment found that the maximum 1-hour average ground level concentration of NO_2 is predicted to be 11.8µg/m^3, which is approximately 5% of the Air NEPM standard.

The maximum ground level concentrations of NO_2 and CO at the nearest sensitive receptor, the Werenbun community, are predicted to be well below the Air NEPM standards (Figure 16-5).

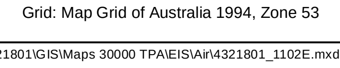
Table 16-9 Peak Ground Level Concentrations from the Mt Todd Power Station at Full Load

Constituent	Averaging Time	Predicted Peak ground level concentrations (µg/m^3)	NEPM Air Quality Criteria (µg/m^3)	Percentage of Criterion (%)
CO	8 hours	15.7	10,260	0.2
NO_2	1 hour	11.8	226	5.2
	1 year	0.8	56	1.4



LEGEND

Sensitive Receptors	Mineral Lease
Deposition g/m^2/month	Emission Sources
Criterion 2 g/m^2/month	



Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

Vista Gold Australia Pty Ltd
Mt Todd Gold Project

Job Number 43-21801
Revision 1
Date 21 Jun 2013

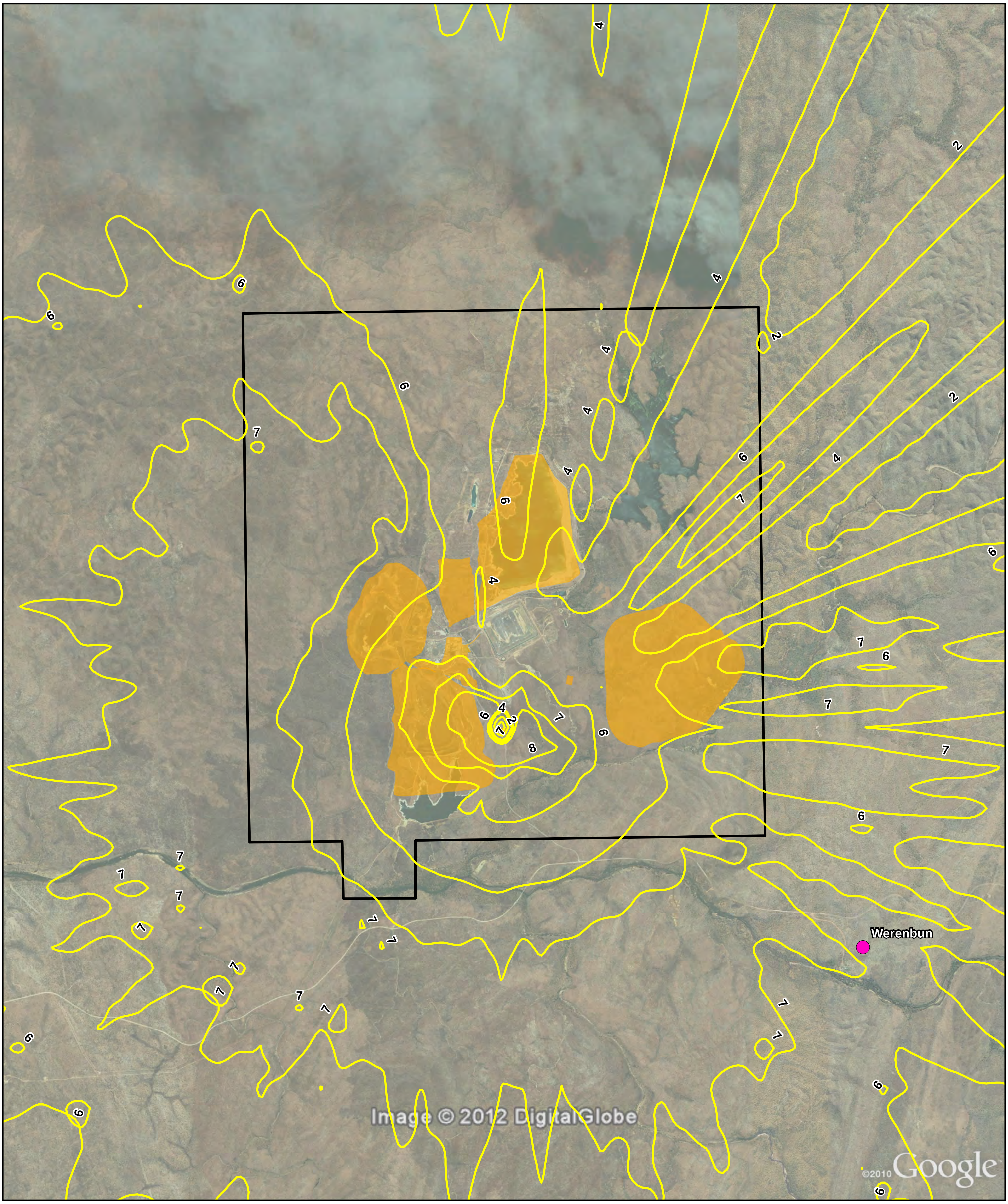
Predicted TSP Concentrations

Figure 16-4

G:\43\21801\GIS\Maps 30000 TPA\EIS\Air\4321801_1102E.mxd

66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com.au

Data source: NRETAS - Mineral Lease (2011). Tetra Tech - Emission Sources (2013). Google Earth Pro - Imagery (Date extracted: 11/05/2012). GHD - Deposition Rate (2012). Created by: CM



LEGEND

Sensitive Receptors

Mineral Lease

Concentration ug/m^3 (Criterion = 226 ug/m^3)

Emission Sources

0 0.5 1 1.5 2
Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

N

Vista Gold Australia Pty Ltd
Mt Todd Gold Project

Predicted Maximum 1-hour Average NO_2 Concentrations

Job Number 43-21801
Revision 1
Date 21 Jun 2013

Figure 16-5

G:\43\21801\GIS\Maps 30000 TPA\EIS\Air\4321801_1103E.mxd

66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com.au

Data source: NRETAS - Mineral Lease (2011). Tetra Tech - Emission Sources (2013). Google Earth Pro - Imagery (Date extracted: 11/05/2012). GHD - NO2 Concentration (2012). Created by: CM

16.5 Dust Emission Management and Mitigation Measures

The following dust mitigation measures are proposed for the Project.

Site Dust Management Plan

The following general site management practices will be implemented:

- development and implementation of a Dust Management Plan;
- prompt mitigation of visible dust emissions from operations, which may involve a combination of:
  - stabilisation of surface silt content through application of localised water sprays, or the use of chemical dust suppressants (suitable for access roads which are traversed less frequently);
  - control of mechanically induced dust emissions (from clearing, scraping, excavation, loading, dumping filling and levelling activities) by application of water sprays;
  - areas of disturbed soil re-vegetated as soon as practical;
  - minimising exposed subsoil through progressive clearing and reinstatement;
- retention of vegetation around the boundary as a buffer, and to limit potential dust sources.
- continuous dust and meteorological monitoring will be undertaken at the site boundary and sensitive areas including Werenbun. Monitors will provide instant alerts to site operators of dust loads that exceed trigger thresholds. Higher levels of mitigation can then be implemented or dust generating activities can be managed in response;
- all monitoring data, analysis and management responses to mitigate dust impacts will be reported on a monthly basis; and
- monthly dust monitoring reports will be summarised in an annual report with monthly and year on year trends analysed and reported.

The following additional dust mitigation measures provide potential mitigation measure which may be used for the mine site:

- operational activities, likely to generate excessive dust impacts on days when meteorological conditions are conducive to dispersing dust in sensitive places, will be modified or ceased during adverse conditions;
- meteorological now-casting (real-time monitoring and reactive decision making) or forecasting (with pro-active decision-making) implemented to inform site operators when conditions likely to cause impacts. This allows for operators to modify activities or implement mitigation measures such as increased watering of haul roads, stockpiles and exposed areas, application of haul road surfactants or stockpile surface veneers; and
- atmospheric and soil moisture conditions will be monitored and / or forecasted to manage conditions conducive to dust generation.

Haul Roads

The following dust mitigation measures are considered to be standard practice for the haul roads:

- defined haul routes will be used wherever it is necessary for vehicles to traverse unsealed surfaces or unformed roads;
- appropriate vehicle speed limits on unsealed roads will be set and observed at all times;

- water spraying onto roads to suppress dust using a water cart. An ultrasonic dry fogging system applied close to the road surface will be used with water droplets in the size range of 0.3-0.5mm;
- chemical stabilisation in the construction of unsealed haul roads to achieve a 90% emissions reduction; and
- regular application of environmentally benign surfactants on road surfaces to reduce the water demand for dust suppression.

The following additional dust mitigation measures are proposed as a contingency for the haul roads:

- all gravel roads to and from the project location could be upgraded from gravel to a spray sealed surface of “all weather” road design.

Stockpiles

The following dust mitigation measures are considered standard practice for the stockpile areas:

- use of water sprays including fine misting over stockpiles to achieve a 50% emissions reduction;
- watering of exposed stockpiles and ROM surfaces as required;
- water spraying / misting applied while loading and unloading of stockpiles and processing equipment, including conveyor transfer points to achieve a 50% emissions reduction; and
- vehicular speeds will be limited to 25km/h on areas of unconsolidated or unsealed soil;

The following additional dust mitigation measures will apply for the stockpile areas:

- covering areas of disturbed soil, stockpiles and temporary spoil containment with mulch or other material as best as practicable;
- application of surface veneers to stockpiles that will be static for an extended period and other exposed areas to binding the fine loose particles on the surface to prevent dust lift off.

Material Handling and Processing

The following dust mitigation measures are proposed for material handling and processing operations:

- application of water to the ore prior to crushing to obtain a minimum moisture content of 4% and a target of 10%;
- hooding of crushers with dust collection system capable of achieving 75% emissions reduction;
- enclosure of the HPGR to achieve a 99% emissions reduction; and
- full enclosure of processing equipment including crushers, screens and transfer points.

Haul Truck and Heavy Earthmoving Equipment

The following dust mitigation measures will apply for the management of emissions associated with haul truck and earthmoving equipment:

- all construction and maintenance equipment / vehicles will be operated and maintained to manufacturers’ specifications to minimise exhaust emission.

16.6 Summary of Impacts and Conclusions

The following conclusions are drawn from the air quality impact assessment:

- compliance with Air NEPM standards was predicted to occur at Katherine and Pine Creek for the worst case scenario;
- an environmental risk assessment evaluated the level of risk associated with predicted ground level concentrations of PM_{10} at the community of Werenbun. This risk was found to be low;
- based on conservative dispersion modelling assumptions and dust emission estimates for the maximum rates of mining activity during the highest production year (year 3) and worst case meteorological conditions, the Project is predicted to exceed the 24-hour average Air NEPM standard of PM_{10} of 50µg/m^3 at the nearest sensitive receptor location of Werenbun for a maximum of two days but comply with the Victorian Government SEPP 2001 PM_{10} intervention level of 60µg/m^3;
- the relevant air quality impact assessment criteria for the annual average of TSP and deposited dust are predicted to be met at Werenbun;
- the incremental increase in concentrations of $PM_{2.5}$ due to emissions from the mine site, are also predicted to meet the Air NEPM advisory standard, however, due to the inclusion of a background concentration monitored at Casuarina near Darwin that exceeds the advisory standard by 40%, the total cumulative annual average ground level concentrations of $PM_{2.5}$ are predicted to exceed the Air NEPM advisory standards. The applicability of the Air NEPM advisory standards of $PM_{2.5}$ should be considered due to the remote rural setting of the Project; and
- dust emissions associated with mining activities can be managed to meet the relevant air quality standards through the implementation of an interactive Dust Management Plan, including:
  - implementation of dust mitigation strategies;
  - real-time monitoring or forecasting of meteorological conditions to inform dust mitigation strategies;
  - continuous real-time monitoring of dust at the boundary and at sensitive places such as Werenbun. Monitoring may be carried out for TSP, PM_{10}, $PM_{2.5}$ and deposited dust;
  - real-time alerting of site operators when dust concentrations at the boundary and sensitive places exceed trigger levels. Additional dust mitigation can then be implemented; and
  - review of mining practices on days when the worst case dust impacts are expected to occur.