Appendix N
Air Quality Report

R E P O R T

Air Quality Assessment
Coburn Mineral Sand Project

Prepared for

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This report is an air quality assessment prepared by URS Australia Pty Ltd (URS) for Gunson Resources Limited (Gunson) for the proposed Coburn Mineral Sand Project near Shark Bay, in Western Australia's Gascoyne region. This report is to form part of a Public Environmental Review (PER) for the proposed development. A full process description is contained within the PER and shall not be reproduced here except where directly relevant to the air quality assessment. This report contains significant technical detail and non-technical readers are advised to refer to the summary chapter contained within the PER.

Air pollution is not a single entity, but comprises a number of pollutants, which may have separate sources and effects. In the case of the Coburn Mineral Sand Project, the main emission with potential for off-site effects is particulates, primarily from large open sources associated with mining activities. Other potential discharges to air include products of combustion of fossil fuels and include:

- On-site power generation for the accommodation camp;
- On-road and off-road vehicles;
- Construction and operation equipment; and
- Modular power generation units for the mining operation.

These emissions and their potential impacts on the surrounding environment are addressed in this report. The structure of the report is as follows;

Section 2 Pollutants Under Review

This section describes each pollutant individually, discusses their chemistry and their potential impact upon human health or amenity.

Section 3 Assessment Criteria

This section details the relevant ambient assessment criteria to be applied to this study.

Section 4 Assessment Methodology

This section outlines the methods used in undertaking the assessment, including atmospheric dispersion modelling techniques and the calculation of pollutant emission data for inventory purposes.

Section 5 Existing Environment

This section considers the local winds and topographical effects that may impact on dispersion of emissions from the development in the vicinity of the proposed site.

Section 6 Impact Assessment

Ground level pollutant concentrations predicted by the modelling study are presented and discussed.

Section 7 Mitigation Measures

This section considers the environmental safeguards currently in place and includes recommendations to eliminate or minimise any adverse impacts.

Section 8 Conclusions

This section sums up the findings of the impact assessment.

Emissions of potential concern from the proposal include the following:

- Particulate: from mining activities and access road construction, concentrators and equipment including vehicles, stockpiles, exposed areas and loading & unloading activities;
- Products of combustion: from on-site power generation, on-road and off-road vehicles and equipment, and the modular power generation units for the concentrators which burn natural gas; and
- Greenhouse gases such as carbon dioxide.

Emissions of particulate matter may give rise to both suspended particulate and deposited particulate depending on their particle size. Products of natural gas combustion include carbon dioxide and carbon monoxide, oxides of nitrogen (of which nitrogen dioxide is of most concern) and small quantities of sulphur dioxide.

Full details of each pollutant and their potential impacts on human health or amenity are given below.

2.1 Particulate

2.1.1 Suspended Particulate

Suspended particulate matter is dust or aerosol that stays suspended in the atmosphere for significant periods. The current nomenclature is to describe fractions of suspended particulate as:

- PM_{10}: all particulate less than 10 microns (µm) in diameter;
- $PM_{2.5}$: all particulate less than 2.5 µm in diameter; and
- TSP: total suspended particulate, generally less than 50 µm in diameter.

Within the range of suspended particulate, the group of particles which are sized 10 µm or less (PM_{10}) have been associated with health effects including increases in mortality, aggravation of existing respiratory and cardiovascular disease, increased hospital admissions and increased asthma incidents. More recent research however, indicates that it may be the $PM_{2.5}$ fraction that has the greatest impact on human health. Particulate that are larger than 10 µm, tend not to be able to penetrate the respiratory tract and do not appear to be significant with respect to potential health effects.

Major natural sources of background particulate levels include bush fires, pollen and wind-blown dust from exposed areas. Anthropogenic sources include stationary and mobile combustion sources, road dust, agriculture, mining, major fires and emissions from industrial processes. Background levels vary widely depending on location, meteorology and proximity of major point or area sources.

2.1.2 Deposited Particulate Matter

Deposited particulate matter is dust that, because of its aerodynamic diameter and density, falls from the air column. In general terms, deposited particulate has a diameter of greater than about 20 µm. However there is no sharp dividing line between these particles and the smaller particles of suspended matter that fall more slowly out of the air. Because of the size of the particulate matter, most of this material will not enter the body. Hence the effects of deposited particulate are primarily nuisance, and may only affect health via annoyance reactions and the like.

The dust deposition rate is measured as the amount of dust deposited on a horizontal surface as a result of gravitational settling over a specified time period. The units for this parameter are grams per square metre per month (g/m^2/month).

Dust rarely presents a serious threat to the wider environment as dust concentrations, and hence deposition rates and potential impacts, tend to decrease rapidly away from the source. In the majority of situations dust produced by mining operations is chemically inert, although exceptions may occur where dust particles contain phytotoxic substances such as cement dusts or fluorides. Damage to vegetation and agriculture is possible through mechanisms such as the blocking of leaf stomata (and the inhibition of gas exchange), or reduced photosynthesis due to smothered surfaces (or in extreme cases lower ambient light levels). However, such effects on vegetation are typically observed to be localised and reversible in nature.

2.2 Products of Combustion

2.2.1 Oxides of Nitrogen

Oxides of nitrogen are formed through a thermal process of combining oxygen and nitrogen. Typically this is from combustion of nitrogen in the presence in oxygen, such as in motor vehicles and thermal power generating plants, but also naturally in the nitrogen cycle. Oxides of nitrogen include nitrogen dioxide (NO_2), nitric oxide (NO) and traces of nitrous oxide (N_2O). The principal species of concern, in terms of human health effects, is NO_2. However, emissions of NO will react with oxygen in the atmosphere to form additional NO_2 as the plume travels downwind, hence stack discharge emission limits are normally specified for NO_x (expressed as NO_2).

Nitrogen dioxide is soluble in water and excessive amounts in the atmosphere can result in “acid rain”. In the stratosphere, oxides of nitrogen play a crucial role in maintaining ozone levels (essential to protect against the greenhouse effect). In the lower atmosphere, oxides of nitrogen play a major role in the formation of photochemical smog in a complex set of reactions that lead to the formation of a variety of nitrated organic compounds (from volatile organic matter) and excessive levels of ozone. It is to protect against potential adverse health impacts from the formation of ozone, as well as the potential for nitrogen dioxide to cause health effects when present in high concentrations, that ambient criteria for nitrogen dioxide are set.

2.2.2 Carbon Monoxide

Carbon monoxide occurs naturally in forest fires, volcanic ash and marsh gases. It is also sourced from incomplete combustion of fuels (particularly in motor vehicles), smoking cigarettes, burning wood and industrial plant exhaust.

2.2.3 Sulphur Dioxide

Sulphur dioxide (SO_2) is a colourless, pungent, irritating and reactive gas, which is soluble in water. SO_2 and its reaction products (sulphurous and sulphuric acids and sulphate particles) are generally removed from the atmosphere by rain, and by direct uptake at plant, soil and water surfaces.

Natural sources of SO_2 are volcanic and geothermal activity. Bacterial and algal processes can produce organic sulphur compounds that are readily converted to SO_2. The main human activities that are sources of SO_2 include power generation from the burning of coal, oil or gas containing significant amounts of sulphur, the roasting or smelting of mineral ores containing sulphur, oil refining, and industrial plants that burn large quantities of fuels with a high sulphur content. In urban areas motor vehicles contribute about 10% to ambient SO_2 levels.

2.3 Greenhouse Gases

The emissions of carbon dioxide (CO_2) from fossil fuel combustion are increasing the concentration of CO_2 in the global atmosphere, which influences the global climate via the enhanced greenhouse effect. Other Greenhouse Gases (GHGs) include methane (CH_4), nitrous oxide (N_2O) and fluorinated gases, which also influence the enhanced greenhouse effect.

The international response to climate change took shape with the development of the United Nations Framework Convention on Climate Change (the "Convention"), UNFCCC (1992). [1] Adopted in 1992 after more than a decade of research and negotiation, the Convention sets a framework for action aimed at stabilising atmospheric concentrations of greenhouse gases at a level that will prevent human-induced actions from leading to 'dangerous interference' with the earth's climatic system. The Convention became effective on 21 March 1994.

The Kyoto Protocol was adopted in December 1997 in Kyoto as an outcome of the Third Conference of Parties (COP-3). The Kyoto Protocol is essentially the set of operational rules by which the Convention can be implemented, and contains legally binding emissions targets for Annex I countries (but not non-Annex 1 countries). For the Protocol to come into force it must be ratified by at least 55% of Parties to the Convention and sufficient Annex I Parties such that it covers at least 55% of Annex I countries CO_2 emissions as at 1990. The Kyoto Protocol officially became effective on 16 February 2005 after Russia signalled its intent to participate in late 2004.

Australia is a signatory to the Kyoto Protocol, but has not yet ratified it. Despite this the Government is committed to participating effectively in international action to address the threat of climate change and has been active in developing greenhouse related initiatives and policies. The National Greenhouse Strategy is the primary mechanism through which the Commonwealth Government will ensure Australia's international commitments will be met. The Strategy extends the program of action implemented under the 1992 National Greenhouse Response Strategy. In part the Strategy addresses limitations to the emission of greenhouse gases and enhancing greenhouse sink capacity. The limitation of Australia's greenhouse gas emissions, in line with the Kyoto Protocol, has been recognised as the most important area for action.

In the absence of any measures to reduce emissions of GHGs, Australia's "Business as usual" emissions growth would reach 125% of the 1990 level by 2010. Australia as a whole is challenged to reduce GHG emissions by 24.5% from the predicted "Business as usual" level in 2010 by implementing a combination of "no regrets" and "beyond no regrets" measures. This is equivalent to limiting greenhouse gas emissions in 2010 to 108% of Australia's 1990 levels.

Despite not being a signatory to the Kyoto Protocol, Australia is on track to meet its internationally agreed commitment by 2008-2012. [2] Specifically on greenhouse emission limits, the Commonwealth Government directs support to 'no regrets' measures at reducing greenhouse gas emissions, and supplementing these with additional measures such as those detailed in the Strategy. These measures include support for renewable energies, reform in the automotive industry, and tree planting and revegetation programmes.

The Western Australian Government has recently (September 2004) released the State Greenhouse Strategy. [3] The Strategy defines a comprehensive response to the greenhouse issue to ensure the State's industry and community contribute to reducing global greenhouse gas emissions in line with Government policy.

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[1] United Nations Framework Convention on Climate Change (UNFCCC) (2004), http://unfccc.int, Accessed 15 December 2004.

[2] Australian Greenhouse Office (2004). Tracking to the Kyoto Target. Australia's Greenhouse Emissions Trends - 1990 to 2008-2012 and 2020. December 2004.

[3] Western Australian Greenhouse Task Force (2004). Western Australian Greenhouse Strategy. September 2004.

Air quality impacts can be assessed by comparing model predictions with appropriate ambient air criteria. A range of assessment criteria are available, and are considered in this study:

- **National Environment Protection Measure (NEPM) for Ambient Air Quality.** The standards defined in this Measure are concentrations set to ensure that public health, amenity and the environment are protected.
- **National Health and Medical Research Council (NHMRC) Air Quality Guidelines.**
- **NSW Impact Assessment Criteria** – These are ground level concentration limits designed to be used in conjunction with dispersion modelling. If maximum predicted downwind concentrations are less than the impact assessment criteria, then there should be no adverse impacts on the environment.

The WA DoE and EPA routinely adopt (where necessary) ambient air quality guideline values in the assessment of new proposals, and in the management of both local and regional ambient air quality. As a matter of policy, the EPA and DoE have now adopted the NEPM standards for ambient air quality.

3.1 NEPM Air Quality Criteria

In June 1998, the National Environment Protection Council (NEPC) released a National Environment Protection Measure (NEPM) for Ambient Air Quality, [4] setting out national standards and goals for criteria pollutants. It should be noted however, that these goals are designed for use as regional goals and are not intended to be used as near-source or site boundary criteria.

In 2003, the Ambient Air Quality NEPM was amended to include an Advisory Reporting Standard for $PM_{2.5}$. Ambient air quality criteria applicable to this proposal are given in Table 3-1.

Table 3-1 NEPC Ambient Air Quality Criteria

Pollutant	Maximum Concentration	Time Average
Carbon Monoxide	9.0 ppm	8-hours
Nitrogen Oxides (as NO_2)	0.12 ppm 0.03 ppm	1-hour annual
Sulphur Dioxide	0.20 ppm 0.08 ppm 0.02 ppm	1-hour 24-hours annual
PM_{10}	50 ug/m^3	24-hours
$PM_{2.5}$ (advisory reporting standard)	25 ug/m^3 8 ug/m^3	24-hours annual

[4] National Environment Protection Measure for Ambient Air Quality – As Amended, EPHC, 2003. Available at www.ephc.gov.au.

3.2 NHMRC Goals

The National Health and Medical Research Council (NHMRC) has published ambient air quality and interim national indoor air quality goals [5]. These are presented in Table 3-2.

Table 3-2 Recommended Ambient Air Quality Goals (NHMRC)

Parameter	Ambient Limit		Measurement Criteria
	(ug/m^3)	(ppm)	
Carbon Monoxide	10,000	9.0	Eight hour average not to be exceeded more than once a year
Sulphur Dioxide	700 570 60	0.25 0.20 0.02	Ten minute average One hour average Annual average
Nitrogen Oxides (as NO_2)	320	0.16	One hour level not to be exceeded more than once a month
Total Suspended Particulate	90	-	Annual average

3.3 NSW Impact Assessment Criteria

Impact assessment criteria apply downwind of a proposed facility. They are set to protect against adverse effects on human health and are therefore, much lower than emission limits set for concentrations in the stack. There are currently no nationally recognised impact assessment criteria nor are there any impact assessment criteria set by the WA Environmental Protection Authority (EPA), but rather refer to the ambient standards of the Air Quality NEPM (see Section 3.1 above).

A comprehensive approach to date has been taken by the New South Wales Environment Protection Agency (NSW EPA) with the publication of impact assessment criteria to be applied in the design stages of an activity to ensure that there will be no impact on people's health or amenity. These criteria are set on the basis of the toxicity of a chemical or, if more stringent, the odour threshold of a pollutant. These criteria cover the full range of pollutants associated with the proposed development and are considered appropriate to this proposal.

NSW EPA impact assessment criteria are given in Table 3-3.

In addition to these, the NSW EPA have set a criterion of 4 g/m^2/month for deposited dust to protect amenity.

[5] NHMRC Ambient Air Quality Goals. Available at http://www.nhmrc.gov.au/publications

Table 3-3 NSW EPA Impact Assessment Criteria

Pollutant	Assessment Criteria ($\mu g/m^3$)	Time Average
Carbon Monoxide	100,000 30,000 10,000	15-minutes 1-hour 8-hours
Nitrogen Oxides (as NO_2)	246 62	1-hour annual
Sulphur Dioxide	712 570 228 60	10-minutes 1-hour 24-hours annual
PM_{10}	50 30	1-hour annual
TSP	90	annual
Deposited Dust	4 g/m^2/month	annual

For the purpose of this assessment, the NSW EPA criterion for deposited dust was compared against other comparable criteria in other jurisdictions. Nuisance criteria vary from country to country. In the UK it is currently 200 mg/m^2/day (i.e. 6 g/m^2/month). In Germany the relevant criterion is 350 mg/m^2/day (equivalent to g/m^2/month). The NSW EPA criterion of 4 g/m^2/month, as the most stringent amenity-based guideline available, was therefore considered appropriate for adoption in this study. No standards are known to exist in relation to dust deposition impacts on non-human (biophysical) receptors.

4.1 Emissions Inventory

An emissions inventory for the project was prepared in accordance with the National Pollutant Inventory (NPI) Emission Estimation Technique (EET) Manual for Mineral Sands Mining and Processing [6] and process data for point source emissions (natural gas powered electricity generation) supplied by Energy Developments Limited (EDL).

Vehicle emissions were calculated by utilising published emission factors from the NPI EET Manual for Combustion Engines [7] and EET Manual for Mining [8] on the basis of fuel consumption and vehicle/equipment data provided by Gunson. Emissions were estimated for the parameters of CO, NO_X, PM_{10}, SO_2 and Volatile Organic Compounds (VOCs) for the following vehicle categories:

- Mobile mining equipment (bulldozer, front end loader, scrapers);
- Site services (cranes, forklift, off-highway 4WD site vehicles);
- Road trains for haulage of HMC product from the project site to Geraldton; and
- On-road light 4WD vehicles to support the project and travel to/from the minesite.

Full calculations are given in Appendix A. Annual emissions for the period of initial mining operations (Years 1 and 2) and subsequent operations (Year 3 onwards) are summarised and discussed in Section 6.

The inventory comprises a large number of fugitive sources such as removal of overburden by bucket wheel excavator, wind erosion of exposed areas, etc. Emission estimates from these types of sources relies heavily upon calculations using emission factors. A full discussion of the limitations and appropriateness of the emissions factors promulgated by DEH (formerly Environment Australia) is given in the NPI EET Manual. Emissions of dust (particulate) were determined for two mining periods for the proposed operations that represent ‘worst case’ scenarios for off-site impacts to surrounding receptors:

1. *Scenario 1* - During the first period of operation during which it is anticipated to have greatest exposed areas of disturbance as the initial pit, infrastructure and haul roads are constructed; and
2. *Scenario 2* - Towards the end of the mining operations, during which the pits will be at their northernmost extent and closest to Hamelin Pool.

Process data was supplied by EDL to characterise emissions of CO, NO_X, PM_{10} and SO_2 arising from operation of the high efficiency modular gas-powered generator units totalling 8 MegaWatt (MW)

[6] Environment Australia (2001). NPI Emission Estimation Technique Manual for Mineral Sands Mining and Processing. Version 1.0, April 2001.

[7] Department of Environment and Heritage (2003). NPI Emission Estimation Technique Manual for Combustion Engines. Version 2.3, October 2003.

[8] Environment Australia (2001). NPI Emission Estimation Technique Manual for Mining. Version 2.3, Dec 2001.

capacity, to provide electricity to the concentrators and bucket wheel excavators. Emissions from the gas-powered generator (800 kW capacity), proposed to provide the accommodation camp's power requirements, were also quantified by EDL. Full details are given in the spreadsheet calculations supplied in Appendix A.

Assumptions used for the preparation of process data and emissions estimation are given below:

- Up to 20 million tonnes of overburden and ore removed from the pits (Yrs 1 and 2), and 40 million tonnes (Years 3 to 10) and 50 million tonnes (Years 11 to 20).
- Mining and HM concentrating carried out 24 hours per day, 365 days per year.
- Concentrators producing 140,000 tonnes HMC per year (Years 1 and 2), operating 24 hours per day, 365 days per year (conservative or 'worst case' scenario), increasing to 280,000 tonnes HMC per year (Years 3 to 20). The modelling of point source (power generation) emissions was based on up to five modular power generators operating simultaneously. (It is noted that recent project revisions have identified up to four units operational in Years 1 to 2, potentially doubling to eight units in subsequent years. Considering the low modelled concentrations for point source emissions (NOx, CO, SO_2) in comparison to assessment criteria (see Section 6), modelling the emissions of five modular gas-powered units in this assessment is considered suitable to provide a representative assessment of potential off-site impacts at nearest receptors.
- During the first two years of production it is anticipated that five haulage road trains per day will be required for transport (i.e. 600 km trip distance x 5 road trains = 3,000 Vehicle Kilometres Travelled (VKT) per day, taking into account the return trip from Geraldton to the Coburn project area). This will increase to around ten trucks per day (i.e. 600 km x 10 road trains = 6,000 VKT per day) once full production is reached (Year 3 onwards).
- The emissions inventory assumes light vehicles operate on average 8 hrs per day during normal mining operation, with an average Vehicle Kilometres Travelled (VKT) of 20,000 km/yr per vehicle.
- Areas subject to wind blown erosion were generally set at 50% of the full area specified for full production. The exceptions to this are:
  - Exposed plant (concentrator) area for which a factor of 0.3 is specified in the NPI EET Manual for Mining to allow for area covered by plant and equipment.
  - Wind erosion from initial pit development was conservatively assumed to exhibit a factor of 70% (0.7), based on the likelihood of greater initial exposed areas from the pit during preliminary works compared to other sources.
  - The area for the accommodation camp was applied a factor of 0.5 during initial project development, decreasing to 0.3 in later years to allow for stabilisation and establishment of vegetation around the camp in subsequent years.

- The dust inventory utilised particle size distribution data acquired as part of baseline soil and landform studies (Appendix C), shows that the typical particle size distribution consists of:
  - Clay (<0.002mm) = 5.1%
  - Silt (0.002-0.06 mm) = 3.8%
  - Sand (0.06-2mm) = 91.0%

4.2 Greenhouse Emissions

An inventory of Greenhouse Gas (GHG) emissions anticipated to arise as a result of the proposal was determined in accordance with the EPA Guidance Statement No. 12 - Guidance Statement for Minimising Greenhouse Gas Emissions. [9]

The inventory utilised current emission factors defined by the Australian Greenhouse Office (AGO) Greenhouse Factors and Methods Workbook[10], and projected fuel consumption and vehicle/equipment data provided by Gunson, to characterise CO_2 equivalent ($CO_{2\text{-eq}}$) emissions from the following sources:

- Mobile mining equipment;
- Concentrate haulage;
- Power generation (assuming the use of LNG);
- Site services (crane, forklift etc);
- Light vehicles; and,
- Emissions from vegetation clearing (removal of above-ground biomass), calculated using factors from the AGO Greenhouse Challenge Vegetation Sinks Workbook and representative values for native vegetation characteristic of the area.

It is noted that progressive rehabilitation of the cleared areas as the Coburn mining operations commence will partially offset the clearing emissions calculated. Over a sufficiently long period of time, these land clearing emissions have the potential to be wholly offset by rehabilitation and reservation of other areas of native vegetation.

For the purpose of the current GHG assessment, the following points are noted:

- Natural gas is anticipated to be trucked to site as LNG. For the purpose of this assessment, it has been conservatively assumed that LNG will be used for power generation, using AGO full fuel cycle emission factors for Western Australian natural gas (AGO 2004, Table 2);

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[9] EPA (2002). Guidance for the Assessment of Environmental Factors. Minimising Greenhouse Gas Emissions. Interim Guidance No.12, October 2002.

[10] AGO (2004). Greenhouse Factors and Methods Workbook. Australian Greenhouse Office, August 2004.

- The unconsolidated nature of the dunal sand does not require any blasting, therefore the inventory does not take into account GHG emissions from explosive use; and
- Emissions from power generation take into account emissions required to fuel the on-site desalination system to provide potable water.

The GHG inventory for the Coburn mineral sand mining project is presented in Section 6.

4.3 Dispersion Modelling

The atmospheric dispersion models The Air Pollution Model (TAPM, Version 2.0) and AUSPLUME (Version 6) were used to undertake dispersion modelling to assess potential air quality impacts arising from the proposal.

TAPM is an advanced model originally developed by the CSIRO and verified for a range of regions throughout Australia. [11] The model essentially comprises:

- a prognostic (predictive) meso-scale meteorological model, which is linked to geophysical and meteorological databases. It can predict 3-D regional meteorological parameters for any location;
- an advanced dispersion model, based on a Lagrangian particle method; and
- a photochemical pollution prediction model.

AUSPLUME is a Gaussian plume dispersion model, developed by the EPA Victoria (EPAV), that is designed to predict ground-level concentrations or deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, or any combination of these. The latest version of AUSPLUME (Version 6) was used in this study.

Meteorological data was generated using the TAPM dispersion model. This data was then verified against a complete year of monitored data (2002) obtained from the Bureau of Meteorology for the Denham Meteorological Station.

Modelling was then carried out using AUSPLUME for the following time averages to enable direct comparison with the relevant guidelines for different pollutants:

- 10-minute maximum (SO_2);
- 1-hour maximum (NO_2);
- 8-hour average (CO);
- 24-hour average (PM_{10}, SO_2);

[11] http://www.dar.csiro.au/tapm/

- Annual averages (PM_{10}, TSP and SO_2); and
- Dust deposition – assessment of deposited dust levels at nearest sensitive receptors, including the Hamelin Pool stromatolites.

Peak 100 %ile modelled concentrations were chosen for comparison with the relevant assessment criteria. Should these conservative peak concentrations satisfy the criteria, compliance at the 99.9%ile level is also attained. While these peaks may only occur in rare meteorological circumstances, this method of comparison goes further to ensure that the potential for adverse air quality effects are investigated.

As a conservative assessment, oxides of nitrogen (NO_X) from power generation were assumed to be 100% nitrogen dioxide (NO_2). Emissions resulting from power generation were modelled. The scenario of emissions from five generators supporting the concentrators were modelled (as noted previously in Section 4.1), in addition to operation of the generator at the accommodation camp.

A receptor grid using Australian map grid coordinates was created to extend 5,000 m east and west, and 5,000 m north and south of the site. When identifying maximum predicted ground level concentrations, values predicted for receptors within the site boundary were removed from the assessment. Gridded files used for preparation of contour plots however, included all concentrations predicted at all receptors.

In addition to these gridded receptors, discrete receptors were located to calculate concentrations at the nearest sensitive receptors to the site. Initial modelling showed that the receptor located approximately 20km east of the Project Area (Coburn Homestead) was the most affected receptor under Scenario 1.

For modelling purposes the terrain was assumed to remain at sea level (flat) for the entire area of the site. Building dimensions were not considered as part of the current modelling exercise. Taking into account the observation that the sensitive receptors subject to this assessment are in the far field, the small number of proximal point sources associated with the proposal, and the final site building details have yet to be finalised by Gunson, it is considered appropriate that potential building downwash effects are limited and were not put into the model for this assessment.

The average canopy height of the terrain surrounding the site is approximately 2 m due to the presence of woodlands. A roughness factor of 0.4 m was therefore designated for land use. This roughness height is categorised as ‘rolling rural’ in AUSPLUME.

All particulate emissions were assigned to either ‘area’ or ‘volume’ sources and included in the dispersion modelling as follows:

- Volume sources (such as truck un/loading and stockpiles experiencing wind erosion) were located on the perimeter of the mine pit and assumed to be 3 m high; and
- The area sources were all approximated to rectangular shapes and were set at ground level (including access roads). They were located based upon the south western corner of the area and aligned upon north within the grid coordinates and terrain already specified in AUSPLUME.

Deposited dust was based on the TSP emissions of Scenario 2 to capture the worst case of deposition into Hamelin Pool. Deposition was modelled as an annual average. This annual average was divided by 12 to convert it to a monthly average for comparison with the guideline value.

5.1 Climate and Meteorology

The Shark Bay district sits within a transitional climatic region that experiences an overlap of tropical and temperate zones, resulting in hot dry summers and mild winters. The area is classified as a Hot Grassland (summer drought) by Bureau of Meteorology.[12] The area is affected by the winter circulation of the south, and the monsoonal summers of the north.

The maximum temperature is high most of year, and extreme in summer. Summer can bring thunderstorm activity, significant rainfall, tropical cyclones, extreme wind, low levels of cloud cover, extended sunshine duration and high levels of incident solar radiation.

Rainfall is sporadic, with annual precipitation ranging 200-400 mm, and the timing and magnitude of rain is highly influenced by cyclonic and thunderstorm activity. Average annual rainfall is about 212 mm at Hamelin Pool. The majority of rain falls between May and August. Evaporation is high ranging from 3,000 mm in the east to 2,000 mm in the west. This is largely attributed to the lack of cloud cover, low humidity and medium to strong winds.

The area is influenced by southeast trade winds, which generate southerly winds for the majority of the year. During summer, southerlies consistently blow over 25 km/hr for several days. Cyclones generating wind gusts up to 180 km/hr occur periodically over summer and autumn.

Table 5-1 provides climate data for the Hamelin Pool weather station, which is located to the north of the Project Area.

[12] Bureau of Meteorology (2003). Climate Classifications – Koeppen System. http://www/bom.gov.au. Bureau of Meteorology, Canberra.

Table 5-1 Climatic Averages for Hamelin Station

Month	Mean Monthly Rainfall (mm)	Mean Daily Maximum Temperature (deg C)	Mean Daily Minimum Temperature (deg C)	Mean Daily Evaporation (mm)	Mean Monthly Evaporation (mm)	Mean Wind Speed (km/h)	Mean Relative Humidity (%)
Jan	7.6	36.9	20.5	13.4	415.4	18.1	39.5
Feb	13.1	36.7	21.2	13.9	392.7	17.8	42.5
Mar	15.7	34.9	20.1	11.6	359.6	16.5	43.0
Apr	13.7	30.3	17.0	7.1	213.0	14.7	48.0
May	33.1	25.2	13.2	5.2	161.2	13.4	54.0
Jun	47.7	21.5	10.6	3.4	102.0	12.2	63.5
Jul	40.2	20.7	9.2	3.4	105.4	13.3	62.5
Aug	21.5	22.2	9.4	4.7	145.7	14.4	55.0
Sep	8.1	25.4	11.1	6.5	195.0	17.5	46.5
Oct	5.2	28.2	13.0	10.0	310.0	19.2	42.0
Nov	3.7	31.8	15.8	11.0	330.0	19.6	39.0
Dec	2.4	34.8	18.3	12.5	387.5	18.5	39.0
Annual	211.9	-	-	-	3,117.5	-	-
Daily	-	29.1	15.0	8.7	-	16.3	47.5

Source: BOM (2004)[13]; BOM station 006025 Hamelin Pool; 20 to 105 years of record.

The following windroses were generated to characterise the existing meteorological conditions and validate the meteorological data files for modelling purposes:

- Figure 5-1 presents an annual windrose of data collected at the Bureau of Meteorology's Denham meteorological station (06044) for the year 2002.
- Figure 5-2 presents an annual windrose of Denham data for 2002, generated using the prognostic features of the TAPM model.
- Figure 5-3 presents an annual windrose of Coburn (the Gunson Project Area) meteorological data for 2002, using TAPM.
- Figure 5-4 shows the Coburn TAPM data split into seasonal windroses.

The Denham windroses can be used to assess the reliability of TAPM for producing meteorological data for locations in the region. That is, if TAPM can reproduce Denham's meteorology well, it can be demonstrated that the meteorology of Coburn can also be reproduced well, based on this confidence.

[13] Bureau of Meteorology (2004) Climate Averages. www.bom.gov.au. Bureau of Meteorology.

When compared against the BOM windrose (Figure 5-1), the TAPM windrose (Figure 5-2) has good similarity in wind directions and frequencies. Low wind speeds may be a little over-estimated, however the anemometer stall speeds can sometimes result in light winds being recorded as having slower speeds.

5.2 Existing Air Quality

There is no ambient air quality data available for the region. Given the rural nature of the area and the lack of either urban population or industry, existing air quality is expected to be good. On occasion suspended and deposited particulate levels may be elevated due to windblown dust, erosion and/or bush fires. Indeed, soil and landform studies commissioned by Gunson have confirmed that the surface sands of the Amy Zone have a minor proportion of fine sand/silt, being 3.8% silt of a 0.002 - 0.06 mm size range, with majority (91%) typically sand between 0.06 - 2.0mm in diameter, and currently demonstrate a high degree of instability due to wind erosion effects. [14]

Despite the likelihood of existing background levels of particulates being elevated on a seasonal basis, the modelling undertaken for this air quality assessment assumed zero background concentrations to represent an estimate of the atmospheric impacts associated with the proposal only.

[14] D.C. Blandford and Associates Pty Ltd (2004). Coburn Mineral Sands Project. Soils and Landforms of the Amy Zone Ore Body. Report prepared for URS Australia Pty Ltd, May 2004.

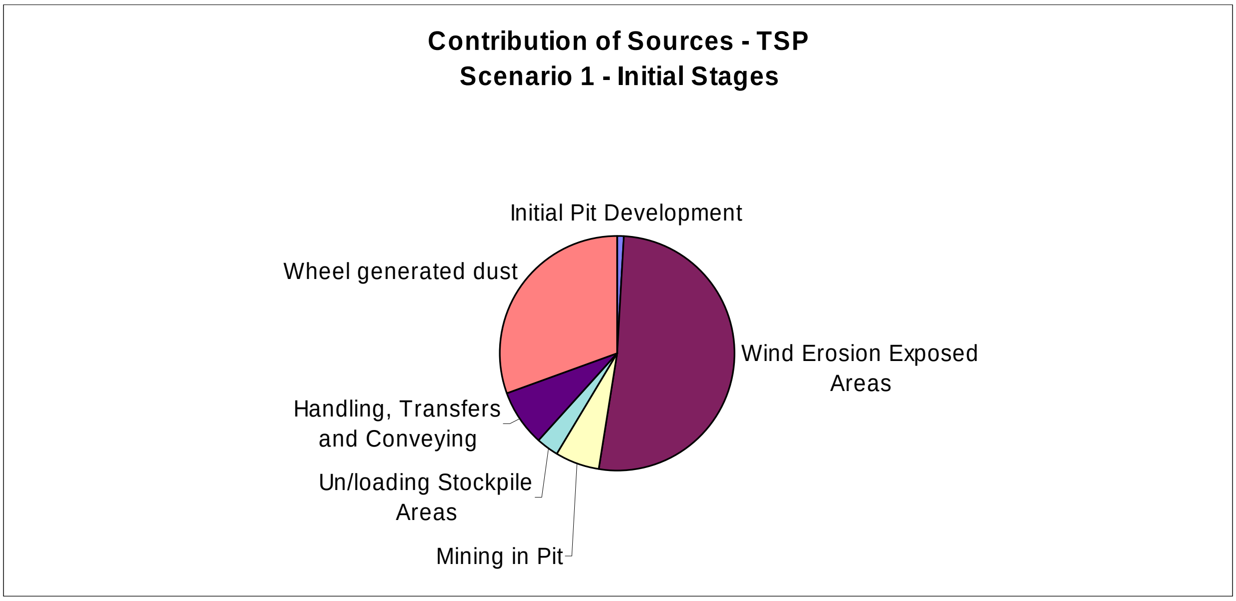
6.1 Emissions Inventory

Gunson estimates approximately 20 million tonnes per annum of overburden and ore will be moved in the first two years, increasing to up to 50 million tones tonnes per annum in subsequent years. Mining activities that have the potential to result in dust emissions include the following:

- topsoil removal and replacement associated the development of discrete mining pits;
- subsoil removal and stockpiling;
- excavation of overburden and ore;
- wheel generated dust from machinery and vehicle movements on site; and
- dust pick-up (wind erosion) from exposed areas, including the operational pit, areas cleared for the concentrators and offices, access roads, stockpiles and the accommodation camp.

These emissions are typically referred to as ‘fugitive’ emissions. That is, they arise from open ‘area’ or ‘volume’ sources (e.g operation of bucket wheel excavators, or wind erosion from exposed areas) and are often intermittent.

Emission sources have been grouped according to exhaust configuration as either point sources (i.e. stacks) or fugitive sources (such as exposed wind blown areas). The emission estimates for each source are shown in Table 6-1 (stack sources), Table 6-2 (vehicles) and Table 6-3 (fugitive sources). Annual emissions (in terms of mass per year) of TSP and PM_{10} predicted for the initial phase of Project development (Scenario 1) are further presented graphically, by source type, in Figure 6-1.



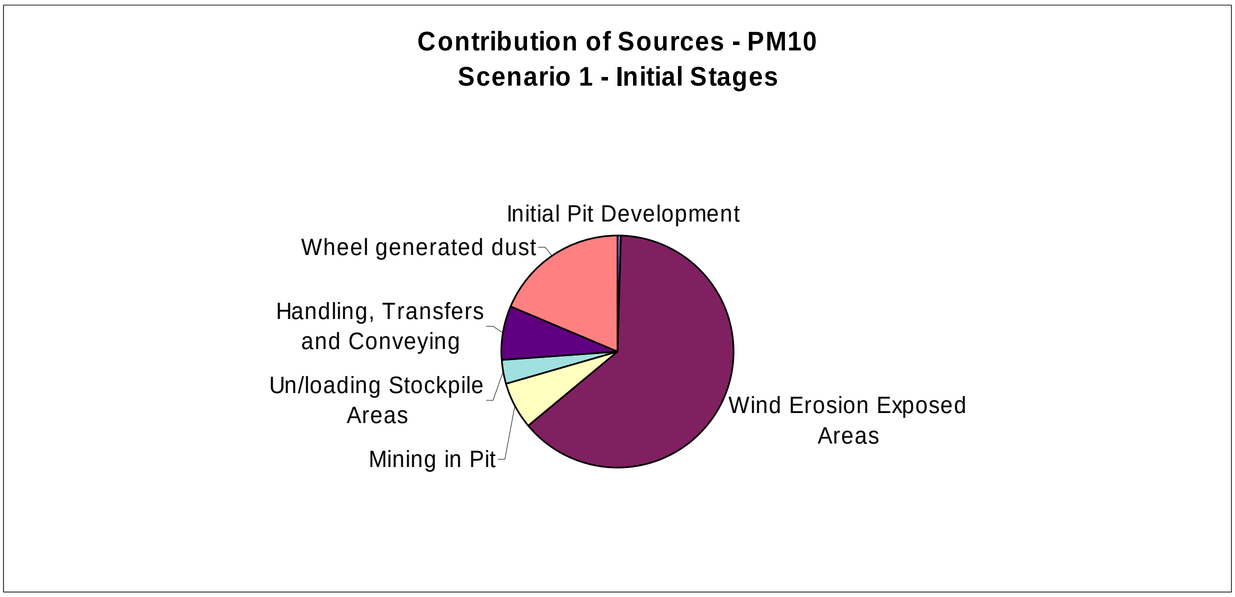


Figure 6-1 Annual PM_{10} and TSP Emissions by Source (Scenario 1 – Initial Development)

Figure 6-1 shows that, on an annual basis, the greatest contributor to PM_{10} emissions is wind erosion of exposed areas. This is also true of TSP emissions. The second greatest contributor to dust emissions is wheel generated dust. As this method of emission is assumed to occur over all the access roads, its effect on ground level dust concentrations at any one point is expected to be less substantial. This is due to the total area of the roads and their proximity to the rest of the access road network.

Table 6-1 Emissions Inventory: Stack Sources

Stack Sources	Pollutant	Height (m)	Diameter (m)	Velocity (m/s)	Flow (Nm^3/min)	Temp (°C)	Emission Rate (per engine) (g/s)	Annual Rate (per engine) (T/yr)	Annual Emissions (Yrs 1 and 2) (T/yr) [1]	Annual Emissions (Yrs 3 to 20) (T/yr) [2]
Caterpillar G3520C Gas Engines (x 5)	CO	8	0.5	35	412	455	2.33	74	147.0	293.9
	NO_X						1.14	36	71.9	143.8
	PM10						0.008	0.25	0.5	1.0
	SO_2						0.002	0.06	0.1	0.3
Gas powered generator (accom. camp)	CO	8	0.35	35	206	412	1.165	36.7	36.7	36.7
	NO_X						0.57	18.0	18.0	18.0
	PM10						0.004	0.1	0.1	0.1
	SO_2						0.001	0.03	0.03	0.03

Notes:

Emissions data provided by Energy Developments Limited (EDL) - December 2004

[1] Based on the assumption of up to two modular power units operating during Years 1 and 2

[2] Based on the assumption of up to four modular power units operating during Years 3 onwards

Table 6-2 Emissions Inventory: All Site Vehicles

		Annual Emissions Years 1 and 2 (kg/yr)					Annual Emissions Years 3 to 20 (kg/yr)				
Vehicle Category [1]	**Vehicle Description**	**PM10**	**CO**	**NOx**	**SO_2**	**VOC**	**PM10**	**CO**	**NOx**	**SO_2**	**VOC**
***Mobile Equipment* [2]**											
Track Type Tractor	D10 Dozer	833	2,585	9,394	468	910	1,667	5,170	18,788	935	1,821
Wheeled loader	992C FEL	965	3,242	10,588	468	1,422	1931	6485	21175	935	2844
Scraper	Scrapers	491	1,524	4,649	255	342	654	2032	6198	340	456
***Site Services* [3]**											
Industrial Vehicle	Crane - 2 x Yr 3 on	0	0	0	0	0	289	1472	3528	298	323
Industrial Vehicle	Forklift	361	1,840	4,410	373	404	361	1840	4410	373	404
Off-highway truck	Cat ITC - 2 x Yr 3 on	0	0	0	0	0	2708	2254	5246	260	242
Off-highway truck	2 x 4WD trucks	2,496	2,077	4,835	240	223	2496	2077	4835	240	223
Concentrate Haulage											
Road transport - Diesel Heavy Goods Vehicles (HGV) [4]	Triple Road Trains [5]	554.1	2,540	13,031	7818.3	389.8	1,108	5,081	26,061	779.6	3219
Light Vehicles											
Road transport - Light Goods Vehicles (LGV) [6]	Light Vehicles - 4WD Patrol or Dual Cab [7]	46.3	186.7	152.6	16.1	49.9	61.8	249.0	203.5	21.4	66.6
TOTAL (kg/annum)		**5,746**	**13,995**	**47,058**	**2,209**	**4,960**	**11,275**	**26,659**	**90,445**	**4,182**	**9,598**

Notes:

1 Fuel consumption for each vehicle category estimated on the basis of fuel data provided by Gunson Resources 23 Dec 04

2 Emission Factors for mining equipment derived from NPI EET Manual for Mining v 2.3 (Table 4)

3 Emission Factors for site equipment derived from NPI EET Manual for Combustion Engines v 2.3 (Table 7), based on estimated fuel use data provided by Gunson.

4 Emission Factors from NPI EET Manual for Combustion Engines v 2.3 - Table 5 (Articulated HGV)

5 Calculated on basis of 300km distance from minesite to Geraldton (i.e. 600km return trip). 5 trips per day for Years 1 and 2, increasing to 10 trips per day from Year 3 onwards

6 Emission Factors from NPI EET Manual for Combustion Engines v 2.3 - Table 4

7 Assumes light vehicles operate 8 hrs per day. Average VKT of 20,000 km/yr per vehicle. 12 light vehicles for Years 1 and 2, and 16 from Year 3 onwards.

Table 6-3 Emissions Inventory: Fugitive Sources

Fugitive Sources	Scenario 1		Scenario 2	
	Annual Emission TSP (kg/yr)	Annual Emission PM_{10} (kg/yr)	Annual Emission TSP (kg/yr)	Annual Emission PM_{10} (kg/yr)
Initial Pit Development	3,100	1,002	3,100	1,002
Wind Erosion Exposed Areas	215,360	107,680	221,235	110,617
Mining in Pit	25,521	11,417	51,042	22,834
Un/loading Stockpile Areas	13,148	5,882	23,172	10,367
Handling, Transfers and Conveying	31,536	12,614	63,072	25,229
Wheel generated dust	127,385	31,591	254,770	63,182
TOTAL (kg/yr)	**416,049**	**170,186**	**616,390**	**233,231**
TOTAL (T/yr)	**416**	**170**	**616**	**233**

These emissions have been included in the atmospheric dispersion study which is discussed further in Section 6.3.

6.2 Greenhouse Emissions

A profile of greenhouse gas emissions predicted to arise from the Coburn Mineral Sand Project was calculated using published emission factors of the Australian Greenhouse Office (AGO). The results are presented in Table 6-4.

It is predicted that approximately 140,000 tonnes of HMC per annum (or approximately 400 tonnes per day) will be trucked to Geraldton during the first two years of mining operations, increasing to 280,000 tonnes per annum (or approximately 800 tonnes per day) from Year 3 of the mine life.

This equates to a measure of greenhouse intensity (ie. amount of GHG emissions, on a CO_2-equivalent basis, per unit production) of 0.26 tpa CO_{2-e}/t HMC exported (Years 1 and 2), decreasing to 0.25 tpa $CO_{2\ e}$/t HMC exported for subsequent years of operation.

Table 6-4 Greenhouse Gas Emissions Inventory

Source Category	Yr 1& 2 - Estimated GHG emissions (t CO_{2-e} per annum)	Yr 3 onwards - Estimated GHG emissions (t CO_{2-e} per annum)
Emissions from Mobile Equipment	1,890	3,510
Emissions from Concentrate Haulage	2,471	2,241
Emissions from Power Generation	30,686	61,371
Emissions from Site Services	651	1,280
Emissions from Light Vehicles	146	194
Emissions from Vegetation Clearing	1,089	1,333
TOTAL	**36,932**	**69,929**

Notes:

1. Calculations of estimated greenhouse gas emissions have been based on published emission factors of the Australian Greenhouse Office (AGO 2004 - Factors and Methods Workbook, August 2004).
2. The source of natural gas is anticipated to be Compressed Natural Gas (CNG) from the DBNGP, trucked to site and liquefied for on-site use as LNG. For the purpose of this assessment, it has been conservatively assumed that LNG will be used for power generation, using AGO full fuel cycle emission factors for Western Australian natural gas (AGO 2004, Table 2).
   If LPG is alternatively selected as the fuel source, estimated annual CO2-e emissions from power generation are predicted to be 30,442 tpa CO_{2-e} (Yr 1 and 2) and 60,885 CO_{2-e} (Yr 3 onwards).
3. Gunson does not intend to undertake any blasting operations at the Amy Zone operations, therefore the inventory does not take into account GHG emissions from explosive use.
4. Emissions from power generation take into account emissions required to fuel the on-site desalination system to provide potable water.

It can be seen from Table 6-4 that the largest contributor to the net GHG emissions profile for the proposal is for power generation (83-88% of total emissions). Gunson intends to utilise high efficiency (38-40%) variable load generator units using natural gas as the energy source for the Project. It is predicted that this will deliver significant greenhouse benefits in comparison to alternative fossil fuel sources. If power generation was to be diesel-fuelled, for instance, the use of this fuel would result in an average of 29 % higher GHG emissions (CO_{2-e}) per GJ of energy required for power generation utilities (on a full fuel cycle basis), than the current design case of using natural gas.

6.3 Dispersion Modelling

All major pollutants were modelled to predict maximum downwind concentrations as outlined in Section 4. Table 6-5 presents a summary of the maximum predicted concentrations at all off-site receptor locations and at the discrete receptors (nearest sensitive receptors) for comparison with the respective guidelines.

Table 6-5 Dispersion Modelling Results

Pollutant	Maximum Predicted Concentration	Guideline	Units, Time Average
SO_2			
Off-site	0.2	712	µg/m^3, 10-minute
Coburn Homestead	0.016		
NO_x (as NO_2)			
Off-site	122	246	µg/m^3, 1-hour
Coburn Homestead	12		
CO			
Off-site	38	10,000	µg/m^3, 8-hour
Coburn Homestead	3.1		
TSP			
Off-site	20	90	µg/m^3, annual
Coburn Homestead	0.16		
PM_{10} (24- hours)			
Off-site	20	50	µg/m^3, 24-hours
Coburn Homestead	1.8		
PM_{10} (annual)			
Off-site	1.7	30	µg/m^3, annual
Coburn Homestead	0.064		

The resulting contour plots of maximum predicted concentrations anticipated during Stage 1 production are shown in Figures 6-2, 6-3, 6-4, 6-5, 6-6 and 6-7 respectively. The model results showed maximum off-site concentrations were within guideline criteria for all pollutants.

Figure 6-2 displays the annual average concentrations of PM_{10}. Ground level concentrations of this pollutant meet the criteria value of 30 µg/m^3 at all off-site locations.

Figure 6-3 displays the mining lease boundary for the area of greatest impact from predicted PM_{10} emissions (24-hour averaging period). While off-site concentrations (outside the mining lease boundary) have been predicted to be within the guideline criteria of 50 µg/m^3, it should be noted that for all dust concentration model runs particle deposition was not included. Incorporation of this process into the modelling run would lead to lower ground level concentrations.

Ground level concentrations of TSP (annual average) are displayed in Figure 6-4. Maximum predicted TSP concentrations outside the project area are below (less than 22%) the assessment criterion of 90 µg/m^3, and less than 2% of the standard at Coburn Homestead.

Figures 6-5, 6-6 and 6-7 display predicted maximum concentrations of SO_2, NO_x and CO predicted to arise from the project. All of these parameters are predicted to be well below with their respective assessment criteria. At Coburn Homestead, concentrations of SO_2, NO_x and CO are anticipated to be less than 0.01%, 4.9% and 0.03% of their criteria respectively (Table 6-5).

6.4 Potential Dust Deposition Impacts

6.4.1 Hamelin Pool

Potential dust deposition impacts on the stromatolites at Hamelin Pool were taken into consideration as part of the air quality impact assessment. A screening modelling assessment of the anticipated emissions to atmosphere arising from the proposal at the nearest sensitive receptors, including the Coburn Homestead (17 km east), Hamelin Homestead (9 km northeast), and Hamelin Pool (to the north), was undertaken.

Figure 6-8 shows the predicted amount of deposited dust associated with Scenario 2, where the operation is closest to Hamelin Pool. The NSW EPA criterion of 4 g/m^2/month is not predicted to be exceeded at the extremities of Hamelin Pool. At the Hamelin Pool, peak modelled deposition is predicted to be 1.2 g/m^2/month. Deposition rates of 0.5 and 0.2 g/m^2/month were predicted at the Old Telegraph Station and Hamelin Homestead, representing 12.5% and 5% of the NSW EPA criterion respectively. Emissions from exposed areas around the Accommodation Camp were not included in this model run as it is not expected to impact air quality in the northern regions of the mine site. This is due to its proximity to the Scenario 2 site. Planned re-vegetation around the Accommodation Camp will also reduce emissions from the levels of Scenario 1.

In summary, the conservative modelling results undertaken to date indicate predicted concentrations to be well below respective guidelines at these receptors. Deposited dust levels are predicted to be below NSW EPA impact assessment criteria at the extremities of Hamelin Pool. It is noted however that this criterion is defined to be applicable to protecting human amenity only (i.e. to ensure protection of nearby residences from soiling of clothes, visual impact of dust deposition on vehicles, etc). Using compliance with this criterion as a guide, deposited dust from the Coburn Mineral Sand Project is likely to have a lower risk to surrounding ecosystems, although noting that this is beyond the technical scope of the current air quality assessment. To confirm this prediction, a combination of best practice dust management and regular monitoring is recommended.

Gunson recognises that dust management will be an integral component of site environmental performance, and will undertake a range of preventative measures to minimise fugitive dust sources as part of its daily operations, and provide ongoing monitoring of deposited dust levels at the boundary of the Project Area and at Hamelin Pool.

6.4.2 Vegetation in the Shark Bay World Heritage Property (SBWHP)

The Project Area is influenced by southeast trade winds, which generate southerly winds for the majority of the year (see Figures 5-1 to 5-4). Therefore the potential for windborne dust arising from the mining project is predicted to be predominantly in a northerly to north-east direction, away from the World Heritage Property situated to the west and south of the Project Area.

There is potential for soil particulate movement from the Project Area to the SBWHP with subsequent risk of smothering vegetation. The conservative modelling results undertaken to date indicate predicted concentrations to be well below respective guidelines at these receptors, and maximum off-site dust concentrations to be to the east of the Project Area, indicating minimal risk to vegetation within the SBWHP. Nonetheless, there is residual risk that some airborne particulates from mining operations may carry to vegetation in the SBWHP under some meteorological conditions. Gunson is committed to ongoing management of dust from fugitive sources (exposed areas, etc) as part of the Project. These management measures are detailed in Section 7 below.

7.1 Environmental Safeguards

7.1.1 Products of Combustion

It is predicted that point source atmospheric emissions produced from the operation of the Project (i.e. power generation to support the accommodation camp and concentrators) and vehicles do not represent a significant risk to off-site receptors. However, Gunson will monitor the latest developments in pollution control technology and implement where practical as a part of their commitment to continuous improvement.

All machinery and equipment will be subject to regular maintenance and performance audits, and if required, appropriate corrective action will be taken to minimise atmospheric emissions and maximise energy efficiency.

7.1.2 Greenhouse Emissions

Throughout the operational phase of the Project, Gunson will progressively continually rehabilitate mined-out and backfilled pits as mining progresses northwards thorough the Project Area.

The clearing of vegetation will be kept to a minimum and vegetation will be respread over rehabilitation areas after contouring of the final landform.

Emissions of greenhouse gases from fuel consumption will be managed through appropriate maintenance of on-site vehicles and equipment to ensure fuel consumption is optimised. Selection of high efficiency variable load power generation using natural gas for the project will provide benefits in greenhouse and energy efficiency during the project.

Gunson is also committed to undertaking an ongoing monitoring and reporting programme to measure its emissions over the life of the Project. This will also include a periodic assessment to review opportunities to further improve energy efficiency and reduce greenhouse gas emissions over time.

7.1.3 Dust

Best practice principles applied to controlling dust involve:

- workforce awareness;
- integrating dust control provisions into operations planning e.g. construction, topsoil stripping, mining and rehabilitation programs;
- integrating dust control provisions into work practices;
- monitoring and feedback mechanisms;

- using observational and quantitative assessments to guide control efforts; and
- awareness of current methods and technology. [15]

If appropriately managed, dust generation during the construction and operation of the mine is unlikely to have a significant impact on nearby land users. A range of effective dust control measures will be implemented during these phases of the Project in accordance with EPA Guidance No.18[16], including:

- vegetation clearing and rehabilitation activities will be undertaken in stages to minimise the areas of exposed soil at any one time;
- providing buffer zones of vegetation to act as windbreaks, reducing wind velocity and dust mobilisation;
- ensuring exposed stockpiles are watered or sprayed where required;
- not overloading trucks or conveyors to avoid spillages;
- regular wetting and grading of all unsealed roads;
- commencing progressive rehabilitation as soon as practical after mining;
- scheduling major earthworks (vegetation clearing) to the months of April and May;
- vehicle speeds on unsealed areas will be strictly controlled to minimise dust; and
- using biodegradable chemical polymers/bitumen to stabilise bare soil surfaces.

Other qualitative assessments undertaken during the construction and operation of the Project will include; complaints from neighbours and visual assessment of dust emissions to ensure no adverse off-site impacts at key receptors beyond the Project Area.

Regular monitoring of deposited dust levels within the project area and at selected locations at the boundary of the SBWHP is also recommended to enable a robust temporal monitoring regime of dust transport before and during mine activities commence.

[15] Environment Australia (1998). Best Practice Environmental Management in Mining.

[16] EPA (2000). Guidance for the Assessment of Environmental Factors. Prevention of Air Quality Impacts from Land Development Sites. No.18. WA Environmental Protection Authority, March 2000.

Emissions from the proposed Project have been quantified. The potential impact of these emissions on air quality in the area of Shark Bay has been assessed utilising the TAPM and AUSPLUME atmospheric dispersion models.

The air quality assessment showed that maximum ground level concentrations of pollutants are anticipated to be well within ambient guideline criteria for all pollutants.

Potential dust deposition impacts on the stromatolites at Hamelin Pool were taken into consideration as part of the air quality impact assessment. The conservative modelling results undertaken to date indicate predicted concentrations to be well below respective guidelines at these receptors. Deposited dust levels are predicted to be below NSW EPA impact assessment criterion at the extremities of Hamelin Pool. It is noted however that this criterion is defined to be applicable to protecting human amenity only. Using compliance with this criterion as a guide, deposited dust from the Project is likely to have a lower risk to surrounding ecosystems. To confirm this prediction, a combination of best practice dust management and regular monitoring is recommended. Gunson recognises that dust management will be an integral component of site environmental performance, and will undertake a range of preventative measures to minimise fugitive dust sources as part of its daily operations.

There is potential for soil particulate movement from the cleared areas of the Project to the SBWHP with subsequent risk of smothering vegetation. The conservative modelling results undertaken to date indicate predicted concentrations to be well below respective guidelines at these receptors, and maximum off-site dust concentrations to be to the east of the Project Area, indicating minimal risk to vegetation within the SBWHP. Nonetheless, there is residual risk that some airborne particulates from mining operations may carry to vegetation in the SBWHP under some meteorological conditions.

TSP and PM_{10} are recognised as the primary pollutants of concern for the Project, in particular, those arising from fugitive sources. As such, appropriate dust mitigation and monitoring measures have been recommended to minimise off-site impacts during the life of the project. Similar dust management practices should also be adopted during construction of the mine and processing plant prior to commissioning.

Appendix A
Emission Spreadsheet Calculations

POINT SOURCE EMISSIONS

POWER GENERATION

Data provided by Energy Developments Limited (EDL): Ben Sheehan
www.edl.com.au

Caterpillar G3520C Gas Engine

8 MW capacity - to supply power to concentrator units (to be moved as mining progresses northwards)

Number of Units	5	(Exhaust stacks to be located 5m apart)
Exhaust temp (oC)	455	
Exit Velocity (m/s)	35	Hours of operation: Assume 7 days/week, 24 hrs/day (mine and concentrating plant)
Stack Height (m)	8	
Nominal Stack Diameter (m)	0.5	Each unit will have a module structure surrounding stack (comparable to a shipping container).
Flow rate (m3/min at exhaust temp)	412	Module dimensions: 4.9 m high x 3.2 m wide x 11.6 m long. Assume stack location to be at end of module.

high efficiency (38-40%) variable load generator units

Emissions per engine (g/s)	g/s (per unit)	**Annual emissions Yrs 1 & 2 (tpa)**	**Annual emissions Yrs 3 onwards (tpa)**
CO	2.33	146.96	293.9
NOx	1.14	71.90	143.8
PM10	0.008	0.50	1.0
SO2	0.002	0.13	0.3
		(assuming 2 modular power units operating)	(assuming 4 modular power units operating)

800 kW gas powered generator (for accommodation camp)

Number of Units	1
Exhaust temp (oC)	412
Exit Velocity (m/s)	35
Stack Height (m)	8
Nominal Stack Diameter (m)	0.35
Flow rate (m3/min at exhaust temp)	206

Emission rates (g/s)	g/s	**Annual emissions (tpa)**
CO	1.165	36.74
NOx	0.57	17.98
PM10	0.004	0.13
SO2	0.001	0.03

Gunson Emissions Inventory: Vehicles

Years 1 and 2

Vehicle Category	Vehicle Description	Fuel Used [1] L/annum	PM10	CO	NOx (kg/1000 L fuel)	SO2	VOCs	PM10	CO	NOx (kg/annum)	SO2	VOCs
Mobile Equipment [2]												
Track Type Tractor	D10 Dozer	275,000	3.03	9.4	34.16	1.7	3.31	833	2585	9394	468	910
Wheeled loader	992C FEL	275,000	3.51	11.79	38.5	1.7	5.17	965	3242	10588	468	1422
Scraper	Scrapers	150,000	3.27	10.16	30.99	1.7	2.28	491	1524	4649	255	342
Site Services [3]												
Industrial Vehicle	Crane - 2 x Yr 3 on	0	3.61	18.40	44.10	3.73	4.04	0	0	0	0	0
Industrial Vehicle	Forklift	100,000	3.61	18.40	44.10	3.73	4.04	361	1840	4410	373	404
Off-highway truck	Cat ITC - 2 x Yr 3 on	0	17.70	14.73	34.29	1.70	1.58	0	0	0	0	0
Off-highway truck	2 x 4WD trucks	141,000	17.70	14.73	34.29	1.70	1.58	2496	2077	4835	240	223
Onroad Vehicles		**VKT**	**PM10**	**CO**	**NOx** (kg/VKT fuel)	**SO2**	**VOCs**	**PM10**	**CO**	**NOx** (kg/annum)	**SO2**	**VOCs**
Concentrate Haulage Road transport - Diesel Heavy Goods Vehicles (HGV) [4]	Triple Road Trains [5]	1,095,000	5.06E-04	2.32E-03	1.19E-02	3.56E-04	1.47E-03	554.1	2540.4	13030.5	389.8	1609.7
Light Vehicles Road transport - Light Goods Vehicles (LGV)	12 x Light Vehicles (Yrs 1&2) - 4WD Patrol or Dual Cab [7]	240,000	1.93E-04	7.78E-04	6.36E-04	6.70E-05	2.08E-04	46.3	186.7	152.6	16.1	49.9
TOTAL (kg/annum)								**5,746**	**13,995**	**47,058**	**2,209**	**4,960**

Notes:

1 Fuel consumption for each vehicle category estimated on the basis of fuel data provided by Gunson Resources 23 Dec 04

2 Emission Factors for mining equipment derived from NPI EET Manual for Mining v 2.3 (Table 4)

3 Emission Factors for site equipment derived from NPI EET Manual for Combustion Engines v 2.3 (Table 7), based on estimated fuel use data provided by Gunson.

4 Emission Factors from NPI EET Manual for Combustion Engines v 2.3 - Table 5 (Articulated HGV)

5 Calculated on basis of 300km distance from minesite to Geraldton (i.e. 600km return trip). 5 trips per day for Years 1 and 2, increasing to 10 trips per day from Year 3 onwards

6 Emission Factors from NPI EET Manual for Combustion Engines v 2.3 - Table 4

7 Assumes light vehicles operate 8 hrs per day. Average VKT of 20,000 km/yr per vehicle

Gunson Emissions Inventory: Vehicles

Years 3 to 20

Vehicle Category	Vehicle Description	Fuel Used [1] L/annum	PM10	CO	NOx (kg/1000 L fuel)	SO2	VOCs	PM10	CO	NOx (kg/annum)	SO2	VOCs
Mobile Equipment [2]												
Track Type Tractor	D10 Dozer	550,000	3.03	9.4	34.16	1.7	3.31	1667	5170	18788	935	1821
Wheeled loader	992C FEL	550,000	3.51	11.79	38.5	1.7	5.17	1931	6485	21175	935	2844
Scraper	Scrapers	200,000	3.27	10.16	30.99	1.7	2.28	654	2032	6198	340	456
Site Services [3]												
Industrial Vehicle	Crane - 2 x Yr 3 on	80,000	3.61	18.40	44.10	3.73	4.04	289	1472	3528	298	323
Industrial Vehicle	Forklift	100,000	3.61	18.40	44.10	3.73	4.04	361	1840	4410	373	404
Off-highway truck	Cat ITC - 2 x Yr 3 on	153,000	17.70	14.73	34.29	1.70	1.58	2708	2254	5246	260	242
Off-highway truck	2 x 4WD trucks	141,000	17.70	14.73	34.29	1.70	1.58	2496	2077	4835	240	223
Onroad Vehicles		**VKT**	**PM10**	**CO**	**NOx** (kg/VKT fuel)	**SO2**	**VOCs**	**PM10**	**CO**	**NOx** (kg/annum)	**SO2**	**VOCs**
Concentrate Haulage												
Road transport - Diesel Heavy Goods Vehicles (HGV) [4]	Triple Road Trains [5]	2,190,000	5.06E-04	2.32E-03	1.19E-02	3.56E-04	1.47E-03	1108.1	5080.8	26061.0	779.6	3219.3
Light Vehicles												
Road transport - Light Goods Vehicles (LGV)	16 x Light Vehicles (Yrs 3 on) - 4WD Patrol or Dual Cab [7]	320,000	1.93E-04	7.78E-04	6.36E-04	6.70E-05	2.08E-04	61.8	249.0	203.5	21.4	66.6
TOTAL (kg/annum)								**11,275**	**26,659**	**90,445**	**4,182**	**9,598**

Notes:

1 Fuel consumption for each vehicle category estimated on the basis of fuel data provided by Gunson Resources 23 Dec 04
2 Emission Factors for mining equipment derived from NPI EET Manual for Mining v 2.3 (Table 4)
3 Emission Factors for site equipment derived from NPI EET Manual for Combustion Engines v 2.3 (Table 7), based on estimated fuel use data provided by Gunson.
4 Emission Factors from NPI EET Manual for Combustion Engines v 2.3 - Table 5 (Articulated HGV)
5 Calculated on basis of 300km distance from minesite to Geraldton (i.e. 600km return trip). 5 trips per day for Years 1 and 2, increasing to 10 trips per day from Year 3 onwards
6 Emission Factors from NPI EET Manual for Combustion Engines v 2.3 - Table 4
7 Assumes light vehicles operate 8 hrs per day. Average VKT of 20,000 km/yr per vehicle

Gunson Emissions Inventory.

Fugitive Dust Sources - Scenario 1

(at southern initial extent of mine area)

DEH (2001) NPI EET Manual for Mining, v.2.3.

1. TOPSOIL REMOVAL - INITIAL PIT DEVELOPMENT

			Comments
X co-ord (m)			LC: area source.
Y co-ord (m)			
X-Area (m^2)	1,001,000		
Emission of TSP =	1.64	kg/VKT	Mining EET Handbook, p 39 Topsoil removal by Scraper
Emission of PM10 =	0.53	kg/VKT	
Assume scraper moves 15 km/hr	1890	VKT	
Assume scraper operates 9 hrs/day			
Assume scraper works for 2 weeks to clear area			
TSP Emission (kg/annum) =	**3,100**		
TSP Emission (g/s) =	0.3		
PM10 Emission (kg/annum) =	**1,002**		Fraction of TSP
PM10 Emission (g/s) =	0.1		
PM10 Emission (mg/s/m^2) =	0.000		

2. WIND EROSION - EXPOSED AREAS

Emission of TSP = 1.9 * (s/1.5) * 365 *(365-p)/235 * (f/15) * C

Where:
s = silt content (%) (Fraction less than 75 µm)
p = days rainfall > 0.25 mm
f = % time wind speed > 0.54 m/s
C = % control

Emission of PM10 = Assume = 0.5 * TSP emissions (as per Mining EET, Appendix A)

Typical particle size distribution (From Blandford, 2004):
Clay (<0.002mm) = 5.1%
Silt (0.002-0.06 mm) = 3.8%
Sand (0.06-2mm) = 91.0%

Area =	INITIAL PIT	CONCENTRATOR, OFFICES ETC	ACCESS ROADS	TOPSOIL STOCKPILES (INITIAL)	OVERBURDEN STOCKPILE AREA (INITIAL)	ACCOMMODATION CAMP	TOTAL	Comments
X co-ord (m)								
Y co-ord (m)								
Z (m)	70	70	70	70	70	70		
X dist (m)	455	300	16	150	270	275		
Y dist (m)	2200	500	45000	330	320	360		
Angle (deg) from North	10	90						
Exposed Area/total area	0.7	0.3	0.5	0.5	0.5	0.5		
Exposed Area (ha)	70.07	4.5	36.0	2.5	4.3	5.0	122.3	
Silt Content (%)	3.8	2	3.8	3.8	3.8	3.8		
Days rainfall >0.25 mm	35	35	35	35	35	35		
%Time wind speed >5.4 m/s	39	39	39	39	39	39		
Control (%)	75	50	75	50	50	50		
TSP Emission (kg/annum) =	**112,365**	**7,596**	**57,730**	**7,938**	**13,855**	**15,876**	**215,360**	
TSP Emission (g/s) =	3.56	0.24	1.83	0.25	0.44	0.50	6.83	
TSP Emission (g/s/m^2) =	5.1E-06	5.4E-06	5.1E-06	1.0E-05	1.0E-05	1.0E-05		
PM10 Emission (kg/annum) =	**56,182**	**3,798**	**28,865**	**3,969**	**6,928**	**7,938**	**107,680**	Fraction of TSP
PM10 Emission (g/s) =	1.78	0.12	0.92	0.13	0.22	0.25	3.41	
PM10 Emission (mg/s/m^2) =	2.5E-03	2.7E-03	2.5E-03	5.1E-03	5.1E-03	5.1E-03		

3. MINING IN PIT (Bucketwheel Excavator)

			Comments
X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
	$E = k \times 0.0016\ (U/2.2)^{1.3} \times (M/2)^{-1.4}$		where k = 0.74 for particles less than 30 microns k = 0.35 for particles less than 10 microns U = mean wind speed = 5.4 m/s M = material moisture content = 2%
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Extracted =	6716000	t/yr	
TSP Emission (kg/annum) =	**25521**		
TSP Emission (g/s) =	2.4		
PM10 Emission (kg/annum) =	**11417**		Fraction of TSP
PM10 Emission (mg/s) =	1086		Approximate as Volume Source

4. UN/LOADING STOCKPILE AREAS

Comments

4.1 UNLOADING TO TOPSOIL STOCKPILES

			Comments
X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Unloaded =	109000	t/yr	
TSP Emission (kg/annum) =	**414**		
TSP Emission (g/s) =	0.04		
PM10 Emission (kg/annum) =	**185**		Fraction of TSP
PM10 Emission (mg/s) =	18		Approximate as Volume Source

4.2 UNLOADING TO SUBSOIL STOCKPILES

			Comments
X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Unloaded =	979000	t/yr	
TSP Emission (kg/annum) =	**3720**		
TSP Emission (g/s) =	0.35		
PM10 Emission (kg/annum) =	**1664**		Fraction of TSP
PM10 Emission (mg/s) =	158		Approximate as Volume Source

4.3 UNLOADING TO OVERBURDEN STOCKPILES

			Comments
X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Unloaded =	2372000	t/yr	
TSP Emission (kg/annum) =	**9014**		
TSP Emission (g/s) =	0.86		
PM10 Emission (kg/annum) =	**4032**		Fraction of TSP
PM10 Emission (mg/s) =	384		Approximate as Volume Source

5. HANDLING, TRANSFERS AND CONVEYING

			Comments
X co-ord (m)			SW corner (line source)
Y co-ord (m)			
Emission of TSP =	0.005	kg/t	Default emission factor, pg 14 Mining EET handbook
Emission of PM10 =	0.002	kg/t	Default emission factor, pg 14 Mining EET handbook
Assume X =	1.5	m	
Assume Y =	50	m	
Operating days / yr	365	days	
Hours / day	24	hrs	
Tonnes Extracted =	21024000	t/yr	
Control	0.7	% Fraction? 70%	Assumed to be enclosed
TSP Emission (kg/annum) =	**31536**		
TSP Emission (g/s) =	1.00		
TSP Emission ($g/m^2/s$) =	0.01		
PM10 Emission (kg/annum) =	**12614**		Fraction of TSP
PM10 Emission (mg/s) =	400		Approximate as Line Source
PM10 Emission ($mg/m^2/s$) =	5.3		

6. WHEEL GENERATED DUST FROM UNPAVED ROADS

Comments

X co-ord (m)
Y co-ord (m)

$$E = k \times (S/12)^{A} \times (W/3)^{B} / (M/0.2)^{C}$$

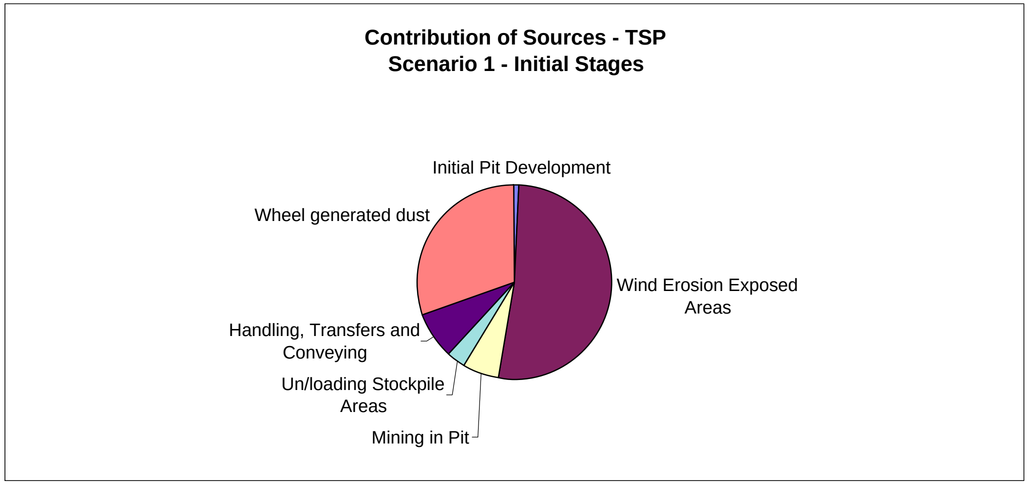
where
k = 2.82 for particles less than 30 microns
k = 0.733 for particles less than 10 microns
S = surface material silt content, %
W = vehicle gross mass, t
M = surface material moisture content, %
A, B, C = Empirical constants (p.40 EET)

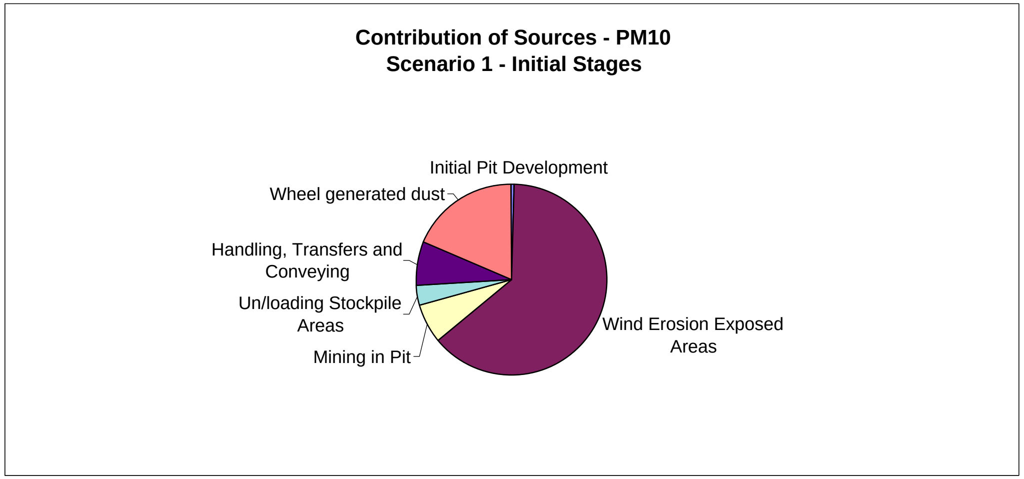
			Comments
Emission of TSP =	1.7897	kg/VKT	
Emission of PM10 =	0.4438	kg/VKT	
Assume trucks move 60-70 km/hr	71175	VKT	
Assume haulage trucks (x3) travel for 1 hour along access road each day			Wheel generated dust, p 40 Mining EET Handbook
TSP Emission (kg/annum) =	**127,385**		
TSP Emission (g/s) =	11.7		
PM10 Emission (kg/annum) =	**31,591**		Fraction of TSP
PM10 Emission (g/s) =	2.9		Approximate as Volume Source

SUMMARY

	kg/yr **TSP**	**PM_{10}**
Initial Pit Development	3,100	1,002
Wind Erosion Exposed Areas	215,360	107,680
Mining in Pit	25,521	11,417
Un/loading Stockpile Areas	13,148	5,882
Handling, Transfers and Conveying	31,536	12,614
Wheel generated dust	127,385	31,591
TOTAL	**416,049**	**170,186**

Annual Dust Emissions By Source (Scenario 1)





Gunson Emissions Inventory. **Fugitive Dust Sources - Scenario 2** DEH (2001) NPI EET Manual for Mining, v.2.3.

(at northern extent of mine project area)

1. TOPSOIL REMOVAL - PIT DEVELOPMENT

			Comments
X co-ord (m)			
Y co-ord (m)			
X-Area (m^2)	960,000		
Emission of TSP =	1.64	kg/VKT	Mining EET Handbook, p 39 Topsoil removal by Scraper
Emission of PM10 =	0.53	kg/VKT	
Assume scraper moves 15 km/hr	1890	VKT	
Assume scraper operates 9 hrs/day			
Assume scraper works for 2 weeks to clear area			
TSP Emission (kg/annum) =	**3,100**		
TSP Emission (g/s) =	0.3		
PM10 Emission (kg/annum) =	**1,002**		Fraction of TSP
PM10 Emission (g/s) =	0.1		
PM10 Emission ($mg/s/m^2$) =	0.000		

2. WIND EROSION - EXPOSED AREAS

Emission of TSP = 1.9 * (s/1.5) * 365 *(365-p)/235 * (f/15) * C

Where:
- s = silt content (%) (Fraction less than 75 µm)
- p = days rainfall > 0.25 mm
- f = % time wind speed > 0.54 m/s
- C = % control

Emission of PM10 = Assume = 0.5 * TSP emissions (as per Mining EET, Appendix A)

Typical particle size distribution (From Blandford, 2004):
Clay (<0.002mm) = 5.1%
Silt (0.002-0.06 mm) = 3.8%
Sand (0.06-2mm) = 91.0%

Area =	PIT	NEW CONCENTRATOR LOCATIONS	ACCESS ROADS	TOPSOIL STOCKPILES	OVERBURDEN DISPOSAL (BACK TO PIT VOID)	ACCOMMODATION CAMP	TOTAL	Comments
Area (X*Y) (m^2)	960,000	102,300	960,000	49,500	86,400	99,000		
Y co-ord (m)								
Z (m)	10	10	10	10	10	10		
X dist (m)	800	310	16	150	270	275		
Y dist (m)	1200	330	60000	330	320	360		
Angle (deg) from North	45	90	0	0	0	0		
Exposed Area/total area	0.7	0.3	0.5	0.5	0.5	0.3		
Exposed Area (ha)	67.20	3.1	48.0	2.5	4.3	3.0	128.0	
Silt Content (%)	3.8	2	3.8	3.8	3.8	3.8		
Days rainfall >0.25 mm	35	35	35	35	35	35		
%Time wind speed >5.4 m/s	39	39	39	39	39	39		
Control (%)	75	50	75	50	50	50		
TSP Emission (kg/annum) =	**107,762**	**5,180**	**76,973**	**7,938**	**13,855**	**9,525**	**221,235**	
TSP Emission (g/s) =	3.42	0.16	2.44	0.25	0.44	0.30	7.02	
TSP Emission ($g/s/m^2$) =	5.1E-06	5.4E-06	5.1E-06	1.0E-05	1.0E-05	1.0E-05		
PM10 Emission (kg/annum) =	**53,881**	**2,590**	**38,487**	**3,969**	**6,928**	**4,763**	**110,617**	Fraction of TSP
PM10 Emission (g/s) =	1.71	0.08	1.22	0.13	0.22	0.15	3.51	
PM10 Emission ($mg/s/m^2$) =	2.5E-03	2.7E-03	2.5E-03	5.1E-03	5.1E-03	5.1E-03		

3. MINING IN PIT (Bucketwheel Excavator)

			Comments
X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
	$E = k \times 0.0016\ (U/2.2)^{1.3} \times (M/2)^{-1.4}$		where k = 0.74 for particles less than 30 microns k = 0.35 for particles less than 10 microns U = mean wind speed = 5.4 m/s M = material moisture content = 2%
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Extracted =	13432000	t/yr	
TSP Emission (kg/annum) =	**51042**		
TSP Emission (g/s) =	4.9		
PM10 Emission (kg/annum) =	**22834**		Fraction of TSP
PM10 Emission (mg/s) =	2172		Approximate as Volume Source

4. UN/LOADING STOCKPILE AREAS

4.1 UNLOADING TO TOPSOIL STOCKPILES

			Comments
X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Unloaded =	148000	t/yr	
TSP Emission (kg/annum) =	**562**		
TSP Emission (g/s) =	0.05		
PM10 Emission (kg/annum) =	**252**		Fraction of TSP
PM10 Emission (mg/s) =	24		Approximate as Volume Source

4.2 UNLOADING TO SUBSOIL STOCKPILES

X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Unloaded =	1328000	t/yr	
TSP Emission (kg/annum) =	**5046**		
TSP Emission (g/s) =	0.48		
PM10 Emission (kg/annum) =	**2258**		Fraction of TSP
PM10 Emission (mg/s) =	215		Approximate as Volume Source

4.3 UNLOADING TO OVERBURDEN STOCKPILES

X co-ord (m)			Volume Source, middle reference point
Y co-ord (m)			
Emission of TSP =	0.0038	kg/t	Un/Loading trucks, p 43 Mining EET Handbook
Emission of PM10 =	0.0017	kg/t	
Mining days / yr	365	days	
Hours / day	8	hrs	
Tonnes Unloaded =	4622000	t/yr	
TSP Emission (kg/annum) =	**17564**		
TSP Emission (g/s) =	1.67		
PM10 Emission (kg/annum) =	**7857**		Fraction of TSP
PM10 Emission (mg/s) =	747		Approximate as Volume Source

5. HANDLING, TRANSFERS AND CONVEYING

			Comments
X co-ord (m)			SW corner (line source)
Y co-ord (m)			
Emission of TSP =	0.005	kg/t	Default emission factor, pg 14 Mining EET handbook
Emission of PM10 =	0.002	kg/t	Default emission factor, pg 14 Mining EET handbook
Assume X =	1.5	m	
Assume Y =	50	m	
Operating days / yr	365	days	
Hours / day	24	hrs	
Tonnes Extracted =	42048000	t/yr	
Control	0.7	%	Assumed to be enclosed
TSP Emission (kg/annum) =	**63072**		
TSP Emission (g/s) =	2.00		
TSP Emission ($g/m^2/s$) =	0.03		
PM10 Emission (kg/annum) =	**25229**		Fraction of TSP
PM10 Emission (mg/s) =	800		Approximate as Line Source
PM10 Emission ($mg/m^2/s$) =	10.7		

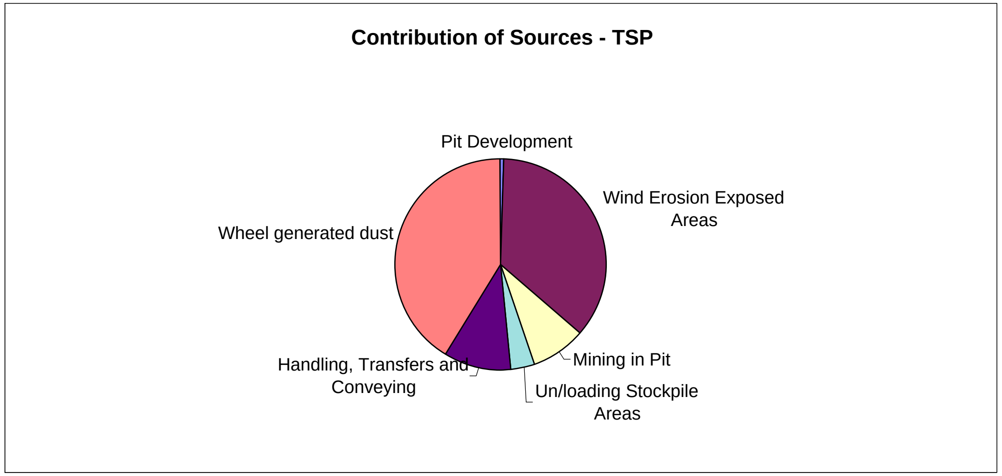
6. WHEEL GENERATED DUST FROM UNPAVED ROADS

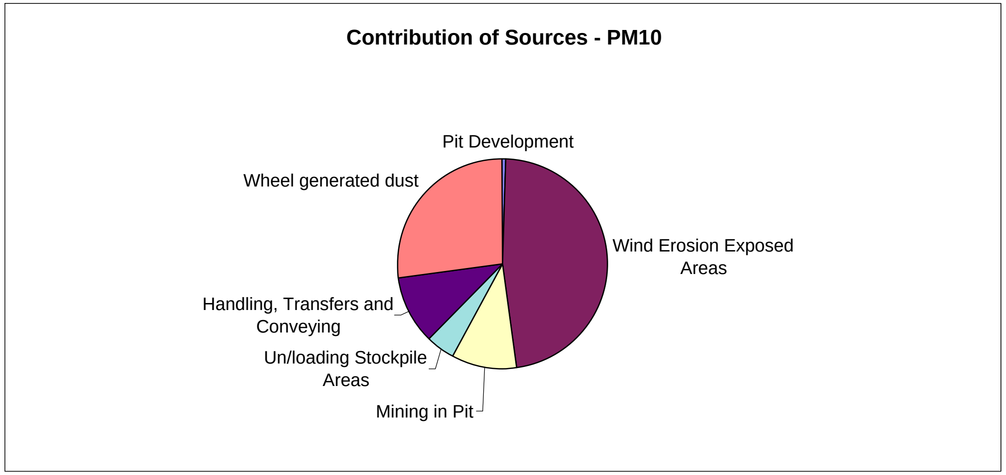
			Comments
X co-ord (m)			
Y co-ord (m)			
	$E = k \times (S/12)^A \times (W/3)^B / (M/0.2)^C$		where k = 2.82 for particles less than 30 microns k = 0.733 for particles less than 10 microns S = surface material silt content, % W = vehicle gross mass, t M = surface material moisture content, %
Emission of TSP =	1.7897	kg/VKT	A, B, C = Empirical constants (p.40 EET)
Emission of PM10 =	0.4438	kg/VKT	
Assume trucks move 60-70 km/hr	142350	VKT	
Assume haulage trucks (x6) travel for 1 hour along access road each day			Wheel generated dust, p 40 Mining EET Handbook
TSP Emission (kg/annum) =	**254,770**		
TSP Emission (g/s) =	23.4		
PM10 Emission (kg/annum) =	**63,182**		Fraction of TSP
PM10 Emission (g/s) =	5.8		Approximate as Volume Source

SUMMARY

	TSP	PM_{10}
Pit Development	3,100	1,002
Wind Erosion Exposed Areas	221,235	110,617
Mining in Pit	51,042	22,834
Un/loading Stockpile Areas	23,172	10,367
Handling, Transfers and Conveying	63,072	25,229
Wheel generated dust	254,770	63,182
TOTAL	**616,390**	**233,231**

Annual Dust Emissions By Source (Scenario 2)





GUNSON GREENHOUSE GAS INVENTORY

Predicted Fuel Consumption for Coburn Mine Operations (Provided by Gunson Resources - Paul Leandri email 23 Dec 2004)

Category	Fuel Type	Annual Consumption Yr 1 & 2	Annual Consumption Yr 3 to 20
Mobile equipment (D10 dozer, 992C FEL, Scrapers)	Diesel	700,000 L	1,300,000 L
Concentrate Haulage (Triple road trains)	Diesel	915,000 L	830,000 L
Power Generation (3.5 x 2MW units Yr 1 & 2, 7 x 2MW units Yr3 on)	LNG	9,225 t	18,450 t
Site Services (Crane - 2 x Yr3 on, Forklift, Cat ITC - 2 x Yr 3 on, 2 x 4WD trucks)	Diesel	241,000 L	474,000 L
Light Vehicles (4WD Patrol or Dual Cab - 12 vehicles Yr 1 & 2, 16 Vehicles Yr 3 on)	Diesel	54,000 L	72,000 L

CALCULATION OF DIRECT GHG EMISSIONS FROM COBURN MINERAL SANDS PROJECT

EMISSIONS FROM MOBILE EQUIPMENT

GHG emissions (t CO2-e) = Q (kL) x EF(tCO2e-/kL)

	t CO2-e (Yr 1 and 2)	t CO2-e (Yr 3 to 20)
= 700 x 2.7		
(Point source EF 2.7 t CO2-e/kL - AGO F	**1890**	**3510**

EMISSIONS FROM CONCENTRATE HAULAGE

GHG emissions (t CO2-e) = Q (kL) x EF(tCO2e-/kL)

	t CO2-e (Yr 1 and 2)	t CO2-e (Yr 3 to 20)
= 700 x 2.7		
(Point source EF 2.7 t CO2-e/kL - AGO F	**2470.5**	**2241**

EMISSIONS FROM POWER GENERATION (assuming LNG)

GHG emissions (t CO_2-e) = Q (GJ) x EF (kgCO2-e/GJ)/1000

	t CO2-e (Yr 1 and 2)	t CO2-e (Yr 3 to 20)
= 505,530 x (60.7/1000)	**30685.7**	**61371.3**

Calculation of CO2-e emissions based on the following assumptions:

1 Estimated natural gas consumption = 9,225 tpa (Yrs 1 & 2) then 18,450 tpa (Yr 3 on), as advised by client.
Using conversion factor of 54.8 GJ/t LNG (Chemlink 1997 http://www.chemlink.com.au/conversions.htm), calculated LNG consumption of 505,530 GJ/a (Yrs 1 & 2), and 1,011,060 GJ/a (Yr 3 on)

2 Full fuel cycle CO2-e Emission Factor = 60.7 kg CO2-e/GJ (AGO (2004) Greenhouse Challenge - Factors and Methodologies Table 2).

EMISSIONS FROM SITE SERVICES

GHG emissions (t CO2-e) = Q (kL) x EF(tCO2e-/kL)

	t CO2-e (Yr 1 and 2)	t CO2-e (Yr 3 to 20)
= 241 x 2.7		
(Point source EF 2.7 t CO2-e/kL - AGO F	**650.7**	**1279.8**

EMISSIONS FROM LIGHT VEHICLES

GHG emissions (t CO2-e) = Q (kL) x EF(tCO2e-/kL)

	t CO2-e (Yr 1 and 2)	t CO2-e (Yr 3 to 20)
= 54 x 2.7		
(Point source EF 2.7 t CO2-e/kL - AGO F	**145.8**	**194.4**

EMISSIONS FROM VEGETATION CLEARING

AGO Greenhouse Challenge Vegetation Sinks Workbook

t CO2 eq (per ha) = Volume (m^3 of merchantable timber) x density x branch/leaf ratio x root factor x carbon content x 44/12

= 11 **t CO_{2e}/ha**

t CO2-e (Yr 1 and 2)	t CO2-e (Yr 3 to 20)
1089	**1333.2**
(Based on average disturbed area over Years 1 and 2, of which 60% is determined to be vegetated cover)	(Based on average disturbed area over Years 3 to 20, of which 60% is determined to be vegetated cover)

SUMMARY

Source Category	**Yr 1& 2 - Estimated GHG emissions** (t CO_{2-e} per annum)	**Yr 3 onwards - Estimated GHG emissions** (t CO_{2-e} per annum)	**% of Total GHG Emissions (Yr 1 and 2)**	**% of Total GHG Emissions (Yr 3 on)**
EMISSIONS FROM MOBILE EQUIPMENT	1,890	3510	5.1	5.0
EMISSIONS FROM CONCENTRATE HAULAGE	2,471	2241	6.7	3.2
EMISSIONS FROM POWER GENERATION (assuming LNG)	30,686	61,371	83.1	87.8
EMISSIONS FROM SITE SERVICES	651	1,280	1.8	1.8
EMISSIONS FROM LIGHT VEHICLES	146	194	0.4	0.3
EMISSIONS FROM VEGETATION CLEARING	1,089	1,333	2.9	1.9
TOTAL	**36,932**	**69,930**	100.0	100.0
GHG intensity (t CO2-e/t HMC)	*0.26*	*0.25*		

Notes:

1. Calculations of estimated greenhouse gas emissions have been based on published emission factors of the Australian Greenhouse Office (AGO 2004 - Factors and Methods Workbook, August 2004).

2. The source of natural gas is anticipated to be Compressed Natural Gas (CNG) from the DBNGP, trucked to site and liquefied for on-site use as LNG. For the purpose of this assessment, it has been conservatively assumed that LNG will be used for power generation, using AGO full fuel cycle emission factors for Western Australian natural gas (AGO 2004, Table 2).

If LPG is alternatively selected as the fuel source, estimated annual CO2-e emissions from power generation are predicted to be 30,442 tpa CO2-e (Yr 1 and 2) and 60,885 CO2-e (Yr 3 onwards).

3. Gunson does not intend to undertake any blasting operations at the Amy Zone operations, therefore the inventory does not take into account GHG emissions from explosive use.

4. Emissions from power generation take into account emissions required to fuel the on-site desalination system to provide potable water.