ENVIRON

Port Hedland

Dust Modelling Assessment

for

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1. INTRODUCTION

Fortescue Metals Group Limited (FMG) holds a large number of tenements in the Western, Central and Eastern Pilbara for the exploration and development of iron ore deposits. FMG is proposing to construct a port facility at Port Hedland and a connecting railway to its proposed mining operations some 345 km to the southeast.

The proposed FMG port facility is situated on land vested with the Port Hedland Port Authority and adjacent Vacant Crown Land. The port will consist of a rail loop, stockyard and a conveyor system that will transfer iron ore from the stockyard to a new wharf and shiploader that will be located at Anderson Point (Figure 1). FMG's Pilbara Iron Ore and Infrastructure Project is planned to initially export 45 million tonnes per annum (Mtpa) of iron ore through the Port Hedland Port.

The ambient particulate (dust) levels at Port Hedland, primarily associated with BHP Billiton's iron ore export operations have been, and will continue to be for sometime, a significant issue.

ENVIRON was commissioned by FMG to undertake air dispersion modelling to predict the potential air quality impacts arising from its proposal to export 45 Mtpa of iron ore through the Port Hedland port. This modelling has utilised information provided by BHP Billiton and the EPA, plus other publicly available information to model the current operations, and then the future scenarios including the approved BHP Billiton's expansions and the Hope Downs project. The potential dust impacts arising from the FMG Project have been considered in isolation and cumulatively with the approved projects (ie. Expanded BHP Billiton's operations and the Hope Downs project).

2. AMBIENT DUST STANDARDS

Dust is generally defined as particles that can remain suspended in the air by turbulence for an appreciable length of time. Dust can consist of crustal material, pollens, sea salts and smoke from combustion products. Dust or particulate matter is commonly defined by the size of the particles with particles commonly measured as:

- TSP (total suspended particulate), which is all particulate with an equivalent aerodynamic particle size below around 50 μm diameter. The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density 1 gm/cm^3;
- PM_{10}, particulate below 10 μm in diameter; and
- $PM_{2.5}$, particulate below 2.5 μm in diameter.

TSP generally consists of larger particulate (though it contains the PM_{10} and $PM_{2.5}$ fractions) and is associated with nuisance impacts such as dust fallout and soiling of washing. PM_{10} and $PM_{2.5}$ are associated with the potential for health impacts because particles below these sizes may enter the lung.

2.1 PM_{10} AND $PM_{2.5}$ - NATIONAL ENVIRONMENT PROTECTION COUNCIL

The National Environment Protection Council (NEPC) has produced the following national ambient air quality standards for the protection of human health relevant to dust:

- National Environment Protection (Ambient Air Quality) Measure (NEPC, 1998) which sets national air quality standards for the criteria pollutants SO_2, NO_X, ozone, CO, particulate (as PM_{10}) and lead;
- Variation to the National Environment Protection (Ambient Air Quality) Measure (NEPC, 2002) which sets an Advisory Reporting Standard for particulate (as $PM_{2.5}$). The purpose of the Advisory Standard is to gather sufficient data to facilitate a review of the Standard as part of the review of this Measure (scheduled to commence in 2005).

These are listed in Table 1 for particulates.

Table 1 National Environment Protection Measures - Ambient Air Standards and Goals

Pollutant	**Averaging Period**	**Standard ($\mu g/m^3$)**	**Goal**
Particles as PM_{10}	1 day	50	5 days a year[1]
Particles as $PM_{2.5}$	1 day	25	To gather sufficient data to facilitate a review of the standard
Particles as $PM_{2.5}$	1 year	9	To gather sufficient data to facilitate a review of the standard

Note: (1) To be achieved by June 2008

These standards have been derived from health studies in major urban centres where the particulate matter was comprised primarily of combustion products from vehicles, industry and smoke from various burning activities. It is generally recognized that these standards are not applicable to crustal material or material such as sea salt.

2.2 BHP BILLITON PORT HEDLAND DUST MANAGAMENT PROGRAM

The current BHP Billiton Iron Ore *Port Hedland Dust Management Program* (BHP Billiton, 2002) has set the following performance targets for dust:

- No exeedances of 260 $\mu g/m^3$ for TSP concentrations measured over a 24-hour period;
- Annual average TSP concentrations to be less than 90 $\mu g/m^3$;
- No exceedances of 150 $\mu g/m^3$ for PM_{10} concentrations over a 24-hour period; and
- No dust related complaints from the community.

These are reflected in BHP Billiton's current licence conditions:

- TSP limit of 260 $\mu g/m^3$ (24-hour average);
- Desirable TSP target of 90 $\mu g/m^3$ (annual average); and
- Maximum PM_{10} level of 150 $\mu g/m^3$ (24-hour average).

The above licence conditions have been derived from the Kwinana EPP and the USEPA National Air Quality Standard (see BHP Billiton, 2002).

These targets and licence conditions are above that generally applied in the rest of the state and the NEPM standards and goals (as presented in Section 2.1). As such it is considered that these levels will be tightened in the future.

3. EXISTING DUST LEVELS

Dust levels in Port Hedland are monitored with a network of high volume TSP, PM_{10} and $PM_{2.5}$ monitors located at the following sites (Figure 2):

- Town monitor;
- Port Hedland Hospital;
- South Hedland;
- Port Hedland Airport; and
- Boodarie.

A summary of the monitoring data is presented in the dust management program (BHP Billiton, 2002) for the period up to the end of June 2001. This shows reasonable variation in dust concentrations between seasons and from year to year. For example exceedances of a 24-hour TSP value of 260 $\mu g/m^3$ varied from 1 to 13 per year and exceedances of a 24-hour 150 $\mu g/m^3$ level varied from 0 to 5 at the Hospital monitor over the years from 1995/1996 to 2000/2001. The data also indicates that though there is a large contribution from BHP Billiton operations, periodically there are also large background contribution from sources such as regional dust storms and fires.

A summary of dust concentrations for the period 1 July 2002 to 30 June 2003 is presented in Table 2. In reviewing the monitoring data, it was noted that data were not available for every day due to the logistical difficulty of sampling daily and the occasional equipment failures. As such the number of exceedances presented in Table 2 is likely to understate the actual annual number of exceedances that occurred over the 12 months. Table 2 indicates that the ambient dust concentrations around the current operations are high. Background levels are also high by Australian standards with a high number of exceedances of the NEPM standard for PM_{10} and the NEPM advisory reporting standard for $PM_{2.5}$. It is noted that as discussed in Section 2, the $PM_{2.5}$ is an advisory reporting standard are is not a compliance standard. For the purposes of this report, the background levels have been determined as the minimum of any of the background monitoring sites (Boodarie, South Hedland or the airport).

Table 2 Summary of Dust Monitoring for 1 July 2002 to 30 June 2003 in Port Hedland

Statistics	Units	Town	Hospital	Airport	Boodarie	South Hedland	Estimated Background
TSP							
# of Observations	(No.)	319	326	262	134	212	302
Maximum	($\mu g/m^3$)	299	324	130	142	142	130
99th Percentile	($\mu g/m^3$)	234	233	110	121	111	86
95th Percentile	($\mu g/m^3$)	198	191	78	87	57	63
# days > 150 $\mu g/m^3$	(No.)	63	48	0	0	0	0
Average	($\mu g/m^3$)	113	91	35	38	32	30
PM10							
# of Observations	(No.)	316	289	276	128	ND	279
Maximum	($\mu g/m^3$)	105	113	81	72	ND	72
99th Percentile	($\mu g/m^3$)	98	90	62	67	ND	60
95th Percentile	($\mu g/m^3$)	80	74	51	52	ND	44
# days > 50 $\mu g/m^3$	(No.)	135	63	15	9	ND	11
Average	($\mu g/m^3$)	47	39	22	23	ND	20
PM2.5							
# of Observations	(No.)	315	126	253	ND	ND	253
Maximum	($\mu g/m^3$)	97	65	52	ND	ND	52
99th Percentile	($\mu g/m^3$)	90	57	37	ND	ND	37
95th Percentile	($\mu g/m^3$)	68	42	24	ND	ND	24
# days > 25 $\mu g/m^3$	(No.)	154	29	12	ND	ND	12
Average	($\mu g/m^3$)	30	18	11	ND	ND	11

Notes:

1) The Boodarie site finished high volume sampling for TSP on 4 February 2003 with monitoring for $PM_{2.5}$ commencing on 8th February at the Hospital site. This will bias the annual statistics for these two sites, especially the number of exceedance of the specified levels.
2) No $PM_{2.5}$ monitoring was undertaken at Boodarie and no PM_{10} or $PM_{2.5}$ monitoring was undertaken at South Hedland in the 12 month period.
3) Estimated background concentrations are the minimum of the background monitored sites (Boodarie, South Hedland or the Airport) and are presented to indicate what dust levels may be without the stockpiling and ship loading operations and other man made activities. These values are used later in the model evaluation (see Section 7.1).

ND – No data available.

4. PROPOSED OPERATIONS - DUST IMPACTS

The FMG proposed 45 Mtpa ship loading facility as detailed in ENVIRON (2004) will handle two ore types:

- 10 Mtpa of direct shipped ore (Mindy Mindy ore); and
- 35 Mtpa of Chichester ore, from a combination of Mt Nicholas, Mt Lewin and Christmas Creek Mines.

The Mindy Mindy ore is a pisolitic ore which is similar to the Yandi product currently shipped through Port Hedland by BHP Billiton and at Dampier by Rio Tinto. The Chichester ore is a marra mamba ore similar to other marra mamba ores exported. However, the Chichester ore will be processed through a beneficiation plant where the majority of ultra fines (<75 μm diameter) are removed. As the beneficiation is a wet process, the resultant ore will have a relatively high moisture content and will be less susceptible to dust generation through material handling than other marra mamba ores.

Under the proposed operation, Mindy Mindy ore (which has been conditioned at the mine to the optimum moisture content) would be transported to the facility by rail, unloaded by a rotary car dumper and transferred to apron feeders onto conveyors feeding either of two stackers within the stockpile area. The Chichester ore will be crushed and screened for beneficiation at the mine site. The beneficiated ore will then be railed to port, where it will be unloaded through the car dumper, screened and then stockpiled as either a lump or fines product. The "live" stockpiles will be reclaimed by "slewing/luffing" bucket wheel reclaimer and loaded onto ships. At this stage there is no plan for re-screening the lump prior to shipment as there should be little degradation (formation of fines) of the lump material.

During exceptional circumstances when the capacity of the live stockpile area is full, stacking may need to be undertaken into bulk stockpiles located on either side of the live stockpiles. This ore when required will be returned to the live stockpiles by front end loaders and trucks in an operation lasting over several weeks.

4.1 POTENTIAL DUST SOURCES

The main dust sources at the site are described below.

Car Dumpers
A dust extraction system for the car dumping facility will be installed. This would include an induced draught at the dumping point and dust extraction using wet scrubbing. The efficiency of this control measure for the purposes of modelling was taken as 98%. This was less than the 99% recommended for a totally enclosed system with dust extraction (mining fugitive emission estimation technique (EET) manual, NPI, 2001), to allow for a slightly larger amount of dust release and to ensure that the modelling remained conservative.

Conveyor Transfer
Conveyor transfer points are potentially a large source of dust emission. Emissions from these sources can arise following the initial start up, where dust which has dried out on the conveyor, falls off at the belt return or can occur as material falls off at the belt idlers on the return belt. For the FMG project all conveyor transfers will be totally enclosed, with water spray jets at each loading point to wet the surface of the ore. Additionally, FMG will undertake installation of insertable dry, reverse pulse bag filters at the transfer points. Dust emitted from belt idlers will be controlled through proper maintenance of belt scrapers to dislodge material sticking to the belt. The efficiency of this control measure for the purposes of modelling was taken as 92% (see Table 7) to reflect enclosed transfer chutes with good seals (70% controls), water sprays (50% control) and dust filtration, though not operating under negative pressure (assumed 50% further control). Note, in the NPI EET (NPI, 2001) a transfer with enclosure and dust extraction fabric filters is given a 99% control rating, and that control efficiencies are multiplicative.

Conveyor Belts
Material on conveyors belts when exposed to high winds can also be lifted off creating nuisance impacts. This is particularly true if there are high conveyors exposed to strong winds. This is generally a small component of overall dust emissions and for the site should be small given the high moisture content of the Chichester ore. Both the conveyer from the car dumper to the screenhouse and out to the ship loader will be covered.

Screening

The Chichester ore that is to be screened will have a high moisture content, reducing the potential for dust emissions. Regardless of this FMG undertakes to investigate any potential for dust emissions and will cover or enclose the screens and include dust extraction with a baghouse to reduce dust to acceptable levels if required.

Stacking

Stackers will be "luffing and slewing" stackers, which will be automated to reduce the drop heights to the stockpiles. The stacker booms will be fitted with spray heads to minimise the emission of dust from this source. Dust controls were taken at 70%. This is slightly higher than the 62.5% control suggested in the NPI manual for stacking in coal mines, based on the use of water sprays (50% control) and use of variable height stackers (25%), in line with the higher controls or lower emissions from these sources for iron ore as found in Pitts (2001).

Stockyards

The stockpiles would be arranged into two rows of "live" stockpiles and one or two outside rows of bulk stockpiles if required. The stockpile area would be fitted out with a fixed water cannon based spray system to reduce the likelihood of dust from wind erosion. Further to reduce the dust, a tree shelter belt along the western side of the stockpiles is being considered to reduce the wind speeds over the stockpiles and therefore reduce wind erosion. For the purposes of modelling, water cannon only were assumed to suppress dust with an efficiency of this control measure taken as 50%, as specified in the NPI mining manual EET (NPI, 2001). With both cannons and an effective shelter belt, the control efficiency may be up to 62% (NPI, 2001).

Reclaiming

Material would be reclaimed from the live stockpiles using a bucket-wheel reclaimer with dust suppression using water sprays. The efficiency of this control measure for the purposes of modelling was taken as 50% in line with the suggested NPI control factor for use of water sprays.

Ship Loading

Dust from ship loading should be minimised due to the beneficiation of Chichester ore, which will remove the superfine (<75 micron) component from the ore and result in a high moisture content, and the maintenance of optimum moisture on the Mindy Mindy ore. Dust control will further be achieved by minimising the discharge point height and through the use of water sprays. The efficiency of the control measure was taken as 60 % based on the control factor for water sprays (50%) and that the ships hold will protect the bulk of the falling material from the wind. That is incorporating some of the 25% control suggested by the NPI for use of a variable height stacker.

Vehicle Movements

Vehicles travelling on unwatered unpaved roads, and paved roads with a layer of dust deposited from conveyors, conveyor transfers, and wind can generate large dust clouds. Under normal site conditions, the trucks generally have the greatest potential for dust generation; however, this is critically dependent on the road conditions. FMG undertake to seal areas which are identified as unacceptable dust generation areas. Areas which receive minimal traffic may not be sealed but when necessary dust will be controlled by use of water trucks and setting appropriate speed limits. As the emissions used in the modelling for FMG have been scaled from the Nelson Point measurements (see Section 6.3.1.2), and as these already include dust control factors, no additional control factors were applied in the modelling. At Nelson Point both water trucks and street sweepers are used.

5. MODELING METHODOLOGY

5.1 MODEL SELECTION

Air quality impacts from the port handling facilities have been estimated using the Victorian EPA's Gaussian plume dispersion model Ausplume (version 5.4). Ausplume is one of the primary models used for assessing impacts from industrial sites within Australia and has been used for the BHP Billiton upgrade studies for a 90 Mtpa throughput (BHP Billiton, 2002) and the Hamersley Iron's Dampier upgrade studies (SKM, 2003). The other model considered for this study was Calpuff (the Californian Puff Model), as it has the capability to model the different dispersion rates over the different surface roughness, can handle dispersion under very light winds and longer range transport of the plume more realistically than a Gaussian plume model. The ability to model different dispersion is important as dust plumes will travel over water surfaces, mangrove areas and flats and urban areas and therefore undergo different dispersion rates. This benefit, along with the improved accuracy under light winds and at greater distances however was countered by the wish to keep the modelling consistent with previous modelling undertaken for the Port Hedland area. Further, for light winds and dispersion over longer distances the use of a Gaussian plume model will be conservative.

5.2 MODEL PARAMETERISATION

For this study, Ausplume was set up with the following parameterisations:

- a model grid area of 10 km by 9 km extending from GDA94 Easting 661500m to 671500m and Northing 7746250m to 7755250m with a 0.5 km grid spacing This covers the nearest receptors (Port Hedland, Cooke Point and Wedgefield). A 0.5 km Cartesian grid was chosen to resolve the dust contours at most locations, although close to the source and on-site it may under-predict the dust concentrations;
- discrete receptors at the Port Hedland Town and Hospital monitoring sites, the Mercure Motel at Spinifex Hill, Cooke Point Primary School and the north west corner of Wedgefield;
- assumption of no terrain as the area is essentially flat;
- dry depletion included to properly model particle settling; and
- average roughness length of 0.10 m, to simulate the average roughness length over sea and land. For dispersion over urban areas this will result in an over-prediction of dust concentrations as this choice of roughness length will result in an underestimate of the dispersion.

5.3 METEOROLOGICAL DATA

An annual hourly meteorological file, containing hourly averaged values of wind speed and direction, ambient air temperature, Pasquill-Gifford stability classes and atmospheric mixing height was derived for the site for the period 1 July 2002 to 30 June 2003. This period was chosen as it corresponded to the year of ambient dust monitoring data provided by BHP Billiton.

The annual Ausplume file was constructed using wind speed and direction observations from Port Hedland airport, with the stability class and mixing heights derived from TAPM (The Air Pollution Model). TAPM was set up with:

- Nested grids of 30 km, 10 km and 3 km with 30 by 30 grid in the horizontal and 25 grid points in the vertical;
- Surface winds were nudged using the surface wind observations collected by the Bureau of Meteorology at the Port Hedland airport;
- Terrain and vegetation classification using the standard TAPM data base and the nine second terrain file; and
- A modified soil classification scheme, where the coarse sandy soils in the TAPM database were converted to a duplex soil (sandy clay loam) with a deep soil moisture specified of 0.1 to develop realistic heat fluxes for the region. This was necessary as the default coarse sand classification (specified for certain areas), gave unrealistically low sensible heat fluxes and large latent heat fluxes and therefore a low percentage of class A stabilities. The changes made have been discussed with the model developers (CSIRO) who agreed with the changes to the soil type, and are looking into modifications of the model code.

A summary of the stability class distribution is presented in **Table 3** with the wind rose for the year presented in Figure **3**.

Table 3 Pasquill Gifford Stability Class Distribution (%)

A	B	C	D	E	F
0.9	6.1	17.3	39.9	24.7	11.1

This shows a distribution with relatively high neutral conditions (Class D), with a low frequency occurrence of Class A and F stabilities, due to the generally moderate wind speeds in the region, as indicated by the annual average wind speed of 5.1 m/s.

5.4 PARTICULATE MODELING

Particle size distribution data used in the modelling were based on the USEPA distributions for batch drop, wind erosion and vehicle emissions (USEPA, 2004a, b and c) as listed in Table 4. It is seen that the batch drop and wind erosion distribution data are similar, whilst the vehicle emission distribution has a lower percentage of $PM_{2.5}$ particulate.

Table 4 Source Particle Size Distributions

Particle Size Range (µm)	Representative Particle Size (µm)	Percentage of Particulate (%) in Various Size Ranges				
		USEPA Batch drop	USEPA Wind Erosion	USEPA Unpaved Road	This Study	
					TSP	PM_{10}
<2.5	1.0	11	14.8	3.3	9	30
2.5 - 5.0	3.8	9	22.2	18.7	8	27
5.0 - 7.5	6.3	15			7	23
7.5 – 10	8.3				6	20
10 – 15	12.5	13	7	52	14	-
15 – 23	19	26	30		15	-
23 – 30	26				15	-
30 – 40	35	26	26	26	15	-
40 – 50	45				11	-

Notes:

1) Particle sizes are equivalent aerodynamic size and not the physical size. The equivalent aerodynamic size relates to the aerodynamic properties of the particle as is used in dust sampling. Foe example PM_{10} samplers measure the dust below 10 µm equivalent aerodynamic size and not the physical size.

2) Wind erosion and vehicle emission size distributions are given for below 30 µm only, but have been adjusted here to less than 50 µm based on assuming 74% of the particulate is less than 30 µm as per the batch drop distribution

For this study, a distribution that was a composite to all three USEPA distributions was adopted with this distribution applied to all emissions. This is noted as a simplification as different sources will have different particle size distributions (eg wind erosion and vehicular dust), whilst there may be differences between particle size distributions between different ore types and between iron ore and DRI dust. This simplification was adopted in the absence of actual data and its implications are discussed later in the results section.

In modelling, an annual variable hourly emission file of TSP was created by multiplying the PM_{10} emissions by 3.33 in accordance with the assumed particle size distribution in Table 4 (i.e. PM_{10} is 30% of TSP). TSP predictions were conducted using this annual variable file and the particle size distribution for TSP presented in Table 4. PM_{10} and $PM_{2.5}$ modelling were performed using this hourly TSP file but by using a multiplicative factor within Ausplume of 0.3 and 0.09 respectively to convert to the appropriate PM_{10} and $PM_{2.5}$ emissions. These emissions were then modelled using the particle size distribution below PM_{10} (four particle sizes) and below $PM_{2.5}$ (one particle size) given in Table 4.

As the USEPA particle size diameters are given in equivalent aerodynamic particle sizes, a particle density of 1 g/m^3 was used. In reality, iron ore has a particle density of about 2.8 g/cm^3. As such a 2.8 g/cm^3 iron ore particle of 6.6 μm size will behave as a 10 μm particle of 1 g/cm^3 density. Therefore, a PM_{10} samplers aerodynamic particle "cut off" of 10 μm will be around 6.6 μm for iron ore particles.

All the particulate sources listed in Section 6 were modelled as volume sources with heights taken as the release height with horizontal and vertical dimension equal to ¼ of actual dimension over which the dust was emitted.

6. PARTICULATE EMISSION ESTIMATES

6.1 FACTORS INFLUENCING DUST EMISSIONS

To predict dust concentrations in a realistic matter, hourly dust emissions are required from all major sources in the area are. Factors which are important for dust generation are the:

- Ore type being handled. This is related to the size distribution of the material, shape and composition of the fines fraction;
- Moisture content. Increasing the moisture content decreases the dustiness of the ores with there normally being a moisture threshold above which dust generation by material handling is negligible. This occurs as moisture acts to apply adhesive forces between particles. For ores such as hematite, the moisture content required to suppress dust is lower than ores which have the ability to hold moisture in internal pores such as marra mamba;
- The operation occurring. Factors which are important are the drop height, the degree to which the falling ore is exposed to the wind such that winnowing of the air stream can occur and the dust control mechanism used. Control mechanisms may include, enclosing the operation, the use of water sprays and dust extraction to a bag filter or to a wet scrubber
- Quantity of ore being moved;
- Size of stockpiles and level of activity;
- Level of vehicle traffic; and
- Ambient wind speed. For material handling operations exposed to the air, the dust emissions increase with the ambient wind speed. For wind erosion, dust emissions are negligible below a wind speed threshold, but increase rapidly above the threshold. Dust emissions from wind erosion are also dependent on the erodibility of the material which is dependent on the size distribution of the material and whether a crust has been developed. Generally material with a large (>50%) fraction of non erodible particles (generally particles greater than 1 mm to 2 mm) will not erode as these particles protect the erodible fraction. As such, lump ores are not erodible by wind erosion though they may be quite dusty during material handling. In this case the small fines fraction can be liberated. Fine ores are generally much more erodible particularly if they have a large fraction of particles in the range from 0.1 mm to 0.25 mm which can be dislodged by wind and then rolled and skipped along the surface (saltation). These larger saltating particles can then dislodge the smaller (<50 μm) dust fraction which can remain suspended in the air.

6.2 PREVIOUS STUDIES AT PORT HEDLAND

Previous dust modelling at Port Hedland, has been conducted by BHP Billiton (2002) for its upgrade to 90 Mtpa and by Hope Downs (Hope Downs, 2002) for the planned 25 Mtpa stockpiling and ship loading facilities. The BHP Billiton upgrade study estimated dust emissions on an hourly basis for all major equipment at the two port operations of Nelson Point and Finucane Island. The estimates were based on the tonnage of ore handled, the ore type and moisture content (BHP Billiton, 2002). Given these factors, dust emissions were determined based on functions that related these parameters to a dustiness index of the ore. These dustiness indices were based primarily on laboratory testing using a rotating drum test and also to a lesser degree on onsite measurements (see Figure 7.5 of the Hope Downs impact assessment for an example of test results from the rotating drum, Hope Downs, 2002). The estimated hourly emissions for all pieces of plant were then used within Ausplume, to predict dust concentrations in the region. The limited data presented in BHP Billiton (2002) indicate that for the year 2000, the model for TSP tended to under-predict slightly the maximum statistics at the Town and Hospital monitors, whilst for PM_{10} over-predicting the maximum statistics at the Hospital monitor whilst under-predicting at the Town monitor observations.

The Hope Downs modelling assessment, (Hope Downs, 2002) used a simpler emission estimation approach based on whether the operations were occurring and dust emissions which were based on the ore type and emission factors sourced from the National Pollutant Inventory (NPI, 2001) emission estimation technique (EET) manual and factors presented in Pitts (2001).

6.3 DUST EMISSION METHODOLGY FOR THIS STUDY

Details of the dust emissions methodologies for both BHP Billiton and Hope Downs were sought from the respective companies but unfortunately were not made available for this study. There are some details on the methodologies and the resultant annual emission estimates that are provided in public documents (BHP Billiton, 2002; Hope Downs, 2002).

In light of the lack of detailed data to reproduce the above projects emissions, an alternative methodology has been used in this study based on:

- Activity data on tonnages shipped from publicly available data for BHP Billiton and the proposed Hope Downs facility along with the design specifications for the proposed FMG operations;

- Emission factors based primarily on the default "high" moisture ore emissions factors in the NPI mining EET manual (NPI, 2001) with some data from the results published in Pitts (2001);
- Control factors for equipment based on NPI recommendations;
- Adjustment of the estimated BHP Billiton emissions based on comparison of the model predicted dust concentrations in Port Hedland to the monitored data. This comparison resulted in modifying the default "high" moisture dust factors by slightly increasing these for Nelson Point operations, with a larger increase necessary for the Finucane Island (Goldsworthy ores). The detailed factors used are presented in Section 6.3.1;
- For the proposed Hope Downs and FMG operation, emission factors have been based on the default "high" moisture content values. This is considered conservative in that the classification into just "high" and "low" moisture groups does not reflect the true variation that can occur in iron ore dust emissions. Dustiness testing using a laboratory rotating drum test (see Hope Downs, 2002) indicates that dustiness can vary by up to a factor of 1,000 and that with sufficient moisture the dust emissions from an ore can be negligible. For the Hope Downs project the design moisture contents of the lump and fine ores were selected such that dust emissions should be minimal. As such in the Hope Downs modelling, emission factors that were half the "high" moisture content ore were used. As the Chichester ore has been through a wet beneficiation process, it will have a high moisture content and a low dust content such that the dust emissions during material handling should also be very low. Therefore a value half that of the "high" moisture value as used in the Hope Downs assessment should be more appropriate. In this study however, as a conservative measure the default "high" moisture values have been used for all ores in both projects. The use of the default "high" moisture content ore, though conservative, allows for variation in the moisture content of the ores and failure in control equipment to occur.

The above methodology though lacking the detail of the BHP Billiton methodology has its advantages in that one consistent approach is used for all projects, with the emission estimates from each facility presented in a standard format to enable comparison of the estimates.

6.3.1 Dust Emission Estimates

A summary of the dust emission factors, used in this study are presented in Table 5. Further details of the emission are provided in the following sections.

Table 5 Adopted Dust Emission Factors for this Study

Source	Units	NPI Uncontrolled PM_{10} Emission Factor (High Moisture)	Adopted Value	Comment if not Based on NPI Default "high" Moisture Value
Car Dumper	(kg/tonne)	0.002	0.002	
Transfers	(kg/tonne)	0.002	0.002	
Crushing	(kg/tonne)	0.01	0.01	
Screening	(kg/tonne)	Not Given	0.015	Based on 25% of the NPI "low" moisture content value
Stacking	(kg/tonne)	0.002	0.002	
Reclaiming	(kg/tonne)	0.002	0.002	
Re Screening	(kg/tonne)	Not Given	0.015	Based on 25% of the NPI "low " moisture content value
Ship Loading	(kg/tonne)	0.002	0.002	
Dozing	(kg/hr)	4	4	Default NPI factor
Haul Trucks	(kg/VKT)	0.96	1.18	Based on NPI equation
FELs		0.002	0.002	Based on Dumping operations only using the default "high" moisture value
Light Vehicles	(kg/VKT)	Not used		Not used as an emissions were based on Nelson Point Emission rate in (g/s)

Notes:

1) The adopted values were used for both the FMG and Hope Downs projects, with the values multiplied by 1.1 and 2.2 for the Nelson Point and Finucane Island operations respectively to match the predicted TSP concentrations with the observations. The large factor of 2.2 for Finucane Island operations is considered due to a combination of different ore type, particle size and shape and/or drier ore.

6.3.1.1 Material Handling Operations

Dust emissions from material handling operations have been based on the default dust emission factors in the NPI EET manual for "high" moisture content ores. The default factor has been used as the alternative equation for batch/continuous drop operations gives unrealistically low emissions (NPI, 2001) and is not recommended. A comparison of iron ore emission factors with the default factors by Pitts (2001) indicated good agreement when appropriate control factors where considered. The exception to this was for screening where Pitts (2001) suggested that a control factor of 92% was inferred for the screening plant tested (Dampier port), which were partially enclosed and had dust extraction.

Additionally, the use of the NPI equation is considered unrealistic for iron ore as it indicates that dustiness is proportional to the silt content of the ore. Studies of iron ore dust emissions (Pitts, 2001), indicate that lump ore (with low silt content) can be dustier than some fine ores at the same moisture content.

The use of the default high moisture content values is considered to be conservative for the Chichester ores given that they will be from a beneficiation plant, resulting in a high moisture content, low fines content ore as discussed in Section 4.

6.3.1.2 Vehicle Emissions

Emissions of dust from light vehicles are dependent on the number of vehicle kilometres travelled on the roads, the mass of the vehicles, silt content and moisture in the roads. Estimates of the vehicle usage for the FMG are not available for the new port, especially for a breakdown of usage on paved and unpaved roads. Additionally, there are no estimates in publicly available data for the BHP Billiton facilities or the Hope Down project. Instead of developing estimates based on kilometres travelled, estimates of the total PM_{10} emissions were obtained from the BHP Billiton report where an average of 2.21 g/s was given for the majority of Nelson Point. This emission rate was scaled to the other sites by:

- The ratio of the tonnages of ore processed at each port;
- Increasing this amount by 50% for Finucane Island to account for the anticipated higher usage of vehicles there due to older plant and higher maintenance requirements and additional handling with the beneficiation plant; and
- Reduced by 25% for each of the proposed projects to account for lower maintenance, lower handling requirements per tonne as there is no crushing, or screening or re-screening at the two projects.

Emission rates for vehicles were then increased by 1.5 for the period from 07:00 hrs to 17:00 hrs to account for higher activity during the day and reduced by 0.7143 for the period from 17:00 hrs to 07:00 hrs. That is, daytime emission rates were set to be 2.1 times higher than the “night” time estimates.

6.3.1.3 Emission Associated with Haulage

Haulage of ore to and from bulk stockpile areas occurs commonly at Nelson Point where ore is moved to areas when there are no immediate requirements for shipping. For the current Nelson Point and Finucane operations there are no publicly available data and as such, these estimates were based on the likely amounts of ore moved as indicated in Table 6. Estimates of the PM_{10} emissions rates per kilometre travelled for an “uncontrolled” road of 1.18 kg/VKT were derived using the wheel generated dust equation in section A1.1.11 in the NPI manual of:

$$EF_{10} = 0.733 * (s/12)^{0.8} * (W/3)^{0.4}/(M/2)^{0.3} \quad \text{(kg/VKT)}$$

Where: s is the surface material silt content (%);
W is the vehicle gross weight (tonne); and
M is the surface material moisture content (%).

Using the typical NPI values of a silt content of 10%, moisture content of 2% but with a gross vehicle mass of 80 tonne for the trucking (based on anticipated truck and payload sizes) at the port gives an emission rate of 1.18 kg/tonne. This is slightly higher than the default NPI emission rate of 0.96 kg/t which is based on a 48 tonne gross weight.

6.3.1.4 Throughputs and Control Factors

Estimated throughputs for 2002/2003 (the existing base modelling) were obtained from the existing port operations from BHP Billiton data which specified a total of 80.6 Mtpa of wet ore shipped through the port. This was apportioned between Nelson Point and Finucane Island on the assumption that all Goldsworthy ore was shipped though Finucane Island. The tonnages crushed and screened at Nelson Point were estimated at 54% of the ore shipped, based on excluding the Yandi fines (as this is a direct shipped product and not crushed and screened). All lump ore was assumed to be re-screened before being loaded onto ships with the percentage of lump taken as 40% of the total ore. Estimates of the number of conveyor transfers used were based on the plant layout as at 2003. Dust control factors were based on the NPI control factors with some variation based on the age of plant. Plant at Finucane Island was generally given a lower control efficiency due to the age of the equipment.

As dust emissions from direct reduced iron (DRI) briquettes are not related to the factors for ores in the NPI EET manual or in any other public data, these were simply estimated at 2 g/s for the loading of hoppers by front end loaders and when ship loading respectively. These emissions were selected to be at least equal to that from iron ore ship loading as it is known that the direct reduced iron (DRI) briquettes are a reasonably dusty product. The dustiness of the DRI is considered due to the covering of fine material to the surface of the briquettes which is easily dislodged in material handling.

Throughputs for the Hope Downs report were obtained from its PER (Hope Downs, 2002) with a total throughput of 25 Mtpa and 40% lump and 60% fines (see Table 7). Usage of the trucks was based on roughly matching the emissions from the Hope Downs PER.

Table 6 Operating Conditions and Control factors adopted for Existing Operations

Source	Tonnage (Mtpa)	# Times	Rate (tph)	Hours	Control (%)	Comments
Nelson Point						
Car Dumper	73.35	1	8373	8760	95	Enclosed, Dust extraction
Transfers	73.35	7	8373	8760	85	Enclosed, few sprays, not optimum operation
Crushing	39.61	1	8000	4951	88	Enclosed, relative good dust extraction
Screening	39.61	1	8000	4951	90	Enclosed, dust extraction though not optimum
Stacker	73.35	1	8373	8760	75	Reduced drop height and water sprays
Reclaimer	73.35	1	8373	8760	50	Water sprays
Re Screening	29.34	1	3349	8760	93	New building, good dust extraction
Ship Loading	73.35	1	8373	8760	60	Reduced drop into hold and water sprays
Dozers (dead to live)	NA	NA	NA	320	0	None
FEL with trucks	3.10	1	NA	904	0	None
Haul Truck dumping	3.10	1	NA	904	0	None
Haul Truck	3.10	1	NA	904	61	Adjusted to match BHPB emissions
Finucane Island						
Car Dumper	7.25	1	2400	3023	85	Poor control on old dumper
Transfers Total	7.25	8	2400	3023	75	Enclosed, with no sprays and poor maintenance
Stacker	7.25	1	2400	3023	65	Variable drop height, with some sprays
Reclaimer	7.25	1	3000	2418	50	Water sprays
Crushing/Screening plant	7.25	1	3000	2418	85	Dust Extraction not optimum
Beneficiation Plant stacking	4.35	1	745	5840	-50	Long fixed drop greater than 10m at times. Increased emissions by 50% over uncontrolled
Ship Loader	7.25	1	3000	2418	50	Old ship loader with two transfers
Dozers	NA	NA	NA	3000	0	
FEL at Bene Fines	4.35	1	NA	2607	-100	Adjusted to match BHP Billiton (Assumed other dust due to dust from wheels. I.e. emissions twice that of a typical uncontrolled FEL
DRI						
Transfers	1.65	1	200	8250	70	Enclosed Only
Transfers out	1.65	4	1500	1100	80	Not applicable. Dust emissions assumed at 1 g/s total
FEL loading	1.65	1	1500	1100	0	Not applicable. Dust emission based on estimate of 2 g/s
Ship loading	1.65	1	1500	1100	0	Not applicable. Dust emission based on estimate of 2 g/s

Table 7 Operating Conditions and Control factors adopted for Proposed Operations

Source	Tonnage (Mtpa)	# Times	Rate (tph)	Hours	Control (%)	Comments
Hope Downs						
Car Dumper	25.00	1	7500	3333	98	Enclosed with good dust extraction
Transfers In	25.00	2	7500	3333	92	Enclosed, water sprays and dust collectors
Stacker Fines	15.00	1	7500	2000	70	Control of drop height and water sprays
Stacker Lump	10.00	1	7500	1333	70	Control of drop height and water sprays
Reclaimer Fines	15.00	1	7500	2000	50	Water Sprays
Reclaimer Lump	10.00	1	7500	1333	50	Water Sprays
Rescreen Lump	10.00	1	7500	1333	95	Enclosed with good dust extraction
Return Fines Stacker	1.50	1	1125	1333	70	Control of drop height and water sprays
Transfers Out	25.00	3	7500	3333	92	Enclosed, water sprays and dust collectors
Ship Loading	25.00	1	7500	3333	60	Reduced drop into hold and water sprays
Haul Truck	0.80	1	NA	333	75	Level 2 watering on roads
Haul Truck to hopper	0.80	1	NA	333	70	Semi enclosed with water sprays
FELs with Haul trucks	0.80	1	NA	333	0	No control
FMG						
Car Dumper	45.00	1	6800	6618	98	Enclosed with good dust extraction
Transfers In	45.00	2	6800	6618	92	Enclosed, water sprays and dust collectors
Screening	35.00	1	6800	5147	95	Enclosed with dust extraction
Stacker Fines	24.50	1	4760	5147	70	Control of drop height and water sprays
Stacker Lump	10.50	1	2040	5147	70	Control of drop height and water sprays
Stacker DSO Fines	10.00	1	6800	1471	70	Control of drop height and water sprays
Reclaimer Fines	34.50	1	8806	3918	50	Water Sprays
Reclaimer Lump	10.50	1	8806	1192	50	Water Sprays
Transfers Out	45.00	3	8806	5110	92	Enclosed, water sprays and dust collectors
Ship Loading	45.00	1	8806	5110	60	Reduced drop into hold and water sprays
Haul Truck	2.60	1	NA	758	75	Level 2 watering
Haul Truck Dumping	2.60	1	NA	758	0	No control
FELs with Haul trucks	2.60	1	NA	758	0	No control

6.3.2 Wind Speed Dependence for Material Handling

For all material handling process exposed to the wind, increasing wind speed acts to increase dust emissions through winnowing of the particles from the falling ore. The USEPA batch drop equations (USEPA, 2004a) specify that the dust emission increase with the wind speed to the power of 1.3. However in this study as there are a number of sources such as conveyor transfers, screening buildings that are primarily shielded from the wind a lower wind speed exponent of 0.8 was used with emissions estimated as:.

$$E_{Actual} = E_{2.2}\,(WS/2.2)^{0.8}$$

Where: WS is the wind speed at the drop height
$E_{2.2}$ is the dust emission given, assumed to be at 2.2 m/s; and
E_{Actual} is the final emission rate.

The alternative to this procedure may be to neglect the wind speed dependence for operations which are partially enclosed or to use the given US EPA wind dependence, but estimate the likely wind speed on the falling ore. For this study the lower exponent was used which is considered to better match observations.

All sources have been assumed to be at 5m above the surface, with the 10m wind speeds reduced using the 1/7 power law given by:

$$WS_5 = WS_{10}\ (5m/10m)^{(1/7)}$$

Where: WS_{10} is the wind speed at 10m.

6.3.3 Wind Erosion

The NPI mining manual EET specifies a value of 0.2 kg/ha/hr for wind erosion for all sources excepting coal stockpiles. This factor is considered approximate as it does not take into account variations in the climate of an area or the soil or ore type. In the Dampier upgrade study (SKM, 2003), based on emission testing in 1998 (SKM, 1998), the PM_{10} emissions for the main live stockyards and surrounding roads were parameterised using the form of Shao (2000) as:

$$E_{wind} = 5.2 \times 10^{-7}\ WS^{3}\ (1 - (WS_T / WS_{10})^2) \quad \text{for} \quad WS_{10} > WS_T \text{ ; and}$$

$$E_{wind} = 0 \quad \text{for} \quad WS_{10} \leq WS_T\text{; and}$$

Where:

WS_T is the threshold for wind erosion in m/s, taken to be 7.5 m/s (SKM, 2003); and
E_{wind} is the PM_{10} emissions ($g/m^2/s$)

Using this equation with hourly wind speeds from Port Hedland and taking into account rainfall effects (see Section 6.3.4) an annual dust emission of 0.58 kg/ha/hr is obtained. This is higher than the NPI default, but is expected given the dry climate and the high wind speeds (annual average wind speed of 5.1 m/s) of the area.

6.3.4 Rainfall Dependence

To account for the combined effects of rainfall and the activity within the stockpile area a simple scheme was used.

For wind erosion, rainfall was assumed to not only suppress dust at the time rain was occurring, but would result in a suppression of dust that would gradually decrease over a period of time. This gradual decrease is primarily a result of activity in the stockpile area as surfaces are either disturbed or reclaimed and new stockpiles created. Without this activity ores such as hematite can form a strong crust and be resistant to wind erosion for extended periods. For this study the dust emissions were taken to linearly return to an uncontrolled state within 400 hours of the rainfall evaporating if the rainfall event was greater than 25mm. During the period when it was raining or the rainfall had not evaporated emission were set to zero. The "evaporation" rate at the surface was also set to be 1.25 times the amount from a class A pan with a limit to the amount of water on/near the surface of 75mm. Class A pan evaporation rates were obtained from monthly averages from the Port Hedland airport station.

The time scales used in the above scheme (eg 400 hours) were adopted to match the return to high dust levels for the one large rainfall event in late January 2003. It is noted that the return to dusty conditions is not just a function of the evaporation of the water, but is determined more importantly from the activity level within the stockpile area, due to surfaces being disturbed, fresh surfaces being created, due to reclaiming, stacking and vehicle movement.

Dust emissions from roads were treated likewise with no emissions when raining and 0.2 of the potential emission when the road was drying out. The drying rate of the road was estimated at four times the evaporation rate to reflect the influence of vehicle activity in drying the road

The overall dust emissions from a material handling source such as stacking are estimated from:

$$E_{Actual} = E_R \times E_{2.2} (WS/2.2)^{0.8}$$

where $E_{2.2}$ is the emission factor given in Table 5 and E_R is the effect of rainfall (a factor between 0 and 1). For example, for stacking at Nelson Point the annual emissions are estimated based on an emission of 0.002 kg/tonne for stacking, multiplied by 1.1 for the increase in dustiness of Nelson Point ores (see footnote to Table 5), 73.35 Mtpa of ore stacked and a control efficiency of 75% (Table 6) to give annual emissions of 40,340 kg/annum or 1.28 g/s. The average emissions are then multiplied on an hourly basis by the wind speed multiplier and the effect of rainfall which results in a higher average stacking emission of 2.47 g/s due to the high average wind speed of the site of 5.1 m/s.

6.4 ESTIMATED EMISSIONS

Annual average emissions predicted for the four iron ore (ie. Nelson Point, Finucane Island, Hope Downs and FMG) and the DRI ship loading operations are presented in Table 8. These indicate that on a per tonne basis that Nelson Point emits around 0.0178 kg PM_{10}/tonne of ore shipped. For the proposed FMG and the Hope Downs projects this factor is 0.0129 and 0.0114 kg PM_{10}/tonne or 72% and 64% of the Nelson Point emissions respectively. The lower emissions from the FMG operations are due to less dusty ore, higher moisture content, better proposed dust control and less requirements to handle the material (no crushing, re-screening and less transfer points). The Hope Downs estimate is the lowest due to the relatively low haulage estimates and that only re-screening of the lump ore is required. The Finucane Island estimates are highest due to the dusty ore and high handling requirements (the beneficiation plant and crushing screening) and lower dust controls assumed for the plant due to its age.

Comparison with the emission estimates that are available from earlier studies indicate that the emissions estimated derived for this study may be generally higher than that in BHP Billiton and are 2.16 times higher than estimated in the Hope Downs PER. This higher estimate for the Hope Down emissions are primarily due to the use of the default “high” moisture NPI emission estimates in this study while the earlier Hope Downs estimate that used half this value.

Table 8 Estimated Annual Average PM_{10} Emissions

Source	Estimated this Study (g/s)					Estimated Previously (g/s)		
	NP	FI	DRI	FMG	HD	NP BHPB	FI	HD (HD 2002)
Car Dumper	0.50	0.26		0.12 (0.06)	0.06 (0.03)			0.003
Crushing	3.20	3.10				4.94	1.30	
Screening	3.99			0.87 (0.43)				
Transfers	12.67	2.83	0.44	3.35 (1.68)	1.25 (0.63)	>1.86		0.36
Stacking	2.47	3.10		3.27 (1.63)	1.02 (0.51)			0.17
Reclaiming	4.89	0.93		2.73 (1.36)	1.53 (0.76)			0.18
Re Screening	0.38				0.49 (0.25)			0.23
Ship Loader	3.90	0.93	0.50	2.18 (1.09)	1.22 (0.61)		0.26	0.17
Vehicles	2.26	0.33		1.05 (1.05)	0.58 (0.58)	>2.21		0.96
Haulage	1.54	1.03		1.23 (1.23)	0.21 (0.21)	4.23 (1.81)		0.16
FELs		2.75	0.50				1.52	
Dozing	0.29	2.58						
Wind Erosion	5.18	4.18		3.61 (2.75)	2.68 (2.68)	>2.57	4.90	1.95
Total	**41.28**	**21.38**	**1.44**	**18.40 (11.28)**	**9.03 (6.25)**	**NA**	**NA**	**4.18**
Total (tpa)	1,302	674	45.6	580 (356)	285 (197)	NA	NA	NA
(kg/tonne)	0.0178	0.0929	0.0276	0.0129 (0.079)	0.0114 (0.079)	NA	NA	NA

Notes:

1) The Nelson Point BHPB Haulage estimate (BHP Billiton, 2002) includes 2.42 g/s from front end loaders, which is a factor of 10 higher than estimated for front end loaders loading trucks in this study.
2) The values are brackets are based assuming emissions from material handling are 50% of the “high” moisture content and considering the effect of a wind shelter belt for FMG operations (see Section 4.1)

Also included in Table 8 is an estimate of the emissions based on assuming lower dust emissions for material handling and for wind erosion considering the relatively high moisture content of the ore and potential reduction in wind erosion due to a tree shelter belt (see Section 7.3 for a further discussion). These indicate that emissions will be 61% of that utilised in this study.

7. PREDICTED CONCENTRATIONS

Dust concentrations have been predicted for four scenarios. These are:

- existing (2002/2003) emissions, with Nelson Point and Finucane Island (including the DRI) stockpiling and ship loading operations;
- the proposed Hope Downs project at a throughput of 25 Mtpa;
- FMG at a throughput of 45 Mtpa; and
- Cumulative impact of the existing and proposed projects.

For future cumulative impacts, the future BHP Billiton port operations (stockpiling and ship loading at Nelson Point and Finucane Island and the DRI stockpiling and ship loading at Finucane Island) have been conservatively assumed to have the same emissions as those in 2002/2003. Despite the large proposed increase in throughput, the BHP Billiton (2002) dust management program predicts that future emissions from BHP Billiton operations will significantly decrease due to improvements in dust control.

Other sources such as other operations at the port, vehicular traffic on public roads and the operation of the DRI plant at Boodarie have been omitted as they are considered to make a relatively small contribution to the dust concentrations in the study area due to either their size or their location.

7.1 COMPARISON TO EXISTING LEVELS

Ambient monitoring data from the Port Hedland monitoring network operated by BHP Billiton were available for 12 months from July 2002 to June 2003 at the Town, Hospital, Boodarie, South Hedland and Airport monitoring sites.

Comparison of selected statistics are presented in Table 9 and Figure 4 and 5. Here the daily model results from the BHP Billiton stockpiling and ship loading operations have been compared to daily monitored data with the "background" levels for that day subtracted. This comparison removes the added uncertainty due to other sources in the region. Background levels were defined as the lowest concentration monitored from any of the "background" monitoring sites (Boodarie, South Hedland and the Airport) for that day.

Table 9 Observed 24-hour Concentrations at Port Hedland versus Predicted Concentrations from the Nelson Point and Finucane Island Stockpiling and Ship Loading Operations

Particulate Size	Statistic	Observations (minus Background) ($\mu g/m^3$)		Modelled ($\mu g/m^3$)	
		Town	**Hospital**	**Town**	**Hospital**
TSP	Maximum	257	296	239	269
	99 Percentile	205	208	193	223
	95 Percentile	163	165	162	187
	90 Percentile	143	142	141	157
	Average	82	64	81	68
PM_{10}	Maximum	69	95	102	132
	99 Percentile	67	75	85	97
	95 Percentile	57	56	72	82
	90 Percentile	49	45	63	69.7
	Average	26	20	36	30.7
$PM_{2.5}$	Maximum	81.4	56.9	38.2	41.8
	99 Percentile	75.0	49.8	32.1	31.9
	95 Percentile	53.4	29.7	26.0	25.5
	90 Percentile	42.9	25.3	21.8	21.6
	Average	18.4	10.1	12.3	9.8

The results from Table 9 and Figures 4 and 5 indicate that the TSP predictions are in good agreement with the observations, with the PM_{10} concentrations over-predicted and the $PM_{2.5}$ concentrations under-predicted. This reversal in the predictions for the PM_{10} and $PM_{2.5}$ concentrations is considered to be primarily due to uncertainty in the size distributions of the particulate used. This is particularly the case for DRI dust which is likely to have a higher fraction of particulate below $PM_{2.5}$ than the assumed size distribution. Therefore to model the $PM_{2.5}$ and PM_{10} concentrations more accurately, data on the particle size distribution for the various sources is required. Other reasons for the differences in the predicted and observed concentrations are due to not accounting for other local sources such as from vehicular activity in and around the town of Port Hedland and that the observations minus the background data contain are uncertain. This is seen in that the PM_{10} concentrations are lower than the $PM_{2.5}$ concentrations for the maximum and 99th percentile statistics. This discrepancy may indicate that the highest observed PM_{10} concentrations (without background concentrations) are underestimated or that the highest $PM_{2.5}$ events are overestimated.

Figure 6 and 7 present the contribution to TSP levels from the existing stockpiling and shipping operations indicating the localised nature of the impacts and the high levels in the town centre area with relatively low contributions to dust levels at Cooke Point and Wedgefield.

7.2 PREDICTED FUTURE CONCENTRATIONS

7.2.1 Predicted Concentrations from the FMG Stockpiling and Ship Loading Facilities

Table 10 and Figures 8 to 12 present the predicted maximum 24-hour and annual average dust concentrations from the FMG operations.

This shows the following:

- The 24-hour TSP concentration contours extend furtherest to the north northeast and to the east of the stockpiling areas. The high levels to the north northeast are considered to be due to the alignment of the stockpiles and ship loading in this direction, such that that for winds from the south southwest, all the sources, excepting the car dumper are in a line. That is the high concentrations are not due to unfavourable dispersion in this direction, but to the alignment of the sources. The other area of high concentrations to the east is considered due to the strong prevailing winds with the maximum occurring to the north of Wedgefield. This indicates that locating the stockpiling areas as far north as possible has reduced impacts on Wedgefield.
- The maximum 24-hour TSP concentration at any of the receptors is 38.2 $\mu g/m^3$ occurring at the Port Hedland town location, due to the alignment of the sources and the proximity of the ship loader to the town monitor.
- Annual concentrations contours are predicted to be more circular and extend slightly further to the east south-east of the site (see the 2 $\mu g/m^3$ TSP contour in Figure 9). This distribution is due to the frequency of annual winds with the higher concentrations to the east south east due to the prevalent westerlies. Dust impacts into the port area of Port Hedland are not as prominent as though the sources line up for this direction, the frequency of south south-westerlies is low (see Figure 1). The maximum annual average TSP concentration at nearby receptors is 5.7 $\mu g/m^3$, occurring at Wedgefield.
- The PM_{10} and $PM_{2.5}$ contours show the same patterns as the TSP contours. The maximum 24-hour and annual average PM_{10} concentrations at the receptors are predicted to be 22.2 and 3.08 $\mu g/m^3$ with maximum 24-hour and annual average $PM_{2.5}$ concentrations of 6.9 and 1.13 $\mu g/m^3$.

Table 10 Predicted Concentrations from Existing and Future Projects (excluding Background Concentrations)

	Maximum 24-hour (μg/m^3)				Annual Average (μg/m^3)			
	Exist	**FMG**	**HD**	**Exist + FGM HD**	**Exist**	**FMG**	**HD**	**Exist + FGM HD**
TSP								
Town	239	38.2	31.8	241	81.1	3.9	3.4	88.5
Hospital	269	29.8	12.4	272	68.0	2.1	1.33	71.4
Spinifex Hill	116	11.1	7.8	130	16.9	1.3	0.63	18.9
Cooke Point	45.4	8.21	4.6	51.6	6.5	0.88	0.36	7.73
Wedgefield	34.5	27.1	8.9	41	4.7	5.7	0.98	11.4
PM_{10}								
Town	111	22.2	14.5	114	39.6	2.11	1.6	43.6
Hospital	141	20.8	7.0	150	33.2	1.29	0.75	35.4
Spinifex Hill	65.4	7.91	5.1	74.8	10.0	0.87	0.41	11.4
Cooke Point	30.0	5.66	3.6	35.4	4.38	0.63	0.25	5.33
Wedgefield	21.6	16.6	5.3	25.6	3.04	3.08	0.57	7.07
$PM_{2.5}$								
Town	38.2	6.9	4.4	39.6	12.3	0.66	0.49	13.5
Hospital	41.8	6.8	2.2	42.9	9.8	0.41	0.24	10.4
Spinifex Hill	19.5	2.7	1.7	22.3	3.0	0.28	0.13	3.4
Cooke Point	9.3	2.1	1.3	11.0	1.3	0.21	0.085	1.62
Wedgefield	9.1	5.7	2.1	9.5	1.0	1.13	0.22	2.39

7.2.2 Predicted Concentrations from Activities to FMG

Table 11 presents the predicted contribution in percent to the overall concentrations predicted from the FMG operations. Table 11 indicates that:

- At the Town and Hospital monitor and at Spinifex Hill and Cooke Point the major contributors to the peak 24-hour concentrations will be haulage, the ship loader and stacking and reclaiming. For annual concentrations, the order is slightly different with the ship loader, stacking and reclaiming and haulage being the major sources. Haulage is less of a source for annual contributions due to the less frequent source than the other two operations.
- At Wedgefield the major sources predicted for the peak 24-hour concentrations are haulage, wind erosion and reclaiming and stacking. Wind erosion is a significant source for Wedgefield as the site is generally upwind of the prevailing westerlies in summer. For the annual contributions the order is reclaiming and stacking, with wind erosion and haulage next. Wind erosion and haulage decrease in their contribution due to the less frequent nature of thee sources.

It is noted that the predicted contributions are indicative and dependent on how dusty the ore is. With the ore expected to be less dusty than modelled the dust emissions from material handling will decrease and therefore the relative contribution from sources such as haulage, wind erosion and vehicles will increase.

Table 11 Predicted Contribution (%) to the Overall PM_{10} Concentrations from the FMG Operations

	Car Dumper	Ship Loader	Transfer at Jetty	Other Transfers	Reclaimer + Stackers	Screen House	Haulage	Vehicles	Wind Erosion
Maximum 24-hour									
Town	0.5	33.9	6.7	5.0	20.1	6.7	56.2	4.5	16.4
Hospital	0.2	20.2	3.0	6.7	20.8	7.1	65.4	7.5	11.0
Spinifex Hill	0.7	28.0	6.3	5.8	32.6	7.7	58.8	8.1	3.4
Cooke Point	0.5	19.0	3.3	11.9	42.0	13.2	60.3	8.7	4.7
Wedgefield	0.8	13.1	2.3	14.5	40.0	18.2	59.3	11.2	43.0
99^{th} Percentile 24-hour									
Town	0.5	49.4	10.4	7.1	30.3	9.4	45.4	6.8	0.8
Hospital	0.3	26.0	4.2	6.3	24.4	8.0	65.1	7.2	0.8
Spinifex Hill	0.5	25.4	5.2	7.3	35.7	9.1	62.3	9.5	2.2
Cooke Point	0.5	19.2	3.6	9.8	30.9	10.3	49.1	7.5	1.8
Wedgefield	0.6	9.0	1.8	16.3	38.7	19.4	32.2	7.9	51.0
Annual Average									
Town	0.3	41.8	8.0	4.7	21.6	5.7	12.4	4.9	0.5
Hospital	0.4	25.2	5.3	6.4	26.2	7.5	22.2	6.4	0.6
Spinifex Hill	0.6	26.2	5.1	6.7	30.6	7.8	15.8	7.1	0.4
Cooke Point	0.5	20.4	4.0	8.8	34.2	10.0	14.5	7.5	3.6
Wedgefield	0.5	5.1	1.0	13.0	35.5	15.3	7.7	6.2	15.5

Note: For the maximum and 99^{th} percentile 24-hour concentrations the sum of the contributions will exceed 100% as the maximums from the individual sources will not occur at the same time.

7.2.3 Predicted Concentrations from the Existing, FMG and HD Ship Loading Facilities

Table 10 and Figures 13 and 14 present the predicted cumulative impacts from the existing stockpiling and ship loading sources with the addition of the FMG and Hope Downs projects. These concentrations exclude background sources which are addressed in Section 7.2.3.

Table 10 and Figures 13 and 14 indicate that:

- Maximum 24-hour TSP concentrations at the locations with existing high levels (the Town and Hospital monitors) will increase only slightly (less than 1%) over the existing levels. This slight increase is due to maximum 24-hour concentrations from the existing and proposed projects occurring under different days and different wind conditions. At sites where the existing concentrations are lower the additional contribution will be greater;
- Annual average TSP concentrations are predicted to increase most at the town location and in Wedgefield with increases of 7.4 and 6.7 μg/m^3. It is noted that the cumulative TSP

concentrations at Wedgefield will be still less than 1/7 of the contribution currently from the existing operations at the town site; and

- The contribution of PM_{10} and $PM_{2.5}$ to levels at the sites with highest concentrations (the Town and Hospital monitors) will add an additional 6% and 10% to the maximum 24-hour and annual average concentrations.

7.2.4 Predicted Concentrations from the Existing, FMG and HD Ship Loading Facilities (including background Concentrations)

Table 12 and Figures 15 to 22 present the dust concentrations for the existing situation with the inclusion of dust from background sources. The data indicates that:

- There will be little or no change to the maximum 24-hour concentrations at the sites with highest existing concentrations (the Town and Hospital monitors). This occurs as the maximum 24-hour concentrations from the existing and proposed projects occur under different days and different wind conditions. At sites where the existing concentrations are lower the additional contribution will be greater, with the greatest increase of 9 ug/m^3 at Spinifex hill;
- Annual average concentrations show a relatively larger increase in concentrations than the maximum 24-hour concentrations with the greatest increase occurring at the town and Wedgefield sites. These sites have the largest increase due to their proximity to the ship loading and to the general stockpiling facilities respectively.

Table 12 Predicted Concentrations from Existing and Future Projects (including Background Concentrations)

	Maximum 24-hour (μg/m^3)				Annual Average (μg/m^3)				Number of exceedances			
	Bkgd	**Bkgd + Exist**	**Bkgd + Exist HD**	**Bkgd + Exist HD FGM**	**Bkgd**	**Bkgd + Exist**	**Bkgd + Exist HD**	**Bkgd + Exist FGM HD**	**Bkgd**	**Bkgd + Exist**	**Bkgd + Exist HD**	**Bkgd + Exist FGM HD**
TSP	# 302								>150			
Town	130	316	316	316	29.7	112	115	119	0	70	74	80
Hospital	130	291	291	291	29.7	97	98	100	0	68	70	75
Spinfex Hill	130	156	157	165	29.7	47.3	47.9	49.3	0	1	1	1
Cooke Point	130	137	137	143	29.7	36.5	36.9	37.8	0	0	0	0
Wedgefield	130	131	132	139	29.7	34.5	35.4	41.1	0	0	0	0
PM_{10}	# 279								>50			
Town	71.6	148	148	148	20.1	59.6	61.3	63.6	17	229	242	255
Hospital	71.6	146	146	155	20.1	53.6	54.4	55.7	17	184	187	192
Spinfex Hill	71.6	86.9	91.5	93.0	20.1	30.1	30.5	31.5	17	44	47	51
Cooke Point	71.6	75.5	75.7	79.3	20.1	24.4	24.7	25.4	17	24	25	25
Wedgefield	71.6	80.6	81.3	88.5	20.1	23.2	23.8	27.0	17	17	20	27
$PM_{2.5}$	# 253								>25			
Town	51.7	65.0	65.0	65.0	10.9	23.2	23.5	24.3	17	130	133	150
Hospital	51.7	55.2	55.3	55.3	10.9	20.3	20.5	20.9	17	100	102	113
Spinfex Hill	51.7	54.0	54.0	54.3	10.9	13.8	13.9	14.3	17	35	36	38
Cooke Point	51.7	52.0	52.0	52.2	10.9	12.2	12.2	12.5	17	19	19	25
Wedgefield	51.7	56.0	56.7	58.9	10.9	12.0	12.1	13.3	17	19	19	22

Note: The number of exceedances have been annualised to that which would occur if monitoring occurred for 365 days in a year. This is unlike the number of exceedances in Table 2 which are based only on the days when observations were taken.

7.2.5 Comparison to Various Standards

As detailed in the model comparison with observations (Section 7.1), the modelling provides good agreement for the TSP concentrations, whilst over-predicting and under-predicting the PM_{10} and $PM_{2.5}$ concentrations respectively. With the relatively large difference in modelled to observed concentrations it is considered that modelling predictions of the PM_{10} and $PM_{2.5}$ should be viewed more in a relative sense showing areas where highest concentrations occur and the changes that will occur with the projects. Predictions of the number of exceedances of PM_{10} and $PM_{2.5}$ standards also can be misleading as the number of exceedances are not linearly related to the predicted concentrations. For an example, over-predicting concentrations by 25% can easily lead to a resultant over-prediction of the number of exceedance by 100%. As such, for comparison to the relevant objectives and standards the following is made noting that the modelling of new projects is considered conservative:

- TSP - There will be no additional exceedances of the 24-hour TSP level of 260 μg/m^3 with no increases in the maximum 24-hour concentrations at the sites most affected currently (The Town and Hospital monitor). This occurs as the conditions which lead to the highest concentrations (i.e. consistent westerly or easterly winds) will have little contribution from the Hope Downs and FMG projects. The predicted largest increase the maximum 24-hour concentration occurs at Spinifex hill with a 9 $\mu g/m^3$ increase. Annual concentrations will increase by around 7 ug/m^3 at the Town monitor and Wedgefield. With the future projects it is noted that Wedgefield will have annual contribution from all operations that is around 14% of that presently (2002/2003) contributed by operations at the Town monitor. Including background concentrations the future annual levels would be 37% of the existing levels at the town monitor;

- PM_{10} - Generally a small increase in the maximum 24-hour concentrations with a maximum increase of 9 $\mu g/m^3$ at the Hospital monitor Annual averages are predicted to increase by up to 4 $\mu g/m^3$;
- $PM_{2.5}$ - An increase less than 1 $\mu g/m^3$ in the maximum 24-hour concentrations at 4 of the locations with the largest increase of 2.9 $\mu g/m^3$ at Wedgefield. Annual averages are predicted to increase less than 1 $\mu g/m^3$ at three of the locations and up to 1.3 $\mu g/m^3$ at the Town monitor and Wedgefield site

7.3 PREDICTED CONCENTRATIONS WITH "ANTICIPATED" DUST CONTROLS

Section 7.2 presents concentrations based on the conservative assumption that the material handling dustiness will be equivalent to the "high" moisture content default in the NPI emission estimation technique. It is argued however that as the ore will be reasonably wet (from a beneficiation plant for the Chichester ore and moisture conditioned for the Mindy Mindy ore), that the dust emissions will be less than this. As such, this section presents what is considered to be more realistic estimates of the dust concentrations from the FMG operations. These estimates are based on:

- Emissions from all handling operations (where the ore is discharged from one surface to another) at 50% of the NPI high moisture content defaults;
- taking into account the effect of shelter belt on wind erosion. In this case the control factor for wind erosion is increased to 62% from 50%; and.
- Other operations such as from vehicles and haulage remaining the same as they are primarily generated by wheels.

For the Hope Downs project material handling operations also were reduced by 50% in line with the Hope Downs Dust assessment (Hope Downs, 2002).

Table 8 presents a summary of the revised emissions, indicating that on an annual basis the FMG and Hope Downs emissions are reduced by 39% and 31% over that used in the more conservative assessment in section 7.2.

Table 13 presents the concentrations from the existing and future projects (excluding background dust) with the "anticipated" dust emissions. Table 13 can be compared to Table 10 which is based on the more conservative (higher) emission rates.

Table 13 Predicted Concentrations from Existing and Future Projects (excluding Background Concentrations) with "Anticipated" Dust Controls

	Maximum 24-hour ($\mu g/m^3$)				**Annual Average ($\mu g/m^3$)**			
	Existing	**FMG**	**HD**	**Existing + FGM HD**	**Existing**	**FMG**	**HD**	**Existing + FGM HD**
TSP								
Town	239	29.9	18.2	240	81.1	2.3	1.8	85.2
Hospital	269	25.0	8.5	269	68.0	1.3	0.75	70.1
Spinifex Hill	116	9.0	6.2	125	16.9	0.8	0.37	18.1
Cooke Point	45.4	6.71	3.8	48.7	6.5	0.54	0.22	7.2
Wedgefield	34.5	22.0	6.9	35.7	4.7	3.5	0.65	8.8
PM_{10}								
Town	111	17.5	9.4	111	39.6	1.2	0.86	41.9
Hospital	141	17.7	5.2	146	33.2	0.83	0.43	34.6
Spinifex Hill	65.4	6.51	4.1	71.8	10.0	0.53	0.24	10.8
Cooke Point	30.0	4.64	3.0	32.9	4.38	0.38	0.15	5.0
Wedgefield	21.6	13.4	4.1	22.6	3.04	1.9	0.38	5.5
$PM_{2.5}$								
Town	38.2	5.4	2.9	38.9	12.3	0.39	0.27	13.0
Hospital	41.8	5.8	1.6	41.8	9.8	0.27	0.14	10.2
Spinifex Hill	19.5	2.2	1.3	21.4	3.0	0.17	0.10	3.2
Cooke Point	9.3	1.6	1.1	10.2	1.3	0.13	0.052	1.51
Wedgefield	9.1	4.2	1.7	9.4	1.0	0.70	0.15	1.89

Table 14 presents the percentage contribution from the various FMG sources to the total contribution to FMG dust levels with the "anticipated" dust controls. This indicates in comparison to Table 11 that haulage is now the dominant source for the maximum 24-hour averages, though wind erosion can be a large source at Wedgefield. For the annual average concentrations, the ship loader is still the largest source to the town monitor, whilst for the other receptors, reclaimers/stackers and haulage are generally predicted to be the largest contributors.

Table 14 Predicted Contribution (%) to the Overall PM_{10} Concentrations from the FMG Operations at the "Anticipated" Dust Controls

	Car Dumper	Ship Loader	Transfer at Jetty	Other Transfers	Reclaimer + Stackers	Screen House	Haulage	Vehicles	Wind Erosion
Maximum 24-hour									
Town	0.3	23.0	4.6	3.4	13.7	4.5	76.3	6.1	16.9
Hospital	0.1	12.8	1.9	4.3	13.2	4.5	83.0	9.6	10.6
Spinifex Hill	0.4	18.4	4.1	3.8	21.4	5.1	77.1	10.6	3.4
Cooke Point	0.4	12.5	2.2	7.8	27.6	8.7	79.1	11.4	4.7
Wedgefield	0.5	8.6	1.5	9.6	26.4	12.0	78.1	14.7	43.0
99th Percentile 24-hour									
Town	0.4	43.4	9.2	6.3	26.6	8.2	79.7	11.9	1.1
Hospital	0.2	16.0	2.6	3.9	15.1	5.0	80.4	8.9	0.8
Spinifex Hill	0.4	17.2	3.5	4.9	24.2	6.2	84.4	12.8	2.3
Cooke Point	0.4	13.9	2.6	7.1	22.3	7.5	71.1	10.9	1.9
Wedgefield	0.5	6.9	1.4	12.6	29.9	15.0	49.8	12.3	59.9
Annual Average									
Town	0.3	35.6	6.8	4.0	18.4	4.9	21.1	8.3	0.7
Hospital	0.3	19.5	4.1	4.9	20.3	5.8	34.5	9.9	0.7
Spinifex Hill	0.5	21.3	4.2	5.4	24.8	6.4	25.6	11.5	0.4
Cooke Point	0.4	16.0	3.2	6.9	26.8	7.8	22.8	11.7	4.3
Wedgefield	0.4	4.2	0.8	10.6	29.2	12.6	12.6	10.2	19.4

Note: For the maximum and 99th percentile 24-hour concentrations the sum of the contributions will exceed 100% as the maximums from the individual sources will not occur at the same time.

Table 15 present the predicted dust levels for the various scenarios (including background dust) with the FMG and Hope Downs operations having dust emissions based on 50% of the dust emitted from high moisture ores. Table 15 indicates that there is generally only a small increase in dust levels over the existing dust levels. For example at the north west edge of Wedgefield, which is generally predicted to be the receptor most impacted by the FMG operations, due to the prevailing westerlies in summer, it is predicted that there will be between a 2.3% and 4.9% increase in the maximum 24-hour average concentrations of TSP, PM_{10} and $PM_{2.5}$; and approximately a 5.8% increase in the annual average concentration of $PM_{2.5}$. These percentage increases are lower than that predicted in Section 7.2, with a predicted increase of between 3.9% and 8.8% for the maximum 24-hour concentrations and 10% for the annual average $PM_{2.5}$ concentrations.

Table 15 Predicted Concentrations from Existing and Future Projects (including Background Concentrations) at "Anticipated" Dust Controls

	Maximum 24-hour (µg/m^3)				Annual Average (µg/m^3)				Number of exceedances			
	Bkgd	**Bkgd + Exist**	**Bkgd + Exist HD**	**Bkgd + Exist HD FGM**	**Bkgd**	**Bkgd + Exist**	**Bkgd + Exist HD**	**Bkgd + Exist FGM HD**	**Bkgd**	**Bkgd + Exist**	**Bkgd + Exist HD**	**Bkgd + Exist FGM HD**
TSP	# 302								>150			
Town	130	316	316	316	29.7	112	113	116	0	70	71	74
Hospital	130	291	291	291	29.7	97	97.4	99.0	0	68	68	73
Spinfex Hill	130	156	157	162	29.7	47.3	47.7	48.5	0	1	1	1
Cooke Point	130	137	137	141	29.7	36.5	36.8	37.3	0	0	0	0
Wedgefield	130	131	131.4	137	29.7	34.5	35.1	38.6	0	0	0	0
PM_{10}	# 279								>50			
Town	71.6	148	148	148	20.1	59.6	60.5	61.9	17	229	241	246
Hospital	71.6	146	146	151	20.1	53.6	54.1	54.9	17	184	187	190
Spinfex Hill	71.6	86.9	90.5	91.3	20.1	30.1	30.4	30.9	17	44	46	47
Cooke Point	71.6	75.5	75.6	78.3	20.1	24.4	24.6	25.0	17	24	25	25
Wedgefield	71.6	80.6	80.9	84.9	20.1	23.2	23.6	25.6	17	17	18	21
$PM_{2.5}$	# 253								>25			
Town	51.7	65.0	65.0	65.0	10.9	23.2	23.3	23.8	17	130	130	141
Hospital	51.7	55.2	55.2	55.3	10.9	20.3	20.4	20.7	17	100	102	107
Spinfex Hill	51.7	54.0	54.0	54.1	10.9	13.8	13.9	14.1	17	35	36	38
Cooke Point	51.7	52.0	52.0	52.1	10.9	12.2	12.2	12.4	17	19	19	20
Wedgefield	51.7	56.0	56.6	57.9	10.9	12.0	12.1	12.8	17	19	19	20

Note: The number of exceedances have been annualised to that which would occur if monitoring occurred for 365 days in a year. This is unlike the number of exceedances in Table 2 which are based only on the days when observations were taken.

8. CONCLUSION

This report presents an assessment of the likely change in dust levels with the introduction of the FMG and HD projects. The study has used emission estimates from the existing stockpiling and ship-loading facilities and proposed projects, the dispersion model Ausplume and an annual meteorological file from Port Hedland.

It is acknowledged that model predictions of fugitive dust are to a degree uncertain due primarily to the complexity and uncertainty in estimating dust emissions. However this was also acknowledged by the EPA (2003) in its assessment of the Dampier port upgrade (SKM 2003), stated that modelling results have a degree of uncertainty and proponents should focus on management measures to control dust.

In this study dust emissions were estimated from:

- emission factors, primarily from the National Pollutant Inventory (NPI);
- operational data for existing sources provided by BHP Billiton, the EPA and from other publicly available data (and where necessary qualified assumptions);
- the conservative assumption that for future cumulative impacts, the emissions from BHP Billiton activities were to remain at the 2002/2003 levels. This is conservative in that BHP Billiton in their dust management plan anticipate that by 2011 there would be a reduction from the 2000 levels in Port Hedland by between 41 to 81%;
- for the new projects, dust emissions for operational activities were estimated from the NPI so called "high" moisture default value. This is considered conservative in that the classification into just "high" and "low" moisture groups does not reflect the true variation that can occur in iron ore dustiness and that at high enough moisture contents the dust emissions are negligible. As the Chichester ore has been through a wet beneficiation process, it will have a high moisture and low dust content such that the dust emissions during material handling should be very low. As such, a value half that of the "high" moisture value as used in the Hope Downs assessment should be more appropriate.

Noting the conservative assumptions in the modelling, the modelling indicates that:

- highest impacts of FMG will be at the:

1) Town monitor due to proximity of the ship loader and that the sources are aligned in a south southwest – north northeast direction such that under a south southest wind dust sources will be cumulative.
2) North west corner of Wedgefield. This is due to the prevailing westerly winds in summer.

- Generally there will a small increase in the maximum 24-hour concentrations in Port Hedland as the wind conditions that lead to the existing high concentrations (westerlies and easterlies) do not favour the transport of dust from HD and FMG to this area.

Again it is noted the modelled dust levels are indicative and considered conservative and that reliance instead should be placed on ensuring robust dust management plan. This will include:

- Applying engineering solutions to reduce dust emissions during the plant design including:
  - Dust extraction and wet scrubbing at the car dumper
  - Totally enclosing conveyor transfer points and installing dry, reverse plug bag filters
  - Covering the conveyor from the car dumper to the screen house and also the conveyor out to the ship loader
  - Enclosing screens and providing dust extraction with bag houses if required after further test work
  - Arrangement of the stockpiles and possibly provision of a tree shelter belt to reduce dust
  - Fitting the stockpile area with a fixed cannon based spray system
  - Providing stacker and reclaim booms with spray heads to minimise dust
  - Minimising the discharge point height and the ship loader and installing water sprays
  - Identifying road/traffic areas which are likely to produce unacceptable dust and ensuring these are sealed. Low traffic areas will be controlled by water trucks and speed limits.
- Installation of a real time continuous dust monitoring network to define accurately the impacts by the operations on the nearest receptors such as Wedgefield. Such a system, including a background site and wind direction measurements will enable the dust contribution from the operations to be evaluated.
- Dust testing of the ore which will ascertain the optimum moisture content of the ore to be delivered. This conditioning of the ore may be necessary for the Mindy Mindy ore dependent on where it is mined relative to water table.

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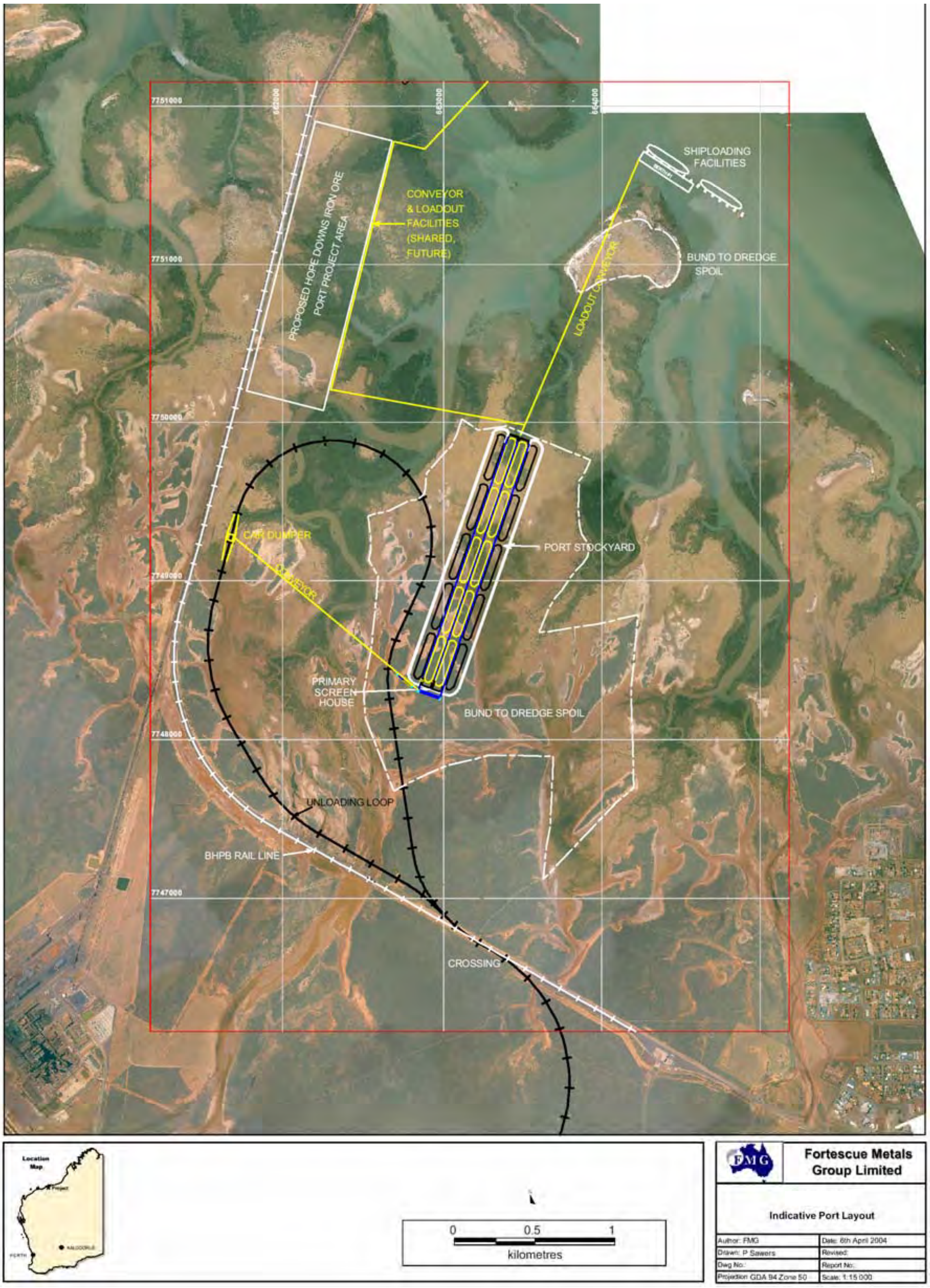


Figure 1

Fortescue Metals Group Proposed Port Layout

Client: FMG	ENVIRON	
Project: Dust Modelling	Drawn: KEH	Date: 30-Jun-04

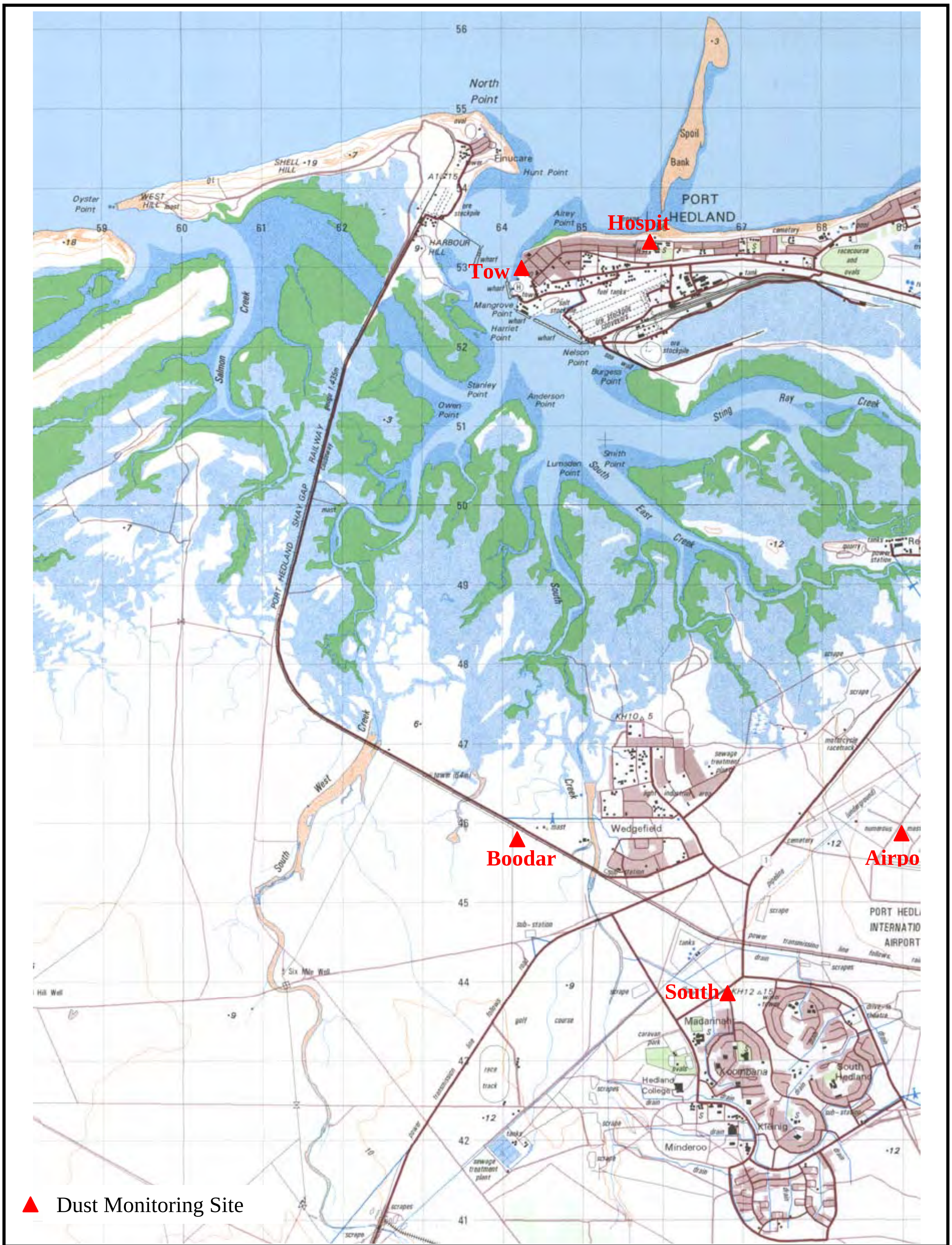


Figure 2

Location of Ambient Dust Monitoring Sites

Client: FMG	ENVIRON	
Project: Dust Modelling	Drawn: KEH	Date: 30-Jun-04

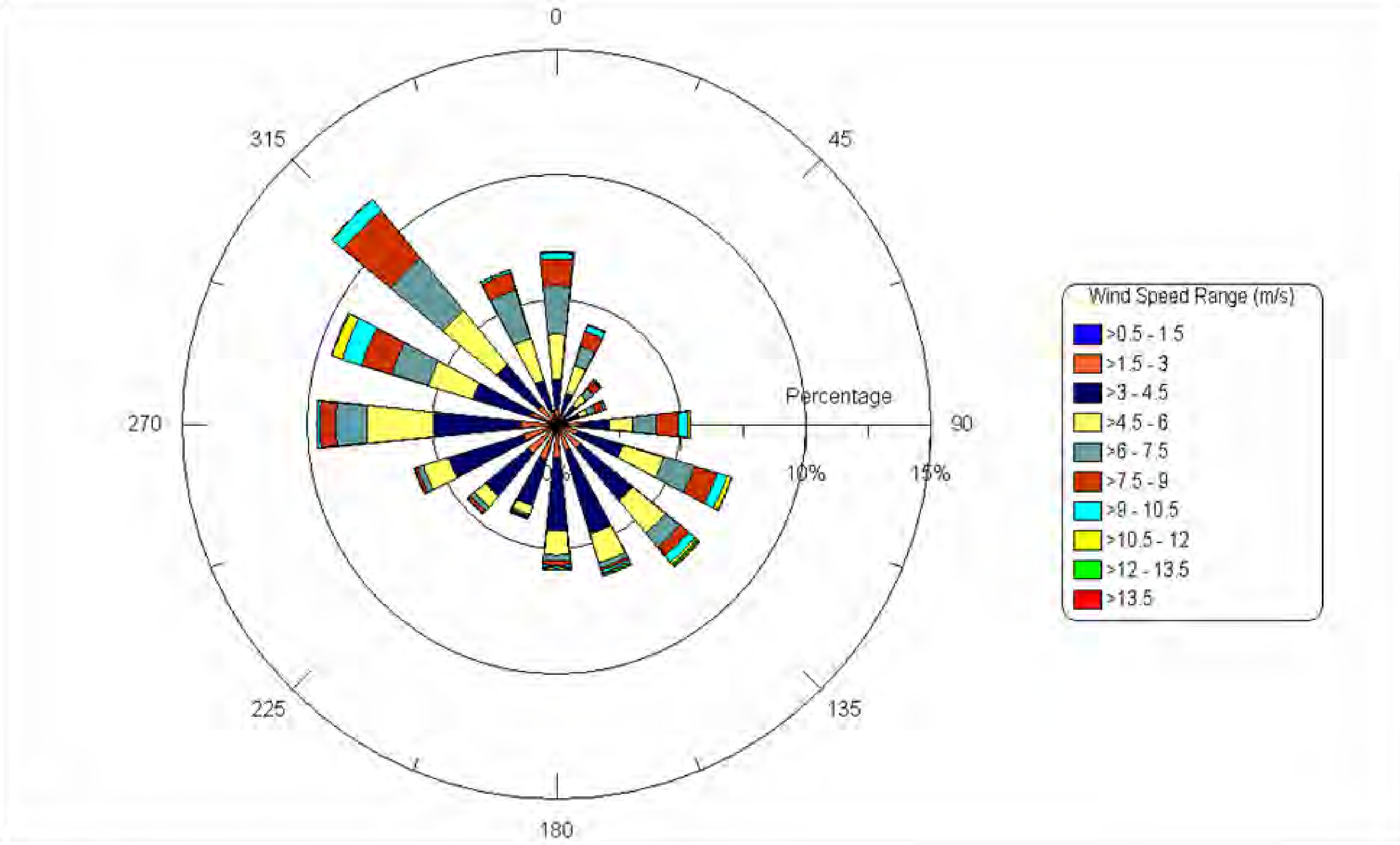
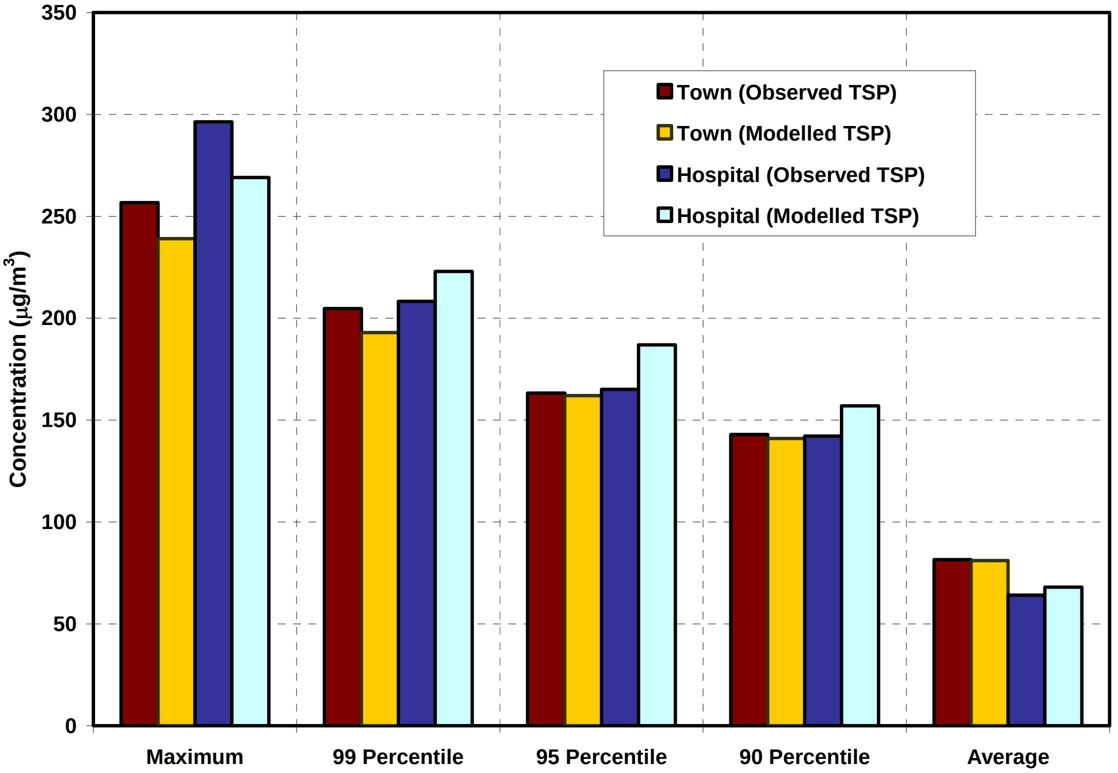


Figure 3

Annual Wind Rose for Port Hedland Airport

1 July 2002 to 30 June 2003

Client: FMG	ENVIRON	
Project: Dust Modelling	Drawing Ref: KEH	Date: 30-Jun-04


350
300
250
200
150
100
50
0
Concentration (µg/m3)
Town (Observed TSP)
Town (Modelled TSP)
Hospital (Observed TSP)
Hospital (Modelled TSP)
Maximum
99 Percentile
95 Percentile
90 Percentile
Average

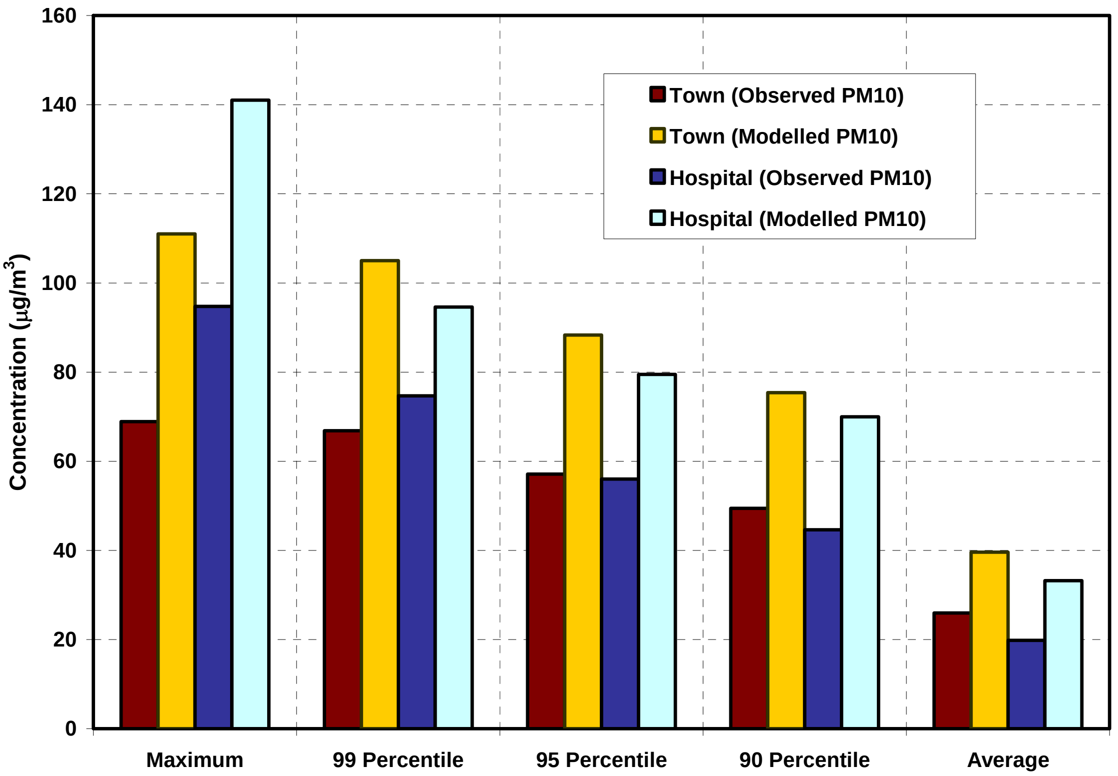

160
140
120
100
80
60
40
20
0
Concentration (µg/m3)
Town (Observed PM10)
Town (Modelled PM10)
Hospital (Observed PM10)
Hospital (Modelled PM10)
Maximum
99 Percentile
95 Percentile
90 Percentile
Average

Figure 4 Predicted TSP and PM_{10} Concentrations from the Nelson Point and Finucane Island stockpiling and ship loading operations versus observations for 2002/2003

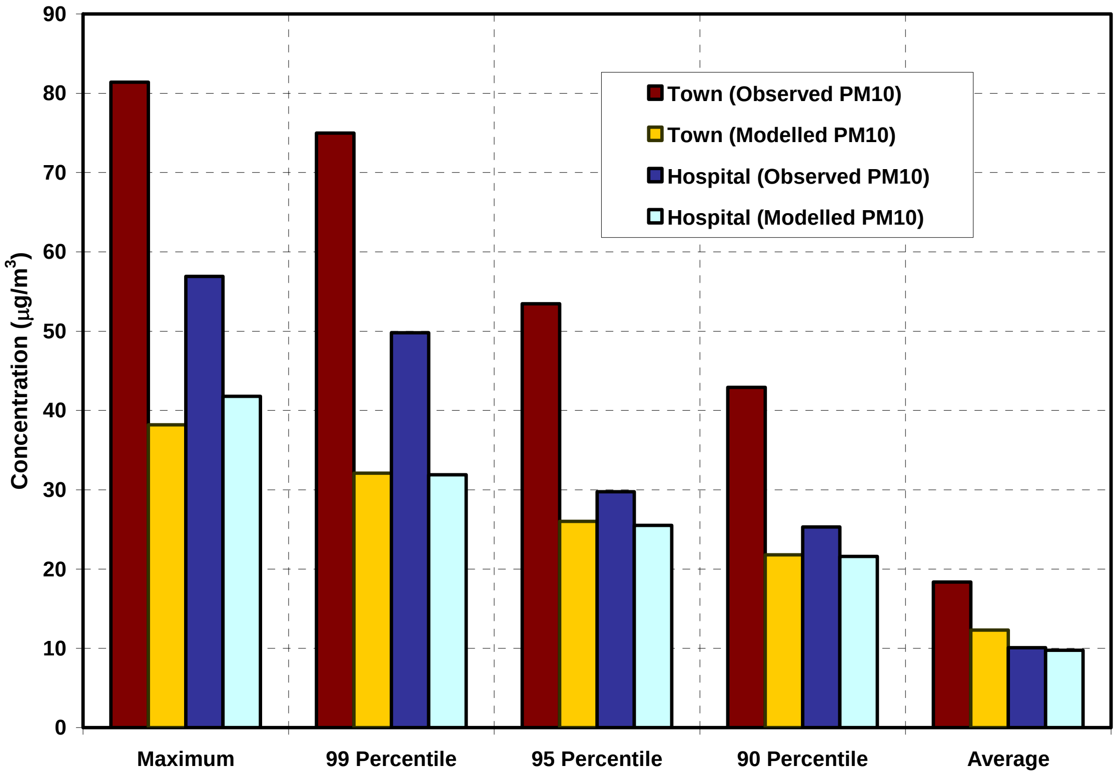


Figure 5 Predicted $PM_{2.5}$ Concentrations from the Nelson Point and Finucane Island stockpiling and ship loading operations versus observations for 2002/2003

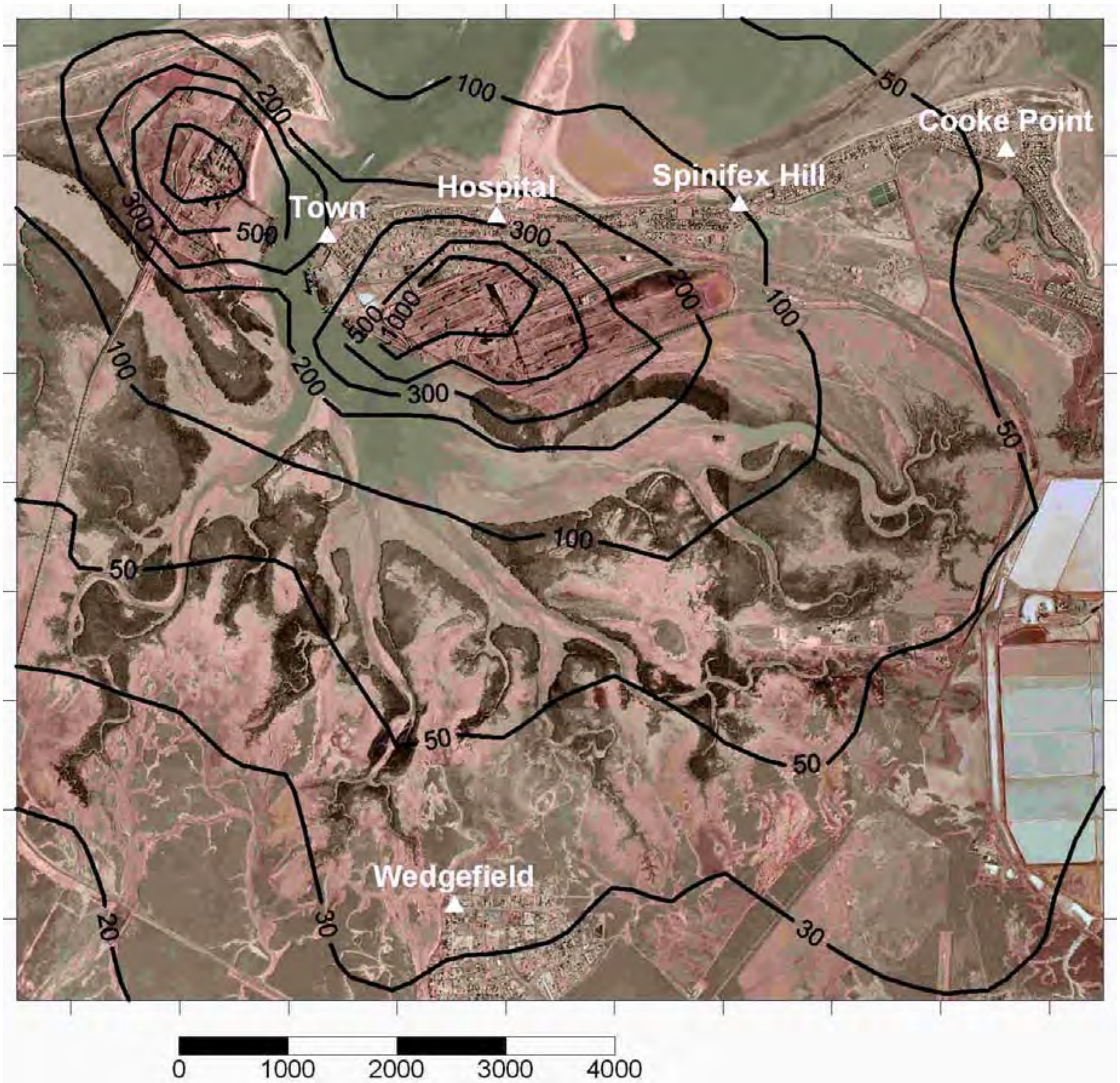


Figure 6 Predicted maximum 24-hour TSP Concentration (μg/m^3) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation

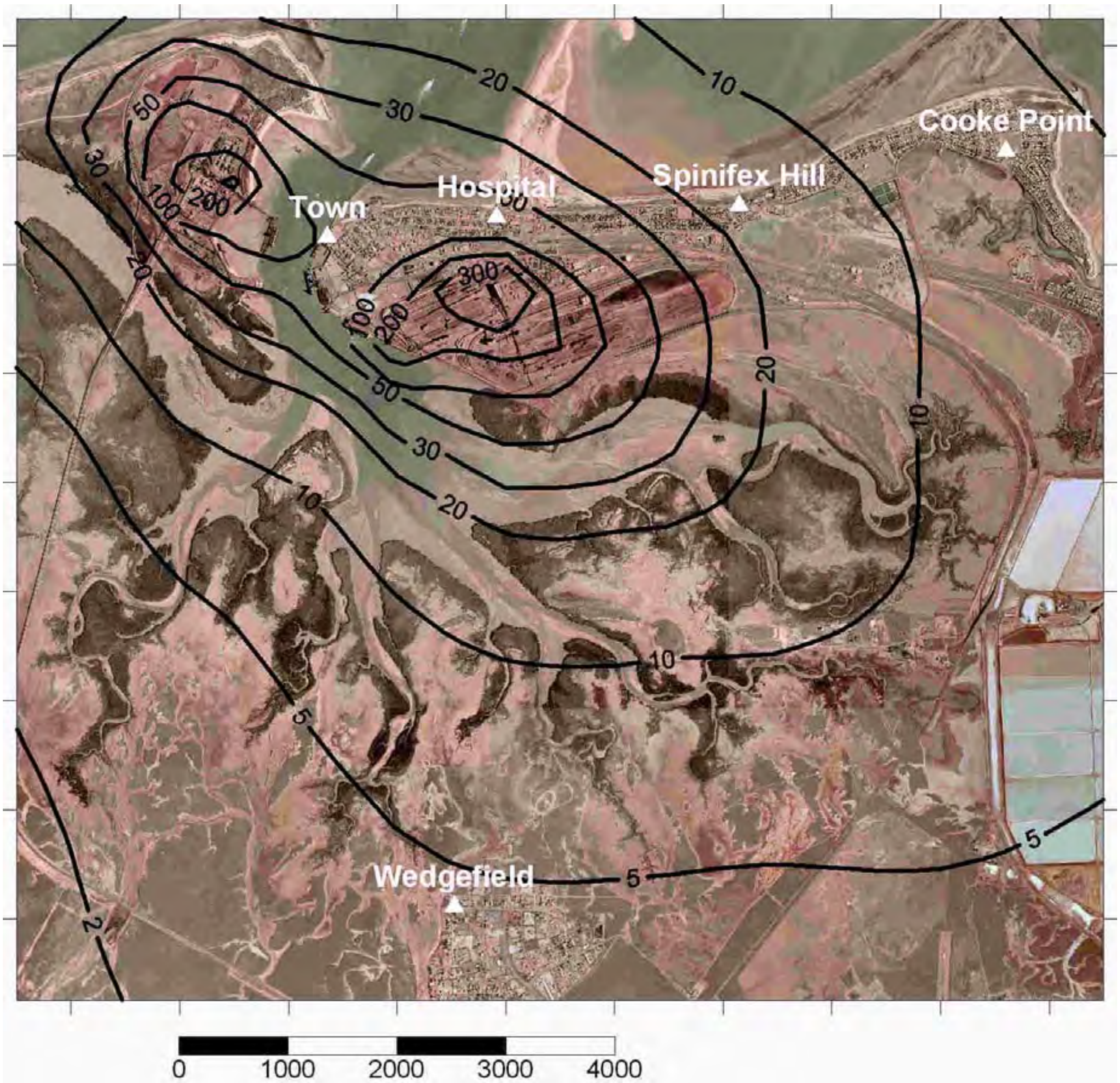


Figure 7 Predicted annual average TSP Concentration (μg/m^3) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation

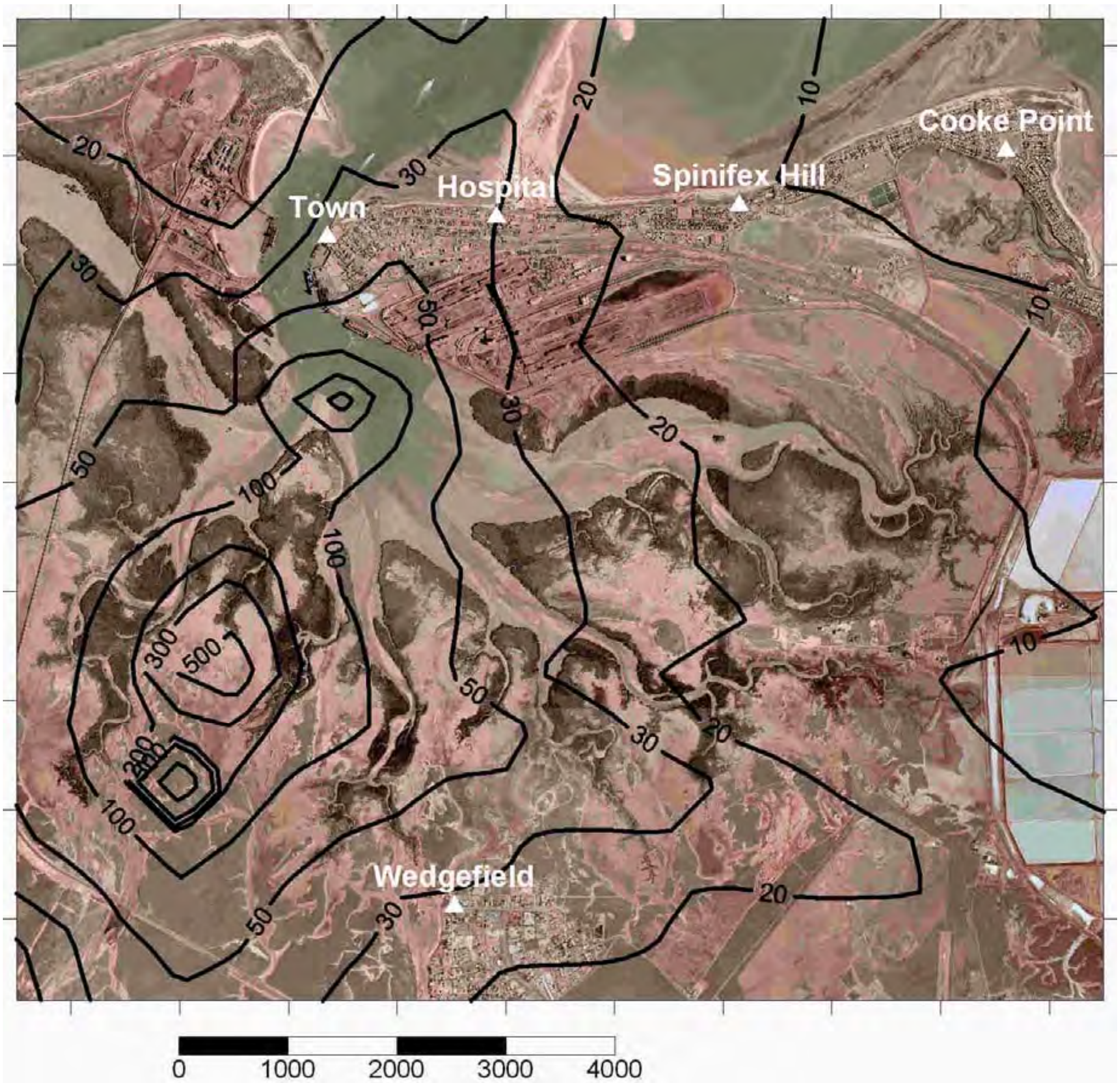


Figure 8 Predicted maximum 24-hour TSP Concentration (μg/m³) from the FMG stockpiling and ship loading operation

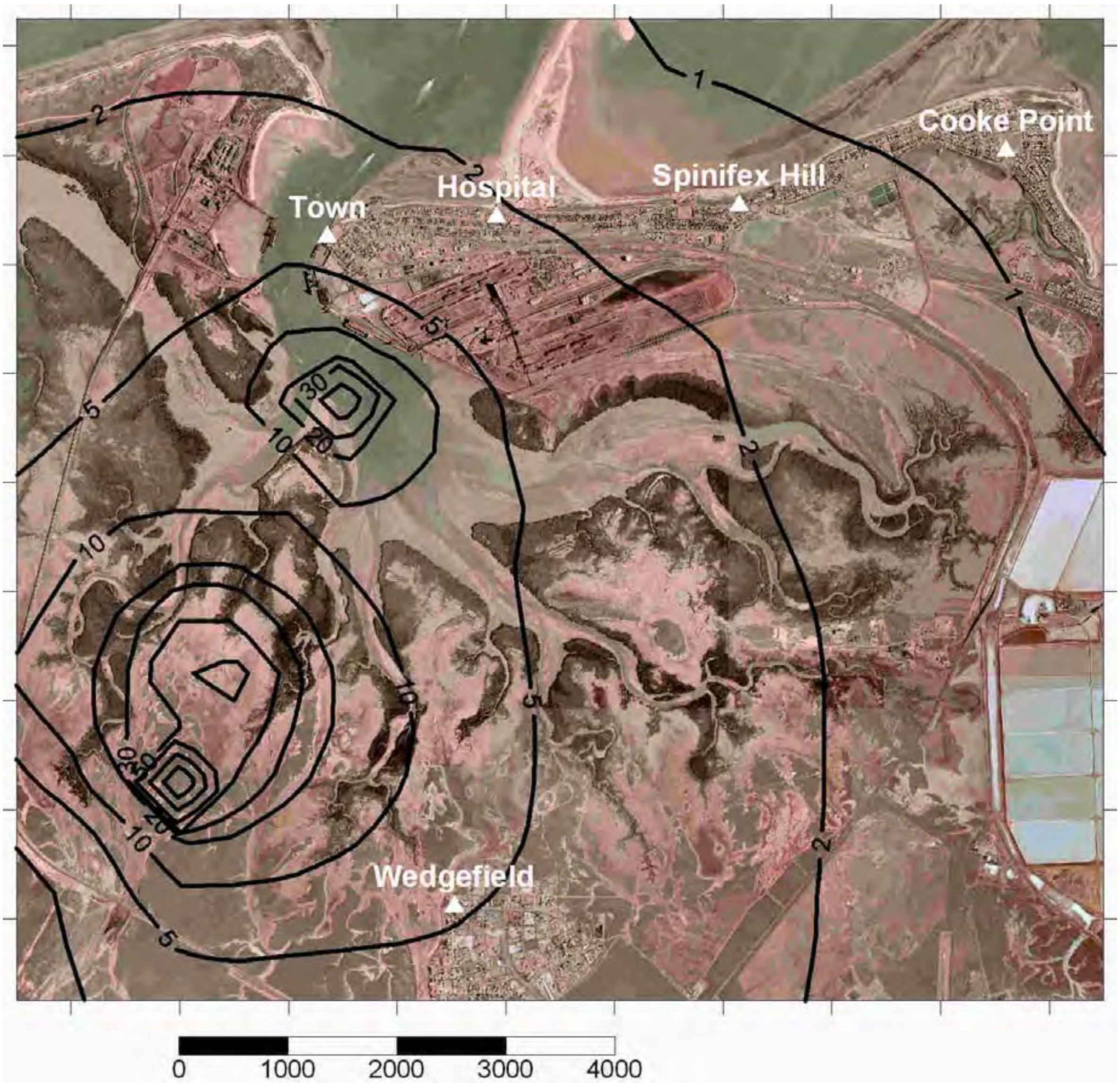


Figure 9 Predicted annual average TSP Concentration (μg/m^3) from the FMG stockpiling and ship loading operation

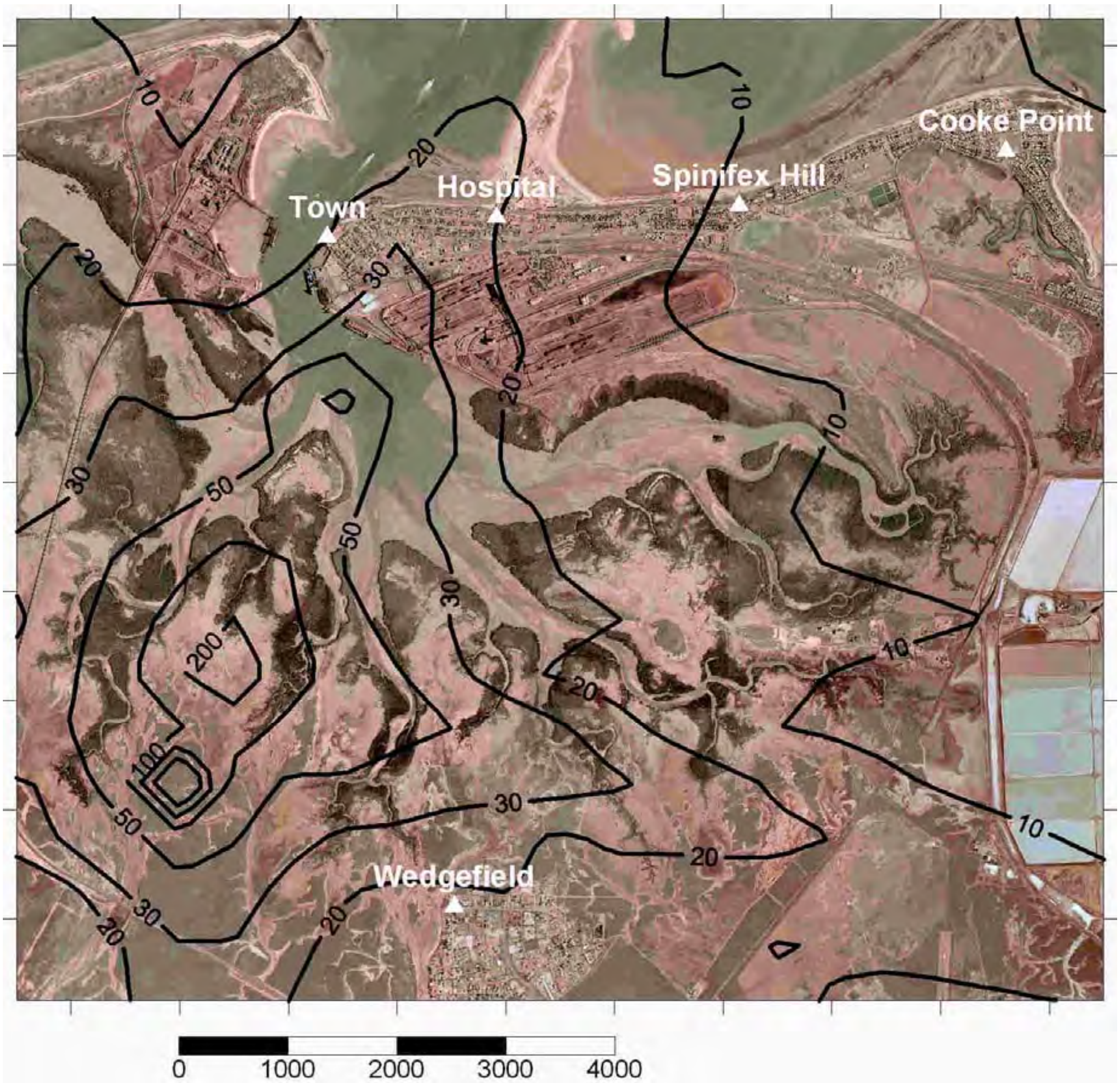


Figure 10 Predicted maximum 24-hour PM_{10} Concentration ($\mu g/m^3$) from the FMG stockpiling and ship loading operation

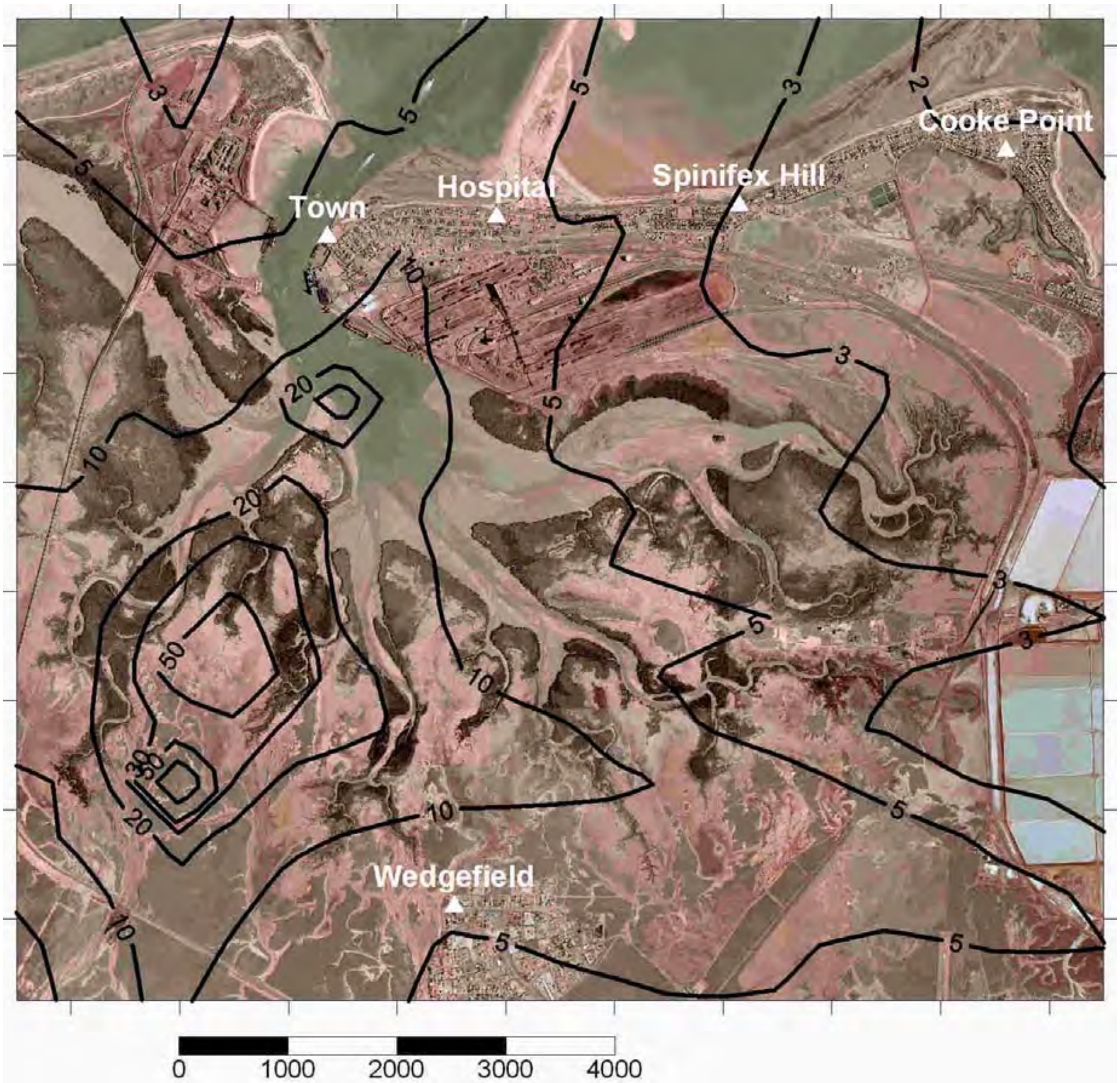


Figure 11 Predicted maximum 24-hour $PM_{2.5}$ Concentration ($\mu g/m^3$) from the FMG stockpiling and ship loading operation

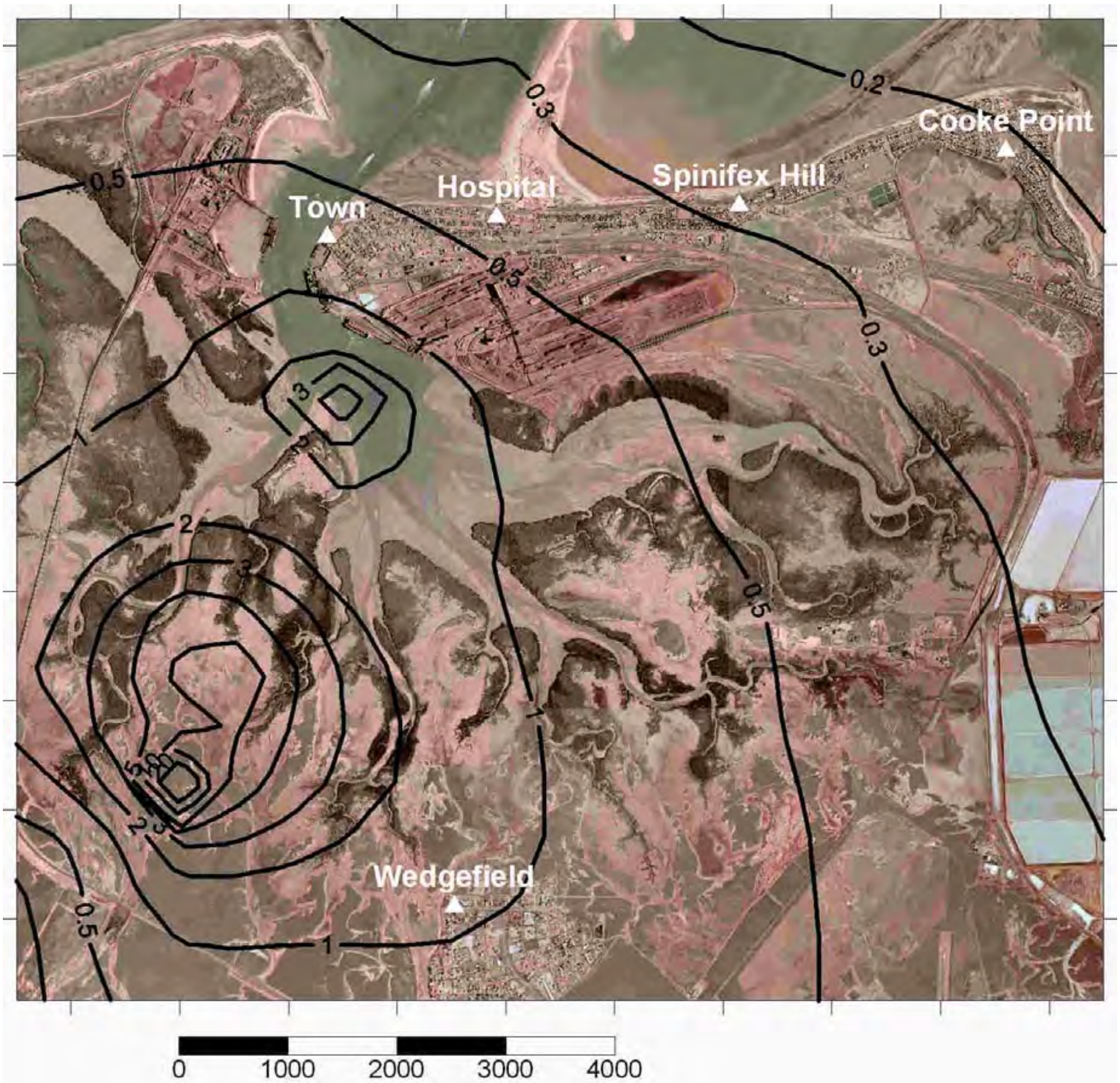


Figure 12 Predicted annual average $PM_{2.5}$ Concentration ($\mu g/m^3$) from the FMG stockpiling and ship loading operation

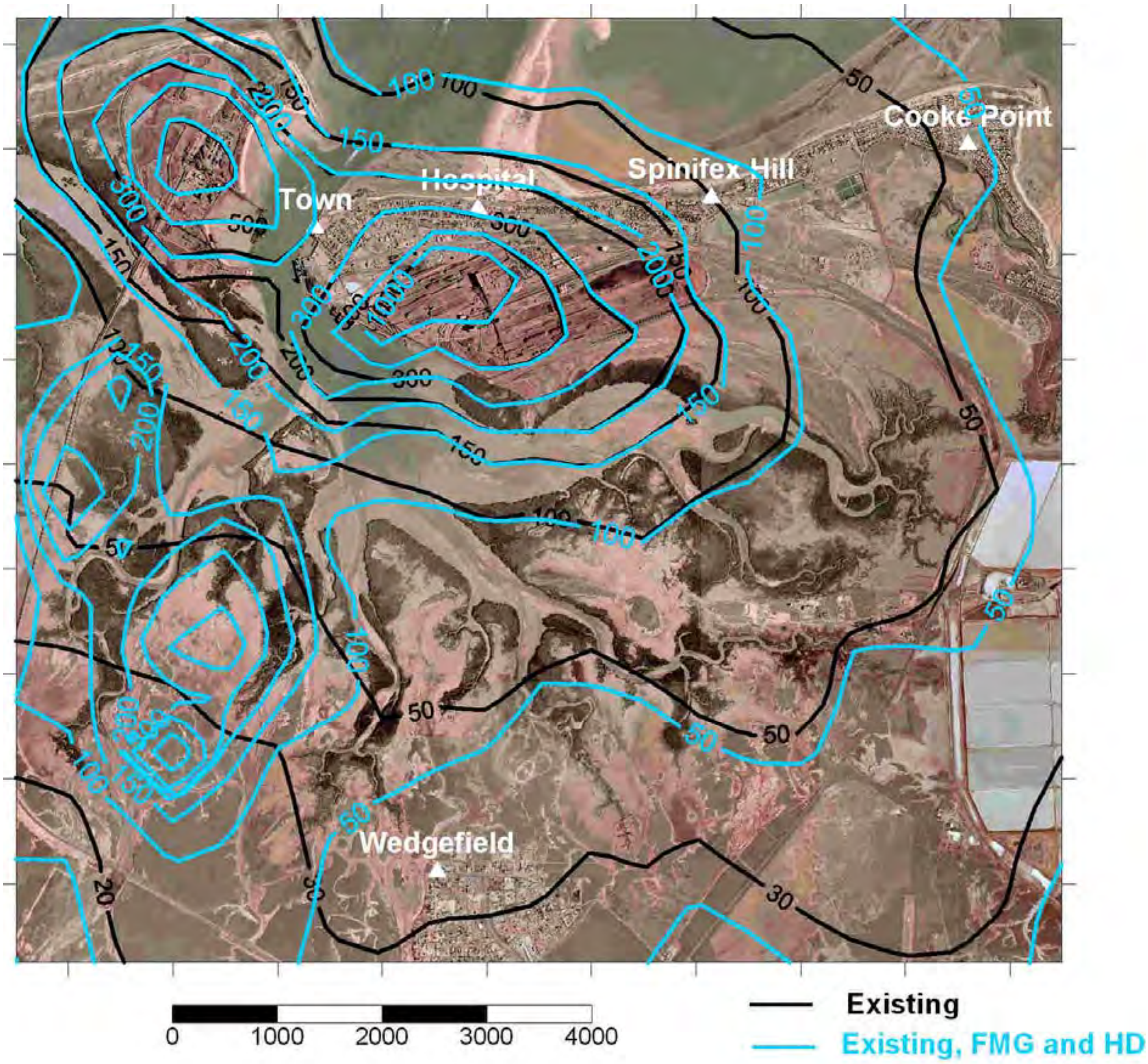


Figure 13 Predicted maximum 24-hour TSP concentration (μg/m³) from the existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects

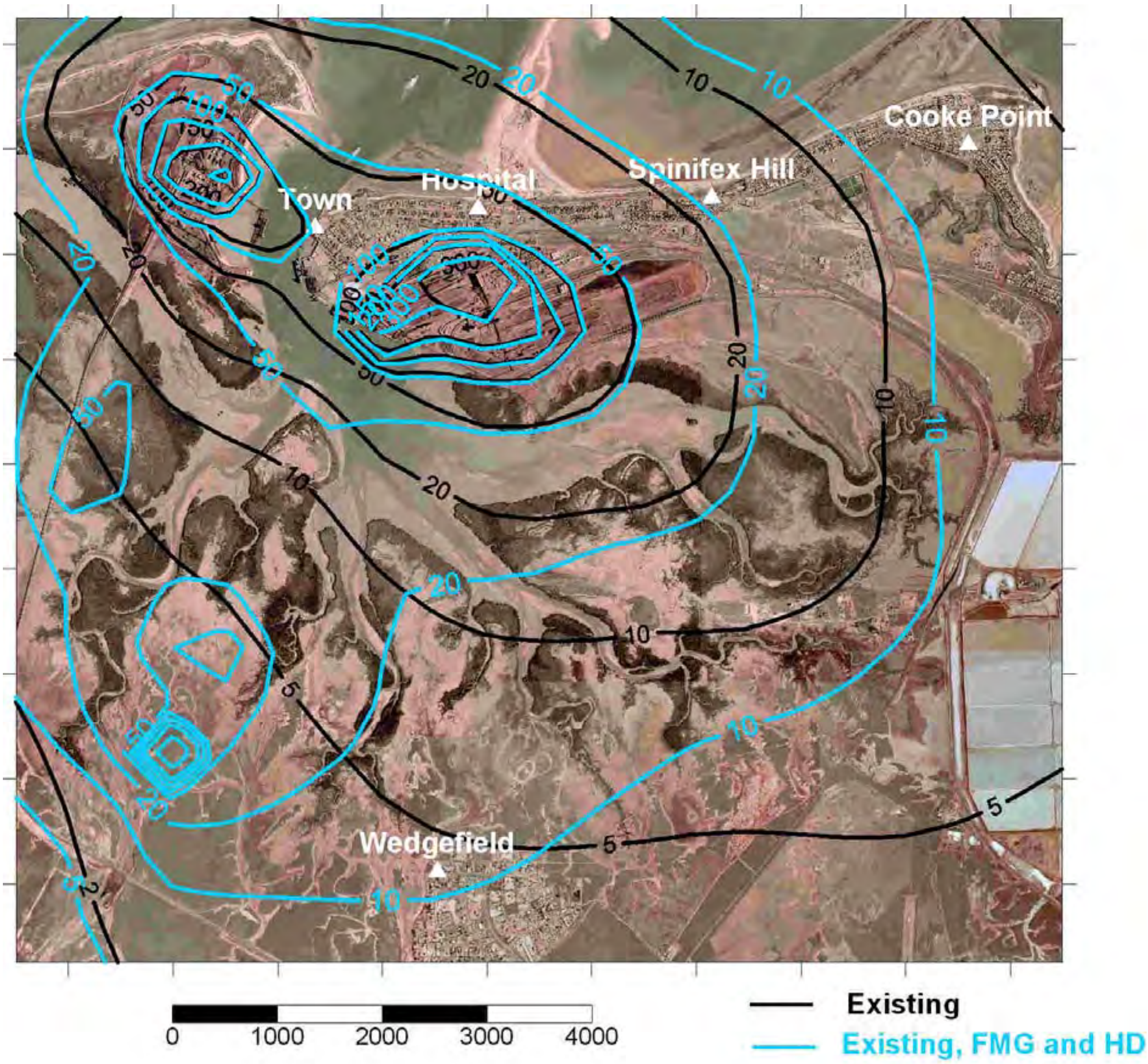


Figure 14 Predicted annual average TSP Concentration (μg/m^3) from the existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects

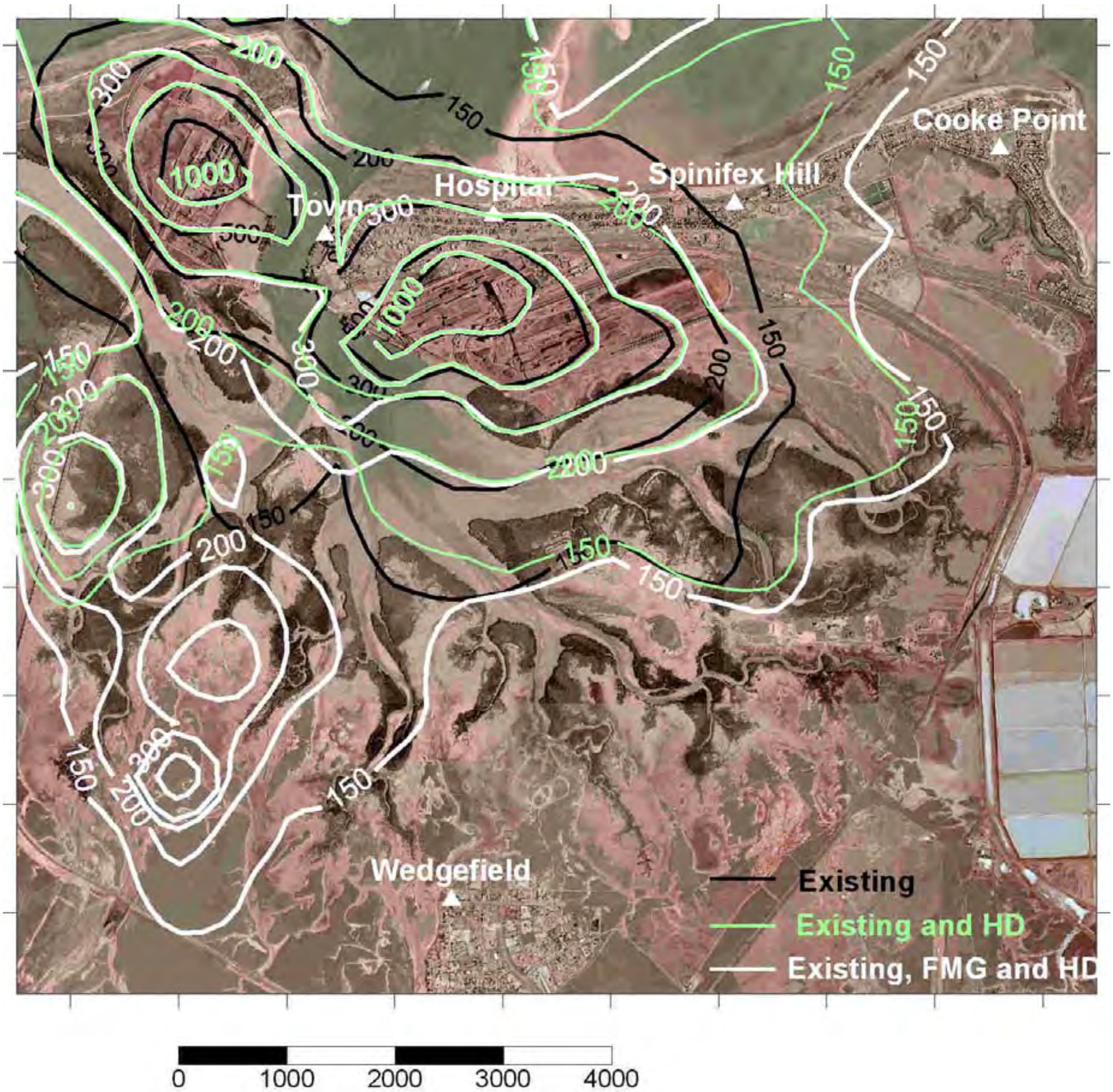


Figure 15 Predicted maximum 24-hour TSP Concentration (μg/m^3) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

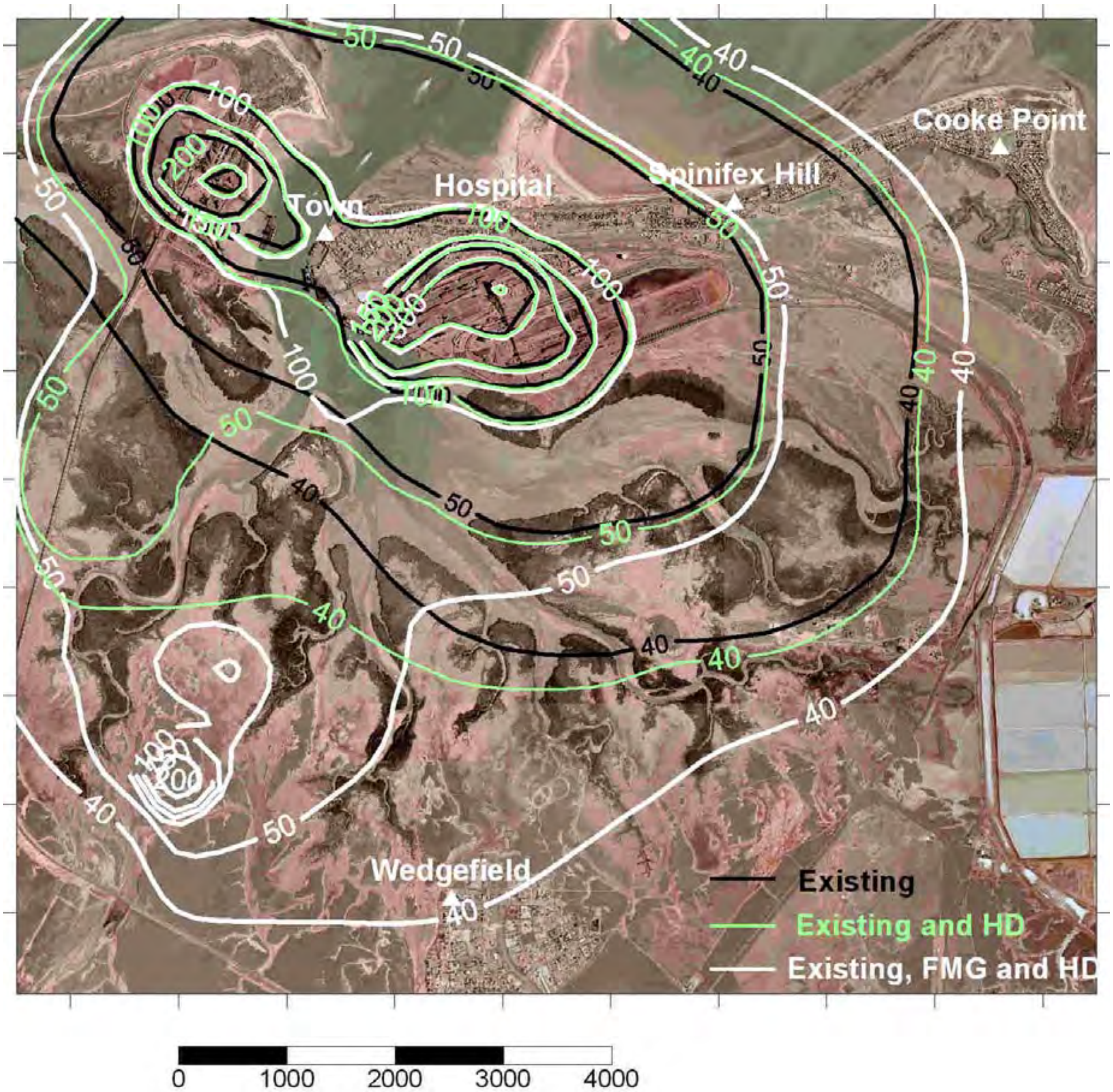


Figure 16 Predicted annual average TSP Concentration (μg/m^3) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD projects (including background levels)

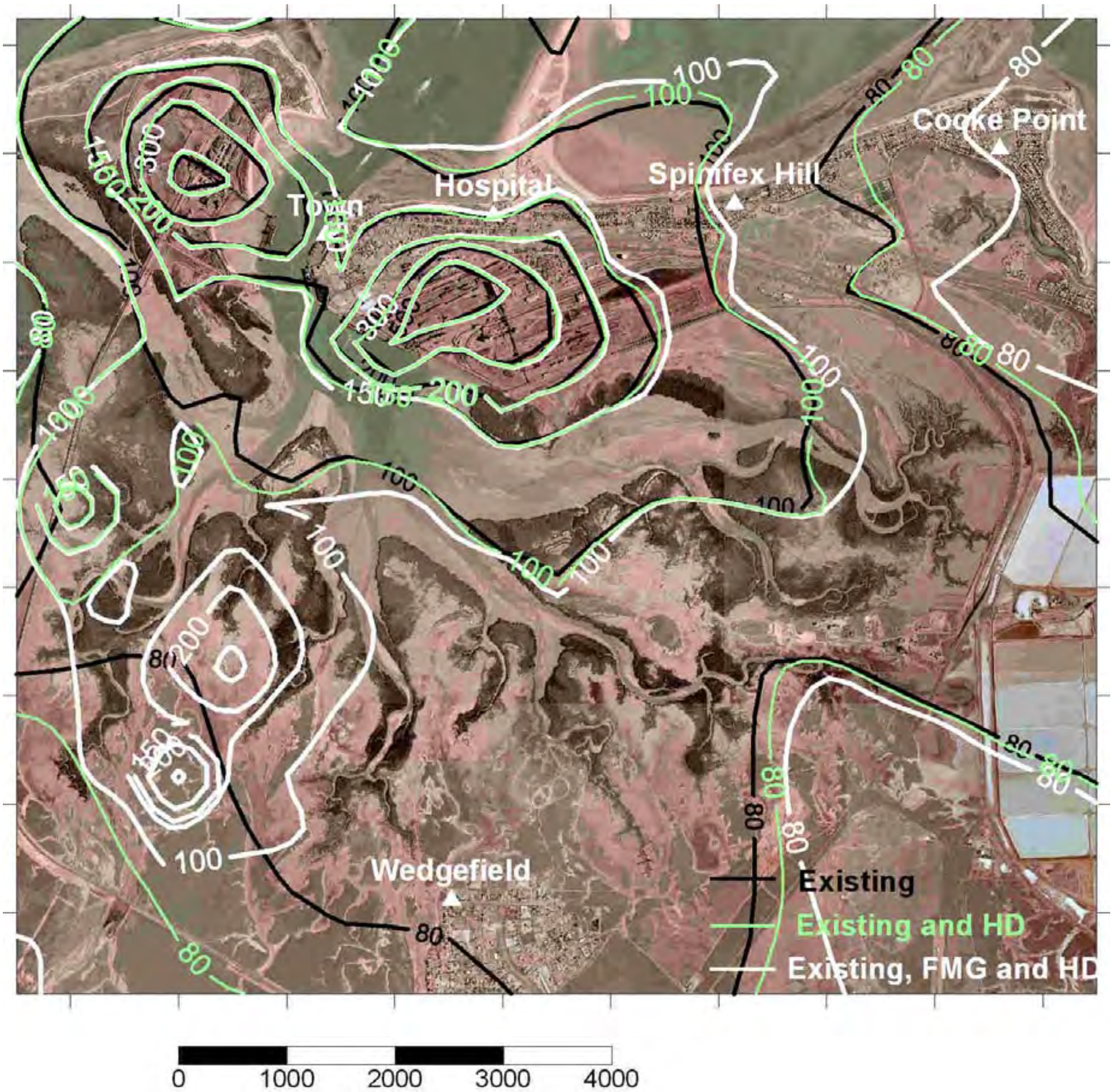


Figure 17 Predicted maximum 24-hour PM_{10} Concentration ($\mu g/m^3$) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

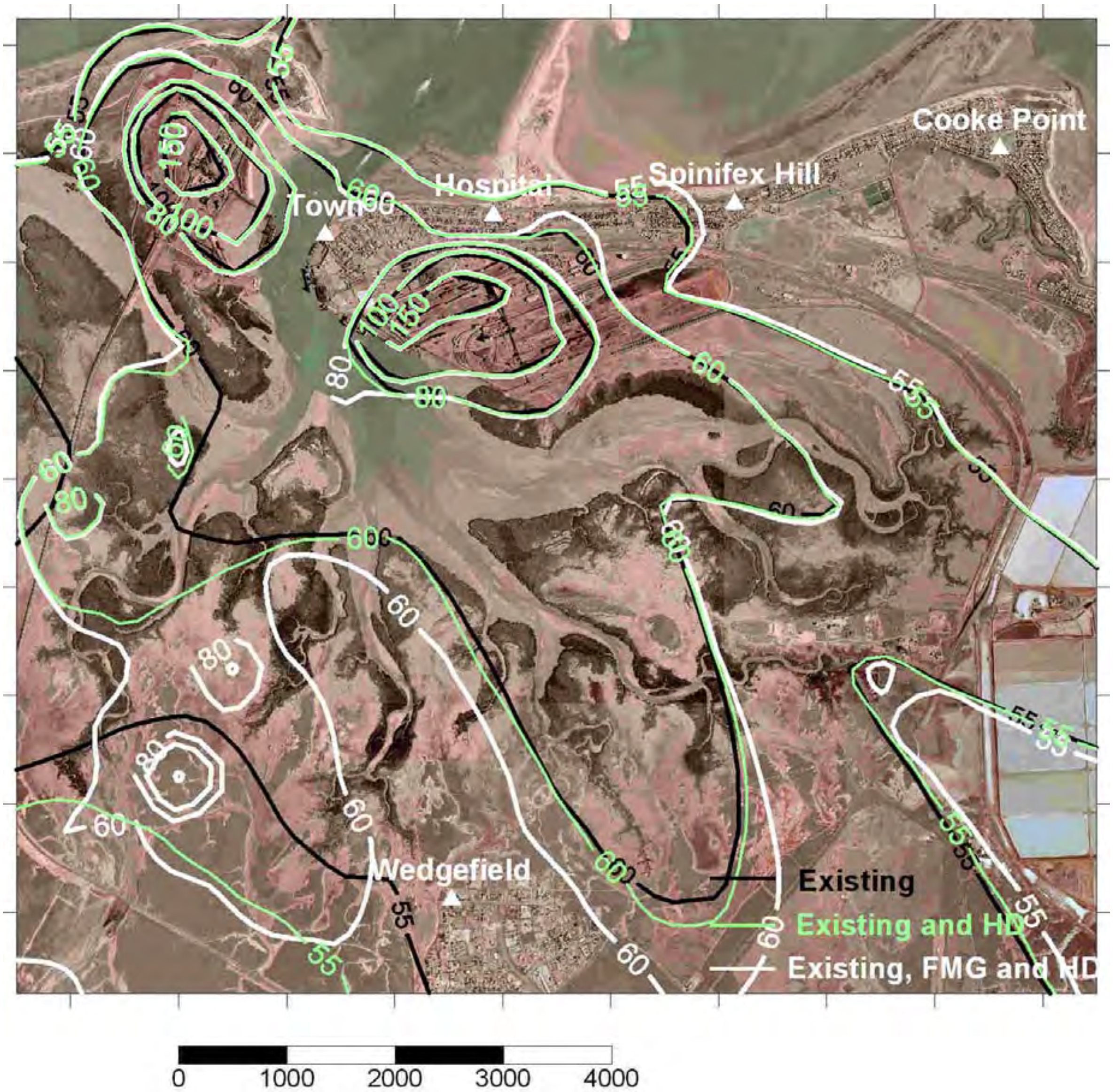


Figure 18 Predicted maximum 24-hour $PM_{2.5}$ Concentration ($\mu g/m^3$) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

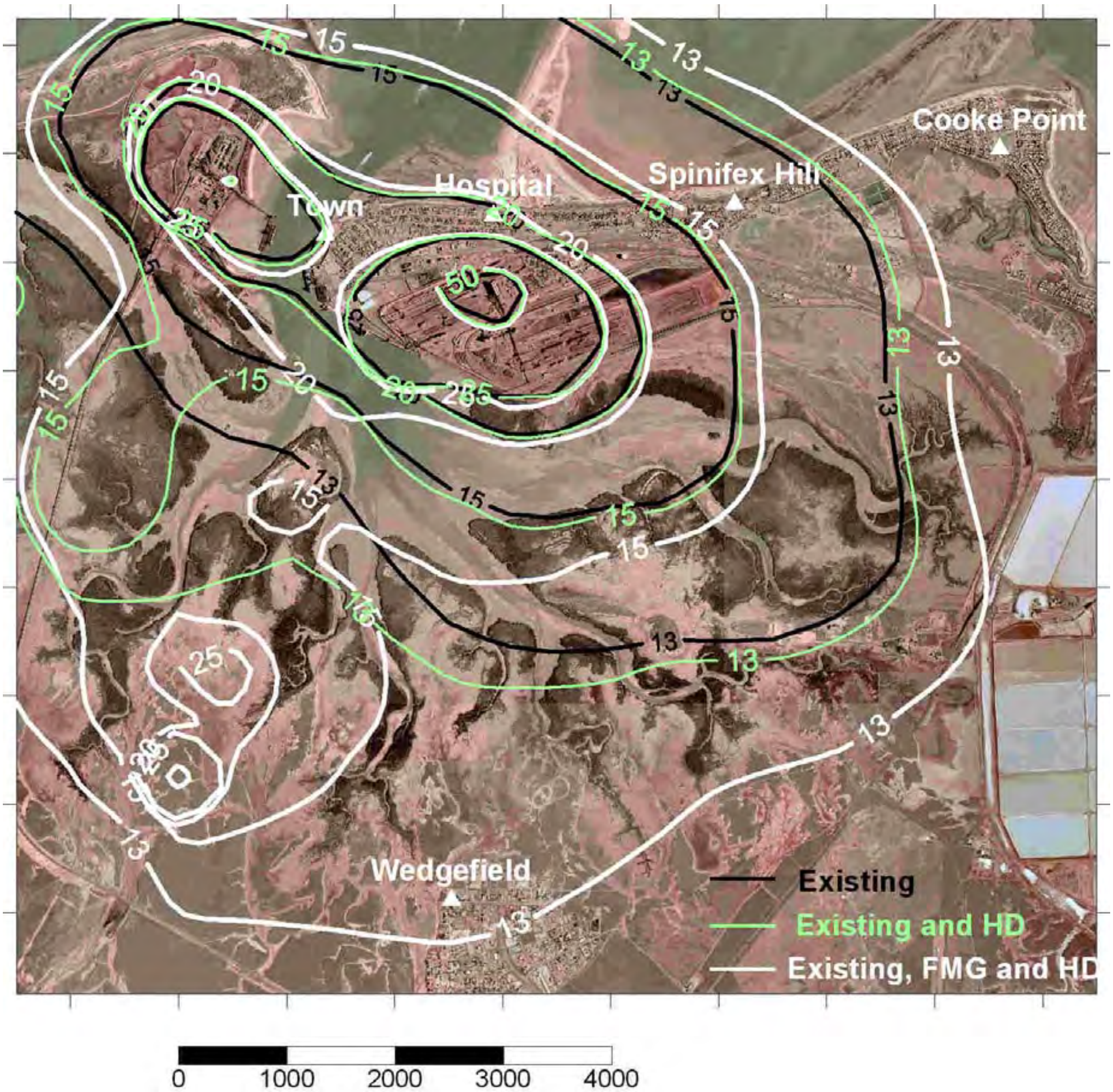


Figure 19 Predicted annual average $PM_{2.5}$ Concentration ($\mu g/m^3$) from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

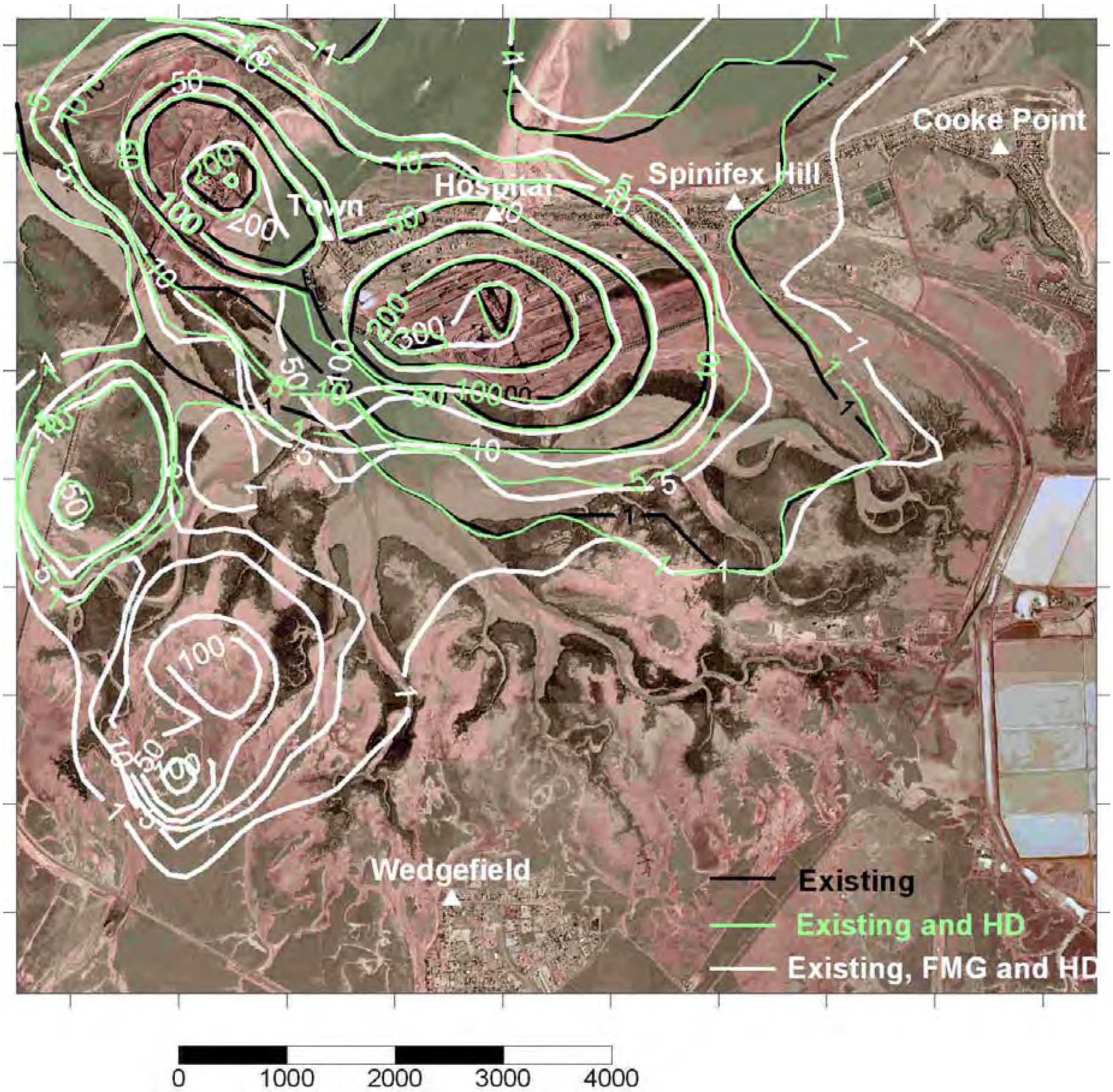


Figure 20 Predicted Annual Exceedances of a 24-hour TSP 150 $\mu g/m^3$ level from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

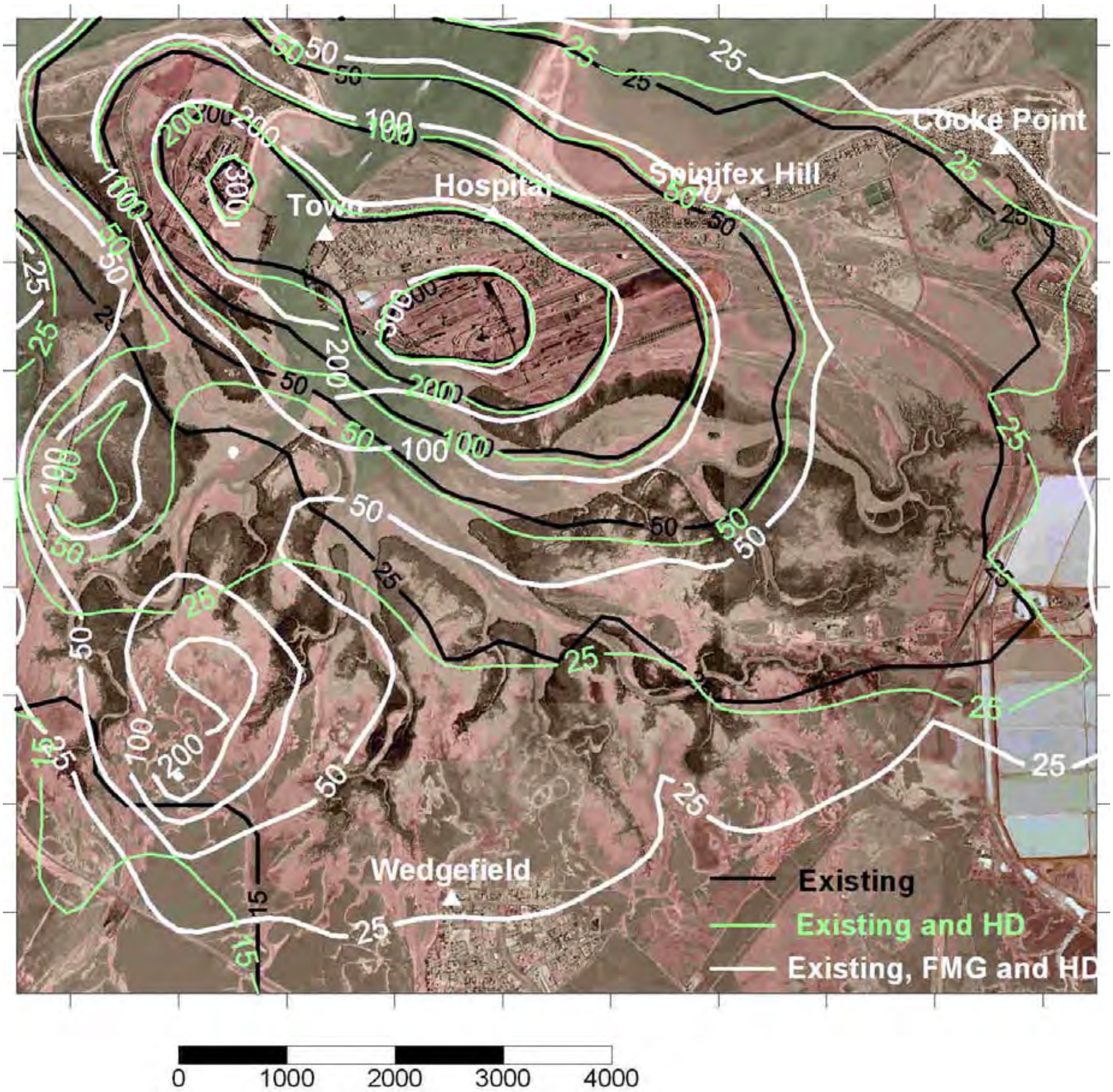


Figure 21 Predicted Annual Exceedances of a 24-hour PM_{10} 50 μg/m^3 level from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

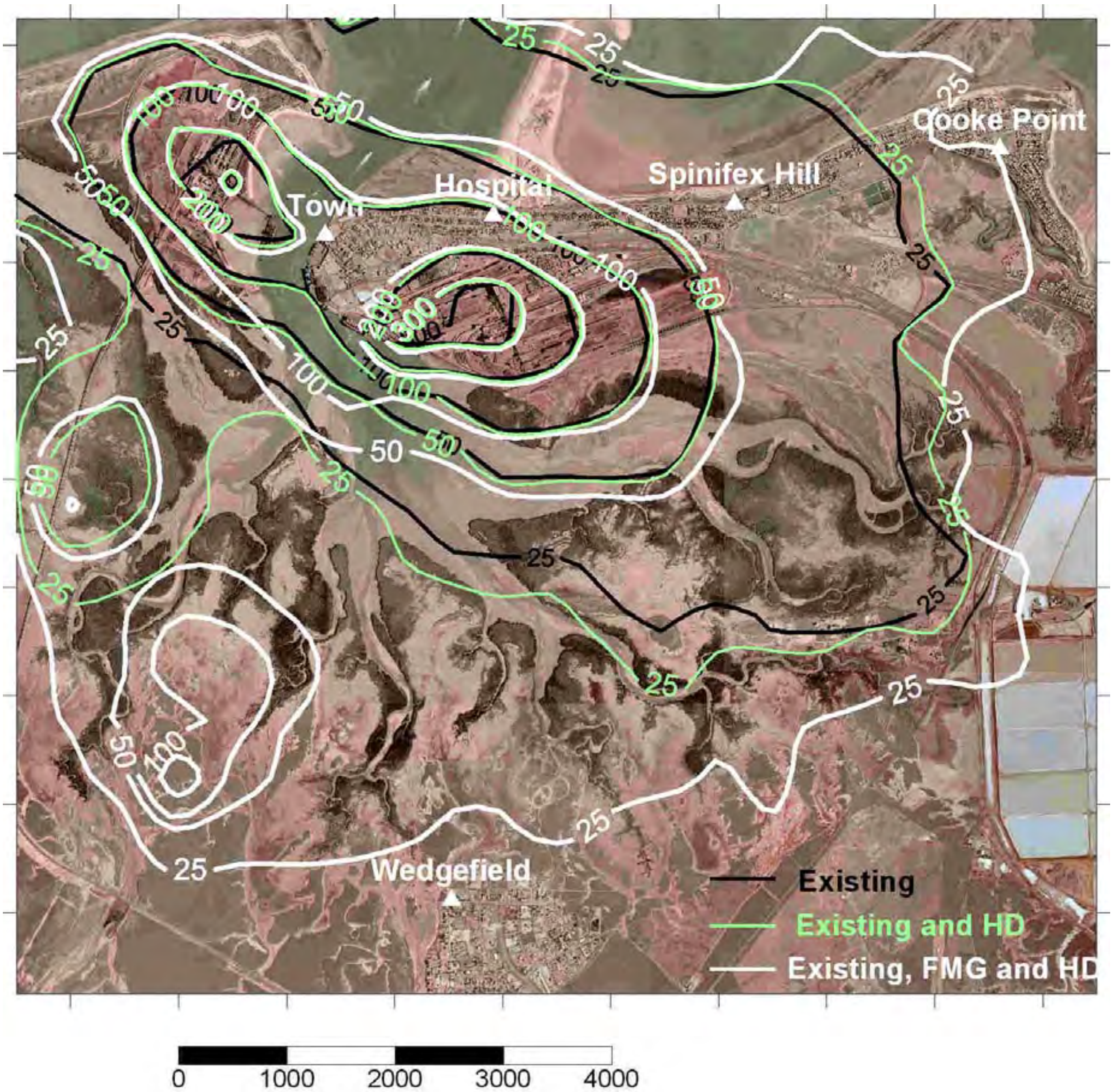


Figure 22 Predicted Annual Exceedances of a 24-hour $PM_{2.5}$ 25 $\mu g/m^3$ level from the Existing (2002/2003) Nelson Point and Finucane Island stockpiling and ship loading operation and FGM and HD Projects (including background levels)

Appendix A

Ausplume Output File For Cumulative TSP Model Run

```
1   ________________________________________________________________________

      Nelson Point, Finucane and FMG and Hope D,  Emiss13.dat revised aus

    ________________________________________________________________________

 Concentration or deposition                         Concentration
 Emission rate units                                 grams/second
 Concentration units                                 microgram/m3
 Units conversion factor                             1.00E+06
 Hourly varying background concentration (see below)
 Terrain effects                                     None
 Plume depletion due to dry removal mechanisms included.
 Smooth stability class changes?                     No
 Other stability class adjustments ("urban modes")   None
 Ignore building wake effects?                       Yes
 Decay coefficient (unless overridden by met. file)  0.000
 Anemometer height                                   10 m
 Roughness height at the wind vane site              0.050 m

                   DISPERSION CURVES
 Horizontal dispersion curves for sources <100m high  Pasquill-Gifford
 Vertical  dispersion  curves for sources <100m high  Pasquill-Gifford
 Horizontal dispersion curves for sources >100m high  Briggs Rural
 Vertical  dispersion  curves for sources >100m high  Briggs Rural
 Enhance horizontal plume spreads for buoyancy?       Yes
 Enhance  vertical  plume spreads for buoyancy?       Yes
 Adjust horizontal P-G formulae for roughness height? Yes
 Adjust  vertical  P-G formulae for roughness height? Yes
 Roughness height                                     0.100m
 Adjustment for wind directional shear                None

                    PLUME RISE OPTIONS
 Gradual plume rise?                                  Yes
 Stack-tip downwash included?                         Yes
 Building downwash algorithm:                        Huber-Snyder method.
 Entrainment coeff. for neutral & stable lapse rates 0.60,0.60
 Partial penetration of elevated inversions?          No
 Disregard temp. gradients in the hourly met. file?   No

 and in the absence of boundary-layer potential temperature gradients
 given by the hourly met. file, a value from the following table
 (in K/m) is used:

    Wind Speed                Stability Class
     Category       A      B      C      D      E      F
   ________________________________________________________
        1         0.000  0.000  0.000  0.000  0.020  0.035
        2         0.000  0.000  0.000  0.000  0.020  0.035
        3         0.000  0.000  0.000  0.000  0.020  0.035
        4         0.000  0.000  0.000  0.000  0.020  0.035
        5         0.000  0.000  0.000  0.000  0.020  0.035
        6         0.000  0.000  0.000  0.000  0.020  0.035

 WIND SPEED CATEGORIES
 Boundaries between categories (in m/s) are:  1.54,  3.09,  5.14,  8.23, 10.80

 WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

 AVERAGING TIMES
  1 hour
```

```
 24 hours
  average over all hours

 ____________________________________________________________________________

1   ________________________________________________________________________

      Nelson Point, Finucane and FMG and Hope D,  Emiss13.dat revised aus

                           SOURCE CHARACTERISTICS

    ________________________________________________________________________


                  VOLUME SOURCE: NP1

    X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
  665950  7752700            0m            10m         20m           5m

             (Constant) emission rate = 3.00E-01 grams/second

        Hourly multiplicative factors will be used with
        this emission factor.

                   Particle  Particle  Particle
                     Mass      Size    Density
                   fraction  (micron)  (g/cm3)
                  _____________________________
                     0.3700      1.3      1.00
                     0.2700      3.8      1.00
                     0.2300      6.3      1.00
                     0.2000      8.7      1.00


                  VOLUME SOURCE: NP2

    X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
  665500  7752600            0m             5m         50m           2m

             (Constant) emission rate = 3.00E-01 grams/second

        Hourly multiplicative factors will be used with
        this emission factor.

                   Particle  Particle  Particle
                     Mass      Size    Density
                   fraction  (micron)  (g/cm3)
                  _____________________________
                     0.3700      1.3      1.00
                     0.2700      3.8      1.00
                     0.2300      6.3      1.00
                     0.2000      8.7      1.00


                  VOLUME SOURCE: NP3

    X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
  664800  7752300            0m            12m         30m           5m

             (Constant) emission rate = 3.00E-01 grams/second
```

```
       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3700      1.3      1.00
                    0.2700      3.8      1.00
                    0.2300      6.3      1.00
                    0.2000      8.7      1.00


                  VOLUME SOURCE: NP4

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
666400  7752200            0m             5m         50m           5m

             (Constant) emission rate = 3.00E-01 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3700      1.3      1.00
                    0.2700      3.8      1.00
                    0.2300      6.3      1.00
                    0.2000      8.7      1.00


                  VOLUME SOURCE: NP5

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
667200  7752500            0m             4m        130m           3m

             (Constant) emission rate = 3.00E-01 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3700      1.3      1.00
                    0.2700      3.8      1.00
                    0.2300      6.3      1.00
                    0.2000      8.7      1.00


                  VOLUME SOURCE: NP6

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
666000  7752500            0m             7m         60m           4m

             (Constant) emission rate = 3.00E-01 grams/second

       Hourly multiplicative factors will be used with
```

this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: NP7

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
666000	7752150	0m	7m	50m	4m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: NP8

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
666200	7752900	0m	5m	25m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: NP9

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
665150	7752250	0m	5m	40m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI1

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663800	7753270	0m	7m	15m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI2

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663840	7753430	0m	7m	5m	2m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI3

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663400	7753650	0m	6m	20m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI4

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663400	7754000	0m	4m	80m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI5

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663125	7753770	0m	4m	45m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI6

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663070	7754050	0m	5m	75m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Particle Particle

Mass fraction	Size (micron)	Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI7

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663125	7753350	0m	4m	40m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FI8

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663250	7753600	0m	3m	60m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FMG1

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
661680	7749215	0m	4m	8m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Particle Particle
Mass Size Density

```
                fraction  (micron)  (g/cm3)
               ─────────────────────────────
                  0.3700      1.3      1.00
                  0.2700      3.8      1.00
                  0.2300      6.3      1.00
                  0.2000      8.7      1.00


                VOLUME SOURCE: FMG2

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 662920  7748300            0m             5m         25m            5m

           (Constant) emission rate = 3.00E-01 grams/second

      Hourly multiplicative factors will be used with
      this emission factor.

                Particle  Particle  Particle
                  Mass      Size    Density
                fraction  (micron)  (g/cm3)
               ─────────────────────────────
                  0.3700      1.3      1.00
                  0.2700      3.8      1.00
                  0.2300      6.3      1.00
                  0.2000      8.7      1.00


                VOLUME SOURCE: FMG3

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 662980  7748480            0m             4m         80m            3m

           (Constant) emission rate = 3.00E-01 grams/second

      Hourly multiplicative factors will be used with
      this emission factor.

                Particle  Particle  Particle
                  Mass      Size    Density
                fraction  (micron)  (g/cm3)
               ─────────────────────────────
                  0.3700      1.3      1.00
                  0.2700      3.8      1.00
                  0.2300      6.3      1.00
                  0.2000      8.7      1.00


                VOLUME SOURCE: FMG4

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 663110  7748800            0m             4m        100m            3m

           (Constant) emission rate = 3.00E-01 grams/second

      Hourly multiplicative factors will be used with
      this emission factor.

                Particle  Particle  Particle
                  Mass      Size    Density
                fraction  (micron)  (g/cm3)
```

0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FMG5

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663220	7749120	0m	4m	100m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FMG6

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663330	7749440	0m	4m	100m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FMG7

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
663440	7749760	0m	4m	100m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)

0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FMG8

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
664265	7751720	0m	10m	3m	1m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: FMG9

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
664430	7751650	0m	10m	20m	3m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00
0.2700	3.8	1.00
0.2300	6.3	1.00
0.2000	8.7	1.00

VOLUME SOURCE: HD1

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
662030	7750515	0m	4m	60m	2m

(Constant) emission rate = 3.00E-01 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.3700	1.3	1.00

```
                 0.2700      3.8      1.00
                 0.2300      6.3      1.00
                 0.2000      8.7      1.00


               VOLUME SOURCE: HD2

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
662120  7750798            0m             4m         50m            3m

          (Constant) emission rate = 3.00E-01 grams/second

     Hourly multiplicative factors will be used with
     this emission factor.

               Particle  Particle  Particle
                 Mass      Size    Density
               fraction  (micron)  (g/cm3)
              _____________________________
                 0.3700      1.3      1.00
                 0.2700      3.8      1.00
                 0.2300      6.3      1.00
                 0.2000      8.7      1.00


               VOLUME SOURCE: HD3

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
662210  7751081            0m             4m         50m            3m

          (Constant) emission rate = 3.00E-01 grams/second

     Hourly multiplicative factors will be used with
     this emission factor.

               Particle  Particle  Particle
                 Mass      Size    Density
               fraction  (micron)  (g/cm3)
              _____________________________
                 0.3700      1.3      1.00
                 0.2700      3.8      1.00
                 0.2300      6.3      1.00
                 0.2000      8.7      1.00


               VOLUME SOURCE: HD4

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
662300  7751365            0m             4m         50m            3m

          (Constant) emission rate = 3.00E-01 grams/second

     Hourly multiplicative factors will be used with
     this emission factor.

               Particle  Particle  Particle
                 Mass      Size    Density
               fraction  (micron)  (g/cm3)
              _____________________________
                 0.3700      1.3      1.00
                 0.2700      3.8      1.00
```

```
                 0.2300      6.3      1.00
                 0.2000      8.7      1.00


               VOLUME SOURCE: HD5

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
662385  7751650            0m             4m         50m           3m

          (Constant) emission rate = 3.00E-01 grams/second

    Hourly multiplicative factors will be used with
    this emission factor.

               Particle  Particle  Particle
                 Mass      Size    Density
               fraction  (micron)  (g/cm3)
              ____________________________
                 0.3700      1.3      1.00
                 0.2700      3.8      1.00
                 0.2300      6.3      1.00
                 0.2000      8.7      1.00


               VOLUME SOURCE: HD6

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
662650  7751900            0m             8m         20m           4m

          (Constant) emission rate = 3.00E-01 grams/second

    Hourly multiplicative factors will be used with
    this emission factor.

               Particle  Particle  Particle
                 Mass      Size    Density
               fraction  (micron)  (g/cm3)
              ____________________________
                 0.3700      1.3      1.00
                 0.2700      3.8      1.00
                 0.2300      6.3      1.00
                 0.2000      8.7      1.00


               VOLUME SOURCE: HD7

  X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
663804  7752670            0m            10m          3m           2m

          (Constant) emission rate = 3.00E-01 grams/second

    Hourly multiplicative factors will be used with
    this emission factor.

               Particle  Particle  Particle
                 Mass      Size    Density
               fraction  (micron)  (g/cm3)
              ____________________________
                 0.3700      1.3      1.00
                 0.2700      3.8      1.00
                 0.2300      6.3      1.00
```

```
                    0.2000      8.7      1.00


                  VOLUME SOURCE: HD8

   X(m)     Y(m)     Ground Elevation    Height   Hor. spread   Vert. spread
 663900  7752460            0m            10m         20m            3m

             (Constant) emission rate = 3.00E-01 grams/second

       Hourly multiplicative factors will be used with
       this emission factor.

                  Particle  Particle  Particle
                    Mass      Size    Density
                  fraction  (micron)  (g/cm3)
                 _____________________________
                    0.3700      1.3      1.00
                    0.2700      3.8      1.00
                    0.2300      6.3      1.00
                    0.2000      8.7      1.00

 _____________________________________________________________________________

1   _______________________________________________________________________

      Nelson Point, Finucane and FMG and Hope D,  Emiss13.dat revised aus

                               RECEPTOR LOCATIONS

    _______________________________________________________________________

 The Cartesian receptor grid has the following x-values (or eastings):
 661500.m  662000.m  662500.m  663000.m  663500.m  664000.m  664500.m
 665000.m  665500.m  666000.m  666500.m  667000.m  667500.m  668000.m
 668500.m  669000.m  669500.m  670000.m  670500.m  671000.m  671500.m

 and these y-values (or northings):
7746250.m 7746750.m 7747250.m 7747750.m 7748250.m 7748750.m 7749250.m
7749750.m 7750250.m 7750750.m 7751250.m 7751750.m 7752250.m 7752750.m
7753250.m 7753750.m 7754250.m 7754750.m 7755250.m


 DISCRETE RECEPTOR LOCATIONS (in metres)

 No.     X       Y    ELEVN  HEIGHT       No.     X       Y    ELEVN  HEIGHT
  1  664360 7753248     0.0    2.0         4  670601 7754040     0.0    2.0
  2  665916 7753433     0.0    2.0         5  665525 7747111     0.0    2.0
  3  668150 7753540     0.0    2.0

 _____________________________________________________________________________

   METEOROLOGICAL DATA : Port H Observed wnds, TAPM stabs and MH (revised)

 ----------------------------------------------------------------------

              HOURLY VARIABLE EMISSION FACTOR INFORMATION
              -------------------------------------------

 The input emission rates specfied above will be multiplied by hourly varying
 factors entered via the input file:
```

```
C:\ausplume\fmg\emissions\emiss13.dat
For each stack source, hourly values within this file will be added to each
declared exit velocity (m/sec) and temperature (K).

Title of input hourly emission factor file is:
Port hedland BHPB 02/03

             HOURLY EMISSION FACTOR SOURCE TYPE ALLOCATION
             ---------------------------------------------

Prefix NP1    allocated: NP1
Prefix NP2    allocated: NP2
Prefix NP3    allocated: NP3
Prefix NP4    allocated: NP4
Prefix NP5    allocated: NP5
Prefix NP6    allocated: NP6
Prefix NP7    allocated: NP7
Prefix NP8    allocated: NP8
Prefix NP9    allocated: NP9
Prefix FI1    allocated: FI1
Prefix FI2    allocated: FI2
Prefix FI3    allocated: FI3
Prefix FI4    allocated: FI4
Prefix FI5    allocated: FI5
Prefix FI6    allocated: FI6
Prefix FI7    allocated: FI7
Prefix FI8    allocated: FI8
Prefix FMG1   allocated: FMG1
Prefix FMG2   allocated: FMG2
Prefix FMG3   allocated: FMG3
Prefix FMG4   allocated: FMG4
Prefix FMG5   allocated: FMG5
Prefix FMG6   allocated: FMG6
Prefix FMG7   allocated: FMG7
Prefix FMG8   allocated: FMG8
Prefix FMG9   allocated: FMG9
Prefix HD1    allocated: HD1
Prefix HD2    allocated: HD2
Prefix HD3    allocated: HD3
Prefix HD4    allocated: HD4
Prefix HD5    allocated: HD5
Prefix HD6    allocated: HD6
Prefix HD7    allocated: HD7
Prefix HD8    allocated: HD8

----------------------------------------------------------------------

     VARIABLE HOURLY BACKGROUND CONCENTRATION INFORMATION
     ----------------------------------------------------

Hourly varying background concentration data will be used.
The concentration units applicable are assumed to be: microgram/m3
The hourly values were read from the input file:
C:\ausplume\fmg\pm10.bgr

Title of input hourly background concentration file is:
Background PM10 file
```