DUST DISPERSION MODELLING FOR PILBARA IRON DAMPIER PORT EXPANSION TO 145 MTPA (PHASE B) – DEVELOPMENT OF DUST EMISSIONS ESTIMATES

Prepared for

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by

Environmental Alliances Pty Ltd

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1. INTRODUCTION

This report contains details on the methods used to estimate dust emissions used to predict dust impacts for Pilbara Iron's proposed increase in throughput to 145Mt/a at its Dampier Port operations.

Other reports which contain relevant information to this proposal are:

Report title	Author	Purpose
Environmental Protection Statement	SKM	Describes the proposal in a form suitable for public comments and review by the EPA
Dust Dispersion Modelling for Pilbara Iron Dampier Port Expansion to 145 Mtpa (Phase B)	Environmental Alliances	Overview report describing the changes in dust impacts predicted to occur following the Port expansion to 145 Mtpa
THIS REPORT		
Dust Dispersion Modelling for Pilbara Iron Dampier Port Expansion to 145 Mtpa (Phase B) – Development of Dust Emissions Estimates	Environmental Alliances	Provides details of the development of dust emissions estimates for the Pilbara Iron operational sources at Dampier
Dust Dispersion Modelling for Pilbara Iron Dampier Port Expansion to 145 Mtpa (Phase B) – Dispersion Model Set-Up and Performance	Environmental Alliances	Provides details of the set-up of the CALMET (meteorological pre-processor) and CALPUFF dispersion models used for the dust dispersion modelling

2. NATURE OF DAMPIER PORT IRON ORE OPERATIONS

Crushed and screened iron ore from the mine sites is railed to the Dampier Port.

Each of the two shiploading terminals (located at Parker Point and East Intercourse Island) has facilities for train unloading, ore-product blending, bulking, screening and shiploading.

On arriving at the two terminals, ore is dumped from the trains at rotary car dumpers, weighed and then conveyed to the live stockpile areas. At East Intercourse Island, the 5E conveyor transports the ore 2.7 km, which includes a causeway.

Parker Point has 24 blending live stockpiles while East Intercourse Island has 14 live stockpiles. The ore is stored in these stockpiles until it is shipped.

Both operations also have areas set aside for the storage of bulk stockpiles. The bulking activity involves using loaders and haul trucks to remove ore from a live stockpile and dump it into a bulking stockpile. Some time later, the ore from the bulk stockpile is loaded into ore trucks and transported to a dump hopper which conveys the ore back into a live stockpile. Bulking is undertaken to help manage product demand requirements.

When ready for shipping, automatic reclaimers reclaim the ore from the stockpiles, which is then transported to the ship via a series of conveyors.

Lump ore is re-screened immediately prior to shipping. Undersize from this re-screening process is returned to the fines stockpiles.

The ore is loaded into ships at wharves at Parker Point and East Intercourse Island through shiploaders.

3. OPERATIONAL SOURCES OF DUST

The mechanisms underlying the generation of airborne dust from iron ore handling operations are very complex. While some aspects of dust emissions are obvious – for example, equipment such as stackers and reclaimers will only generate emissions while they are actually operating, other aspects such as the relationship between ore mineralogy and dustiness are poorly understood.

Dust emissions from operational sources may depend on:

- the frequency at which a dust-generating activity takes place (eg. vehicles travelling on roads, shiploading etc) – there is no dust emission when the activity is not being undertaken;
- prevailing meteorological conditions, in particular, the frequency at which the wind speed exceeds a defined limit for dust lift-off from an unconfined source (eg. stockpiles, unpaved roads etc);
- ore particle size distribution; and
- ore moisture content.

The resulting dust emission rate may be either:

- fairly constant, where dust is made airborne by the nature of the activity (eg. vehicle generated dust); or
- highly variable, dependent on the wind speed (eg. stockpiles, unpaved roads etc).

Dust sources can be broadly categorised as:

- Activity-dependent, where equipment needs to be operating in order to cause a dust emission;
- Wind-dependent, where the source is exposed to dust lift-off from frictional wind forces; and
- Vehicles, where dust results from wheels and the movement of the vehicle.

The dependencies taken into account in estimating dust emissions in this study are shown in Table 1.

Table 1 Dust emissions dependencies for various source types

Source type		
Activity	**Wind**	**Vehicles**
• Whether operating or not • Source-specific empirical emission function • Ore-specific dustiness potential • Wind speed (net vector for conveyors) • Applicable dust control	• Amount and shape of exposed surface area • Source-specific empirical emission function • Wind speed • Applicable dust control	• Rate of vehicular traffic • Vehicle-specific empirical emission function • Vehicle speed • Vehicle parameters (mass, wheels) • Applicable dust control

A summary of the specific Dampier Port dust sources and their categorisation for the purpose of describing emission rates later in this document is shown in Table 2. A more detailed description of dust emissions controls as at 95 Mtpa and proposed for 145 Mtpa is given later in Table 21.

4. HISTORY OF DUST EMISSIONS ESTIMATES

The source emissions functions and supporting data used for modelling in this study have been developed and updated over time based as follows.

Used for modelling expansion to 95 Mtpa

- Results from several weeks of on-site measurements during 1997 and 1998 described in SKM (1998) (note that wind dependent functions based on BoM Karratha wind speeds therefore DPS wind speeds multiplied by 1.3 times for consistency with derivation of functions);
- Revisions described in Environmental Alliances (EA) (2003);

Used for modelling expansion to 120 Mtpa

- Revisions from the results from a further field sampling program in May 2004 pursuant to the Ministerial Conditions of approval for the expansion to 95 Mtpa (EA 2004).
- Revisions to the 5E conveyor and road emissions following a sampling program in December 2004 (EA 2005). It is understood that newly installed top belt water sprays were operating during this monitoring, however an improved belt cleaning system (both installed as part of the 95 Mtpa upgrade) was not operating. The emissions rate subsequently determined may therefore be an over-estimate once the belt cleaner is fully operational.
- The period modelled was updated from 17/12/2001 to 16/12/2002 to 1/6/2003 to 31/5/2004. This introduced the following variations-
- Emissions from sources based on wind generated dust functions will vary due to differences in wind speeds over the periods – the emissions are very sensitive to the highest wind speeds over a period. Consequently, a rainfall function was incorporated to set all source emissions to zero when the 24-hour average rainfall exceeded 0.25 mm for modelling of the 1/6/2003 to 31/5/2004 period. This is based on the NPI emission estimation equation for open area wind erosion (NPI 2001).
- The emissions from bulking are dependent on the extent and time of bulking operations – these vary from year-to-year. Bulking data for the modelling period was used as the basis for this study.
- More detailed activity related data for vehicles in operational areas, and PP car dumpers, screenhouses, and ship loaders specific to the period modelled in this case, were used.
- For sources for which there were no previous emissions estimates, NPI or AP42 emissions estimates were used.

Table 2 Summary of key dust sources and fundamental mechanisms affecting dust emissions

Source name (in approx order of transfer through Port)(a)	Description	General controls	Emission frequency	Emission rate dependencies	Source category(b)	Emission configuration for modelling
Car Dumpers	Large buildings in which rail cares containing ore are turned dumping ore into a below-ground hopper for subsequent conveyor transfer to Live Stockpiles.	Internal water sprays, Baghouse	Activity dependent	-	“Operations”	Wake-effected point
1E/4E-5E transfer (on mainland)	Dust generation from conveyor surface and dropping during transfer to 5E conveyor.	Enclosures, water sprays	Activity dependent	Wind speed	“Operations”	Volume
EII 5E Conveyor	Airborne dust may be generated from the conveyor top and return strands and from deposits on the ground below the conveyor. Most of the ore deposited from the underside of the conveyors belt falls closer to EII than the mainland. These are cleaned up periodically (during conveyor shutdowns) using a specially designed front-end loader.	Water sprays along conveyor, belt cleaning and washing, wind barriers and partial covering.	Activity dependent	Wind speed	“Operations”	Multiple volume sources
EII 5E Causeway Vehicles	The causeway road alongside the conveyor is sealed (speed limit 60 km/h) however dust generated from the conveyor or deposits underneath may be redeposited on the road surface. Vehicles running over the deposited dust may grind the particles further and cause dust generation. Vehicle may also emit dust deposited while on EII as they increase speed along the causeway, as well as drop accumulated mud onto the causeway.	Road sweepers used to clean road. Sealed road widened with kerbing installed preventing vehicles running off road and raising dust	Activity dependent	-	“Vehicles”	Multiple volume sources
EII/PP Transfers inloading	Dust generation from dropping during transfers on the way to live stockpiles.	Transfer sealing and for new transfers at PPt - design	Activity dependent	Wind speed	“Operations”	Volume
EII/PP Stacking	Dust generation from dropping of ore from conveyor onto live stockpiles.	Water sprays on stackers. At PPt these are automatically operated	Activity dependent	Wind speed	“Operations”	Volume
EII/PP Live Stockpile areas (includes stockpile surfaces, open areas and road surfaces)	Wind-generated dust from the surface of these stockpiles.	Water trucks for road surfaces. Water cannons are being installed for all live stockpiles at EII and PP.	-	Wind speed	“Open”	Area

Source name (in approx order of transfer through Port)(a)	Description	General controls	Emission frequency	Emission rate dependencies	Source category(b)	Emission configuration for modelling
EII/PP operational area vehicles (excluding dust from bulking – treated separately)	Vehicle-generated dust from vehicle movements within the operations area.	Road sealing Water trucks on unpaved roads Bitterns application on unsealed roads Road sweeping on sealed roads	Activity dependent	-	"Vehicles"	Area
EII/PP Reclaiming	Dust generation during reclaiming from live stockpile and transfer to conveyor.	Water sprays fitted to reclaimers at PPt as part of the 95 Mtpa and at EII as part of 145 Mtpa	Activity dependent	Wind speed	"Operations"	Volume
EII/PP Transfers Outgoing	Dust generation from dropping during transfers ex live stockpiles.	Transfer sealing and for new transfers at PPt - design	Activity dependent	Wind speed	"Operations"	Volume
EII/PP Screening Buildings	Dust generation during ore screening.	Baghouse	Activity dependent	Wind speed	"Operations"	Volume
EII/PP Ship Loading	Dust generation during dropping of ore to ship.	Chute + water sprays	Activity dependent	Wind speed	"Operations"	Volume
EII/PP Bulk stockpiles	Wind-generated dust from the surface of these stockpiles. These vary in size and distribution within the bulk stockpile storage area.	Water application	-	Wind speed	"Open"	Area
EII/PP bulking	Vehicle-generated dust during bulking operations. Bulking involves the transfer of ore from live stockpiles to a separate bulk stockpile to blend ores. Typically, a front end loader loads from a live stockpile into haul truck. The haul truck transports the ore to a bulk stockpile where it is dumped and dozed. In the reverse operation, a front end loader loads from a bulk stockpile into haul truck which transports and tips the ore through a elevated grate inloading hopper onto a conveyor for stacking to a live stockpile.	Water trucks used on haul roads. Water cannon used to wet bulk stockpiles during tipping or loading. Truck-activated water sprays on in-loading hopper.	Activity dependent	-	"Vehicles"	Area

[a] Sources denoted "EII/PP" mean the same general facility/operation is in the EII and PP operational areas.

Used for modelling expansion to 145 Mtpa

- The emissions estimation approach used for modelling dust for the 2005 year and for the proposed increase in throughput to 145 Mtpa incorporated revised functions for estimating emissions from some sources based on

  a field sampling program in December 2005 by Environmental Alliances in response to Ministerial Conditions attached to the approval for the 120 Mtpa upgrade; and

  field sampling programs over 2006 by SKM pursuant to Condition:M7-3 of Ministerial Statement 734 (see Appendix 3).

The following Sections describe the methods used to estimate dust emissions from the Dampier Port operations for 2005 – at a nominal Port throughput of 95 Mtpa, and for an increased throughput to 145 Mtpa.

5. DUST EMISSIONS FROM VEHICLES

This Section described the equations and supporting data used to estimate dust emissions from "Vehicles" sources. A diagram outlining the emissions estimation steps is shown in Figure 1.

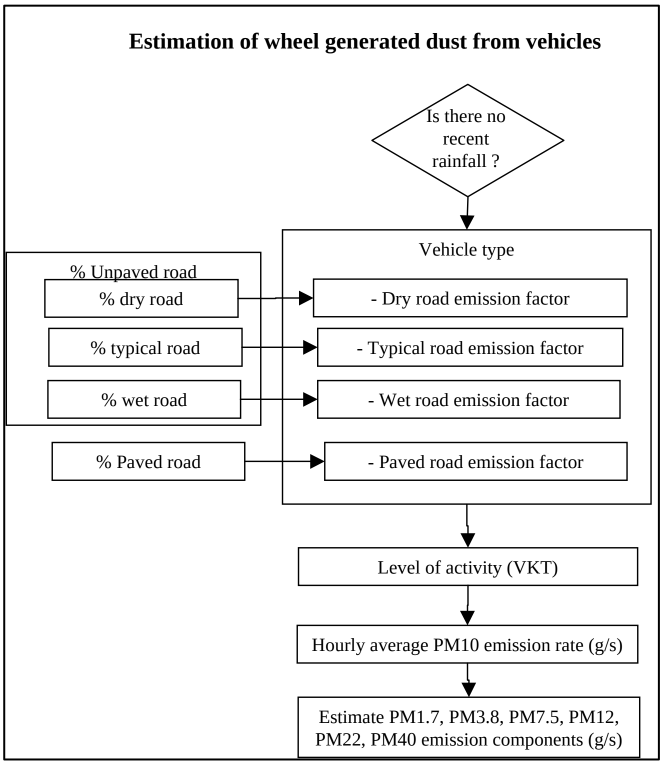

Figure 1 Outline of steps for estimating vehicle dust emissions

5.1 EMISSION RATE PER VEHICLE

The hourly PM10 emissions rate per vehicle is calculated simply from:

$$Q_{PM10,Vehicles} = \frac{VKT_{1-hour} \times EF \times 1000}{60}$$ **Equation 1**

where:

$Q_{PM10,Vehicles}$ = PM10 emission rate (g/s).

$VKT_{1\text{-}hour}$ = vehicle kilometres travelled in 1 hour.

EF = PM10 emission factor (kg/(vehicle.km)=kg/VKT).

5.2 ESTIMATING VEHICLE KILOMETRES TRAVELLED

A fundamental parameter in estimating dust emissions from roads irrespective of method used, is the number (and characteristics) of vehicles using the road. In order to improve previous estimates, a traffic survey using an automated traffic classifier was conducted on the EII Causeway between Monday, 12 May 2003 and Tuesday, 20 May 2003. A summary of the results is shown in Table 3.

Table 3 Summary of results of vehicle survey on 5E causeway

Parameter	Value
Average no of vehicles/24 hours	288
Average no of vehicles/"day" (0600-1800 hours)	220
Average no of vehicles/"night" (1800-0600 hours)	67
Average Mass (T)	3.1
Average speed (km/hr)	58.8

Total vehicles counted over the survey period was 2550.

For the 2 km length of causeway[1], the total distance travelled per day is 564 km. This compared quite well to the 648 km assumed for modelling the 95 Mtpa expansion (SKM 2003).

The average hourly vehicle distribution over each 24-hour period is shown in Table 4.

[1] From the mainland T-junction to the EII conveyor underpass.

Table 4 Hourly vehicle counts on 5E causeway

Daily time period (hours)	Vehicle count	Daily time period (hours)	Vehicle count
0000-0100	6.9	1200-1300	15.1
0100-0200	5.6	1300-1400	18.0
0200-0300	4.9	1400-1500	21.6
0300-0400	4.7	1500-1600	17.9
0400-0500	3.4	1600-1700	16.6
0500-0600	11.7	1700-1800	13.4
0600-0700	9.0	1800-1900	9.1
0700-0800	10.9	1900-2000	5.4
0800-0900	22.0	2000-2100	9.9
0900-1000	22.0	2100-2200	7.1
1000-1100	24.0	2200-2300	5.1
1100-1200	17.6	2300-2400	5.5

Average speed of 60 km/hr (speed limit) assumed.

This distribution was used to estimate an hourly emissions profile for wheel generated dust from the 5E causeway as well as provide a basis for vehicle VKTs during day and night-time within each operation area.

5.3 ACTIVITY DATA

The activity data provided by PI used for the emission rate calculation is shown in Table 6.

5.4 VEHICLE EMISSION RATES

- Emissions rates (in VKT/hr) for haul trucks within the different operational areas were distributed on a probabilistic basis each hour using the weightings in Table 5. This was to reflect the variability in dust emission rates depending on the level of moisture in the road surface.
- Emissions rates for road vehicles were distributed on a daytime/night-time basis since water trucks do not operate at night-time and emissions rates (per VKT) are therefore likely to be higher than during daytime when roads are watered.
- Emissions from the 5E causeway (vehicles and wind-generated dust) were treated as ten equally spaced volume sources, with relatively higher emissions closer to EII. This was to reflect understanding of the dust generation mechanisms from that source.

Table 5 Estimated PM10 emission rates from vehicles for existing operations

Source	Surface condition	PM10 emission rate for 95 Mtpa (kg/VKT)	Weighting for probabilistic distribution
EII Haul trucks (unpaved roads)	very wet	0.15	0.10[b]
	wet	0.40	0.20
	medium	0.80	0.60
	very dry [b]	3.5	0.10
PP Haul trucks (unpaved roads)	very wet	0.15	0.030 [b]
	wet	0.40	0.87
	medium	0.80	0.067
	very dry [b]	3.5	0.033
5E causeway (paved) road EII end and Mainland end [c]	typical	0.20 to 0.056[d]	Frequency as per vehicle counts in Table 4
EII operational areas (predominantly unpaved roads)	Unpaved Day/watered	0.34[a]	0600 – 1800 hours
	Unpaved Night/dusty	0.80[a]	1800 – 0600 hours
PP operational areas (predominantly unpaved roads)	Unpaved Day/watered	0.34[a]	0600 – 1800 hours
	Unpaved Night/dusty	0.80[a]	1800 – 0600 hours
EII and PP operational areas	Paved Any time	0.13[e]	All hours

[a] Results from field monitoring May 2004 (EA 2004).
[b] Added function based on field survey May 2004 (EA 2004).
[c] Emissions rates graded between EII and Mainland end.
[d] As per study described in EA (2005).
[e] From 5E road vehicle dust measurements undertaken in December 2004 shown in EA (2005a).

5.5 INCREASED ROAD SEALING AT EII

The current works associated with the replacement of key facilities that will enable an increase in throughput to 145 Mtpa (compared to pre-expansion to 95 Mtpa) incorporates additional road sealing at EII. The benefit from the increased paved roads is summarised in Table 7.

Table 6 Estimated vehicle activity in operation areas

Parameter	Time periods	No of vehicles operating	Average speed (km/hr) [(b)]	Activity factor	VKT/hr (km/hr)
EII Vehicles within operational area (excluding those related to bulking operations)	Day 0600-1800	4 operations + maintenance, contractors, transport, visitors, labs = 10 assumed	25	0.1	25
	Night 1800-0600	67/220[(a)] x 10	25	0.1	7.6
PP Vehicles within operational area (excluding those related to bulking operations)	Day 0600-1800	4 operations + maintenance, contractors, transport, visitors, labs = 10 assumed	25	0.1	25
	Night 1800-0600	67/220[(a)] x 10	25	0.1	7.6

[(a)] Based on day versus night distribution in Table 3 above.
[(b)] Speed limit is 25 km/hr.

Table 7 Estimated dust reduction benefit for road sealing and dust retardant at EII

Source	Distribution	PM10 upaved road emission rate from Table 5 (kg/VKT)		PM10 emission rate with dust retardant (kg/VKT)	PM10 paved road emission rate (kg/VKT)	Proportion of new paved roads	Overall dust emissions rate (kg/VKT)	VKT/hr (km/hr)	Overall dust emission benefit
EII operational areas	0600 – 1800 hours	Unpaved Day/ watered	0.34	0.34	0.13	0.15	0.31	25	0.86 = 14%
	1800 – 0600 hours	Unpaved Night/ dusty	0.80	0.72[(a)]	0.13		0.63	7.6	

[(a)] Assumed to be 10% effective for night-time conditions when roads are not routinely watered.

6. DUST EMISSIONS FROM BULKING

Bulking also involves front-end loader and dozer usage, dumping into haul trucks and the haul trucks dumping their load.

6.1 EMISSION ESTIMATION EQUATIONS

Emissions for these activities were based on NPI (2001) equations as follows:

Loading/dumping

$$E_{Load/Dump} = k0.0016\left(\frac{U_{10,Dmpr}}{2.2}\right)^{1.3}\left(\frac{M}{2}\right)^{-1.4}$$ **Equation 2**

$$Q_{PM10} = E_{Load/Dump}\left(\frac{1000}{3600}\right)T$$ **Equation 3**

where-

$E_{Load/Dump}$ = PM10 emissions rate (kg/t).

T = Material throughput (t/hr).

k = constant of 0.35 for PM10[2].

$U_{10,Dmpr}$ = wind speed at 10 metres (m/s) – DPS measurements used.

M = material moisture content (%) – assumed default of 2%.

Emissions were estimated for loading and dumping separately.

[2] This was multiplied by 2.8 for estimating TSP emissions for consistency with other emission estimates. The NPI factor for TSP is 0.74. 0.74/0.35 gives a [TSP]/[PM10] ratio of 2.1 therefore using 2.8 could arguably overestimate TSP emissions however it is noted in the NPI handbook that this equation may underestimate emissions based on Australian data.

Dozer

$$E_{Dozer} = 0.34\left(\frac{s^{1.5}}{M^{1.3}}\right)$$ **Equation 4**

$$Q_{PM10} = E_{Dozer}\left(\frac{1000}{3600}\right)$$ **Equation 5**

where-

E_{Dozer} = PM10 emissions rate (kg/h)[3].

s = material silt content (%) – assumed default of 10%.

M = material moisture content (%) – assumed default of 2%.

6.2 ACTIVITY FACTORS FOR 95 MTPA

Wheel generated dust emissions from Haul Trucks were calculated using Equation 2 and the vehicle parameters in Table 5. The emissions rate can be converted into a time-based emission over a year using the bulking activity parameters summarised in Table 8.

Table 8 Bulking activity factors

Activity factor	EII	PP
	Actual for 2005	Actual for 2005
Material bulked per year (t)	5.8×10^6	1.7×10^6 (b)
Number of shifts per year	281(a)	47
Average time per shift (hrs)	10	10
Ore handling rate (t/hr)	2773	2169

(a) There may be more than one shift in a day. The assumed average speed of haul trucks for calculating distance travelled is 25 km/hr.
(b) All of the bulking at PP was between July and December.

Note that the bulking activity at PP for 2005 was considerably less than that previously assumed for 95 Mtpa modelling in EA (2003).

6.3 ACTIVITY FACTORS FOR 145 MTPA

6.3.1 EII

The level of bulking at EII for 145 Mtpa will not increase beyond the 2005 actual levels. Therefore, the activity factors are those shown in Table 8.

[3] This was multiplied by 2.8 for estimating TSP emissions for consistency with other emission estimates. The NPI defaults give a [TSP]/[PM10] ratio of 4.25 therefore using 2.8 could, in this case, underestimate TSP emissions.

6.3.2 PP

The bulking activity at PP is expected to increase from about 1.7 Mtpa actually undertaken for 2005, to 5.9 Mtpa at 145 Mtpa. These are total ore tonnages moved into the bulk stockpile, then back to the live stockpile.

Two additional bulk stockpile areas will be constructed:

- Northern (Sea Wall) Bulk stockpile – this will be stacked using stackers fitted with water sprays; and
- North-eastern (Triangle) Bulk Stockpile.

The Northern Bulk stockpile formed part of the scope to achieve 120 Mt/a. The North-East (Triangle) Bulk Stockpile is additional.

The dimensions and utilisations of all of the PP bulk stockpile areas are shown in Table 9.

Table 9 Bulk stockpiles and ore movement assumptions

Parameter	Eastern Bulk stockpile	Northern (Sea Wall) Bulk stockpile	North-eastern (Triangle) Bulk Stockpile	Total
Stockpile maximum capacity (t)	1.0×10^6	1.5×10^6	0.30×10^6	2.8×10^6
Stockpile maximum surface area (m^2)	61500	62500	20000	144000
Average capacity utilisation (%)	80	95	70	-
Stockpile average surface area (m^2)	49200	59400	14000	120500
Total ore moved (t/yr) = Material bulked per year into and out of the bulk stockpile assuming material in = material out (t/year)	2.0×10^6	3.3×10^6	0.6×10^6	5.9×10^6

Assumptions used to create a simulated bulking activity for 145 Mtpa were:

- It is only possible to bulk one area at a time since the fleet of haul trucks is kept to a minimum;
- The total elapsed time per shift is 11 hours which equates to a working time of 10 hours after allowing for a 1 hour break within a shift;
- Night shift bulking is 1800-0400 with break at 0100 end times;
- Day shift bulking is 0600-1600 with break at 1300 end times;
- Day shift bulking is arranged preferentially to night-time bulking;
- Bulking scenarios were simulated as utilising complete shift periods at a time (this should ensure that the maximum 24-hour average dust predications are not under-estimated); and
- Other assumptions shown in Table 10 and Table 11.

Table 10 Bulking constants for all stockpiles

Bulking constants for all stockpiles	Value
Water control effectiveness for Live Stockpile (LS) dump hopper (%)	30
Time/shift (hrs)	10
Total available shifts/year	730
Rate of ore moved (t/hr)	2000
Number of haul trucks operating	3

Table 11 Haul truck and equipment assumptions

Parameter	Eastern Bulk stockpile	Northern (Sea Wall) Bulk stockpile	North-eastern (Triangle) Bulk Stockpile
Haul dist from LS to Bulk Stockpile (BS) (km)	0.38	-	0.60
Haul dist from BS to LS dump hopper (km)	0.71	0.89	0.59
Average on-road speed (km/hr) [d]	40	40	40
Average speed incl stoppage time (km/hr)	11	18	12
VKT/hr for 3 trucks inbulking	12	n/a	21
VKT/hr for 3 trucks outbulking	23	48	21
Avg VKT/hr for 3 trucks (avg dist for LS to BS and BS to LS)	40.70	66.94	44.34
Average speed incl stoppage time inbulking (km/hr)	3	n/a	6
Average speed incl stoppage time outbulking (km/hr)	6	13	6
Equipment operating at LS during inloading to BS	loader	reclaimer[c]	loader
Equipment operating at BS during inloading to BS[b]	nil (Haul Truck dumping only)	nil (Haul Truck dumping only)	nil (Haul Truck dumping only)
Equipment operating at BS during outloading[b]	dozer, loader	dozer, loader	dozer, loader

(a) The level of activity for the amount of ore bulked is double that which would be based on the ore handling rate, because ore is moved into, then out of, each bulk stockpile except for Northern seawall stockpile.

(b) There may be more than one shift in a 24-hour day.

(c) Northern row bulk stockpile has stacker for inloading to the stockpile.

(d) Higher speeds assumed for PP than EII due to longer travel distances.

The simulated profile of bulking at PP for 145 Mtpa over January is shown in Figure 2. Note that there is no bulking into the North Bulk Stockpile since this is filled using a stacker.

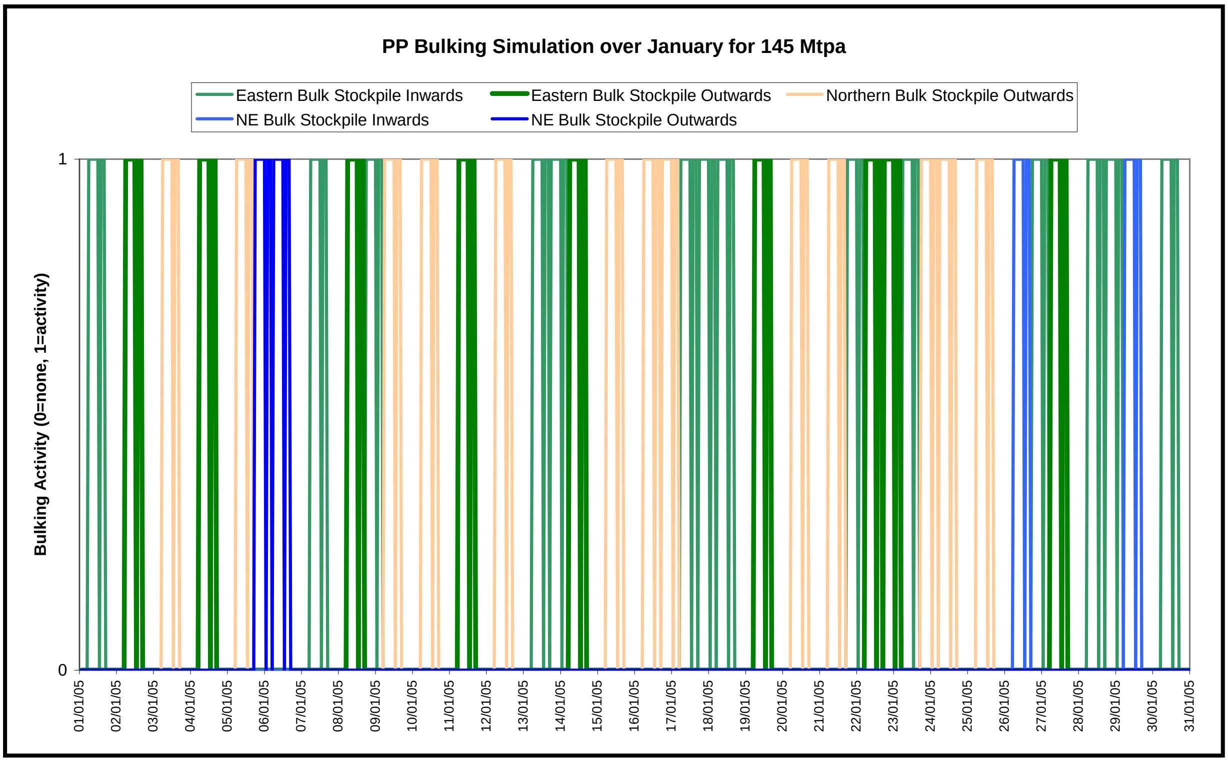

Figure 2 PP bulking simulation over January for 145 Mtpa

7. DUST EMISSIONS FROM ACTIVITY SOURCES

This Section describes the equations and supporting data used to estimate dust emissions from “Activity” sources. A diagram outlining the emissions estimation steps is shown in Figure 3.

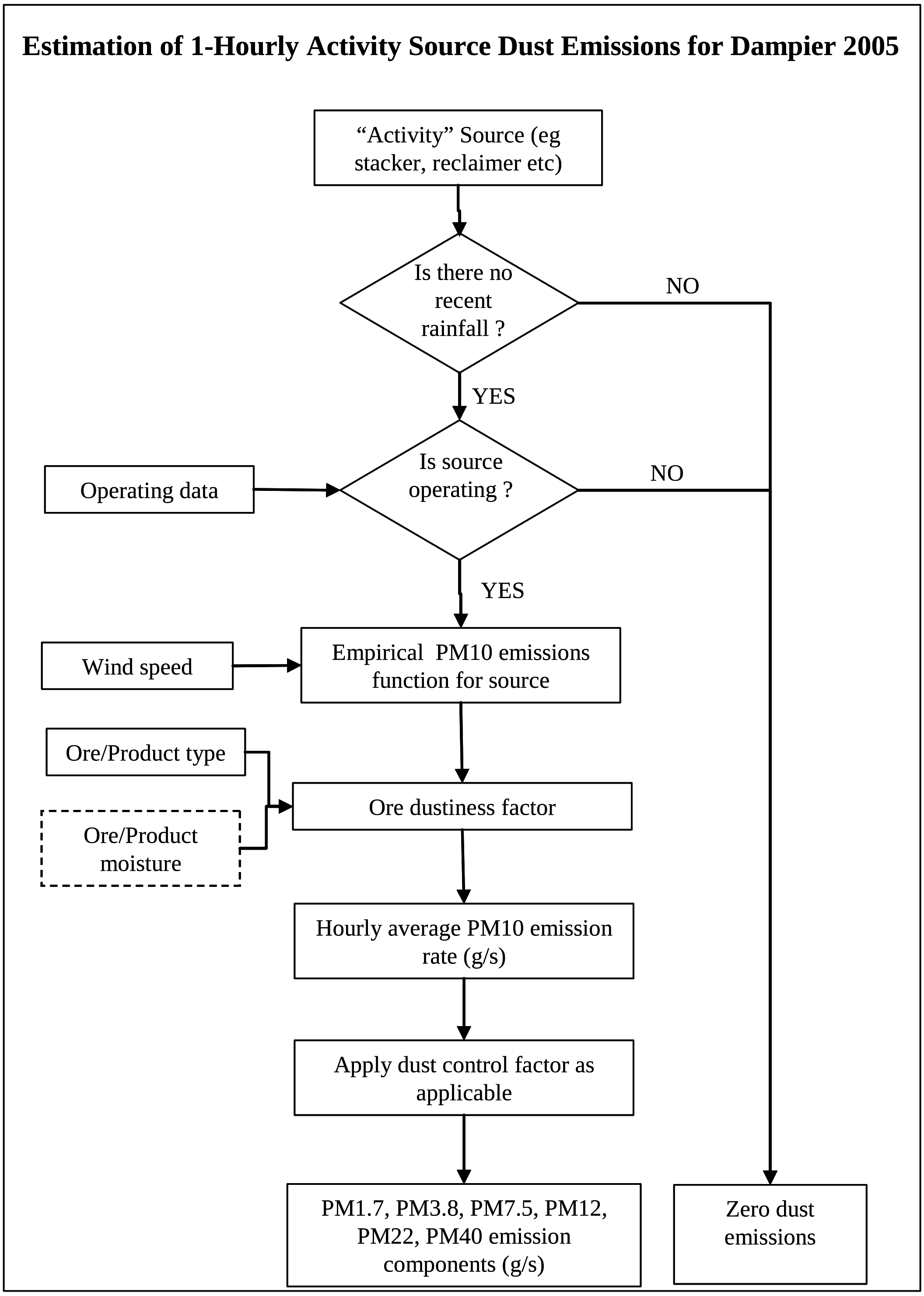

Figure 3 Outline of activity sources dust emissions estimation steps

7.1 DUST EMISSION EQUATIONS

7.1.1 Sources other than conveyors

The initial emissions estimate, as PM10, based on the wind speed is given by:

$$Q_{PM10} = K_s U_{10,\mathrm{KA}}{}^{p}$$ **Equation 6**

where-

K_s = Source-specific empirical constant (g/m).

$U_{10,KA}$ = Wind speed measured at 10 m at Karratha Airport (m/s).

p = Source-specific empirical exponent.

The values of K_s and p along with the assumed emissions frequency based on activity times are shown in Table 12.

Table 12 Empirically derived parameters for wind generated dust from "activity" sources

Source name	Unit ID	K_s (g/m)	p	Modifier
1-4E/5E Transfer	1-4E/5E	0.25	0.5	-
EII Reclaiming[(b)]	Various	0.18	1.4	+ 1.0 g/s
EII Screening Building	SH1E	1.22	0.5	-
EII Ship Loading	SL1E	0.19	1.4	-
EII Stacking[(b)]	Various	0.080	1.4	Or 0.1 g/s for $U_{10,KA}$ < 2 m/s
EII Transfers inloading[(b)]	Various	0.060	1.4	Or 0.1 g/s for $U_{10,KA}$ < 2 m/s
EII Transfers outgoing	Various	0.095	1.4	-
PP Screening Building 1	SH1P	2.4	0.5	-
PP Screening Building 2	SH3P	1.22	0.5	-
PP Ship Loader 1	SL1P	0.19	1.4	-
PP Ship Loader 2	SL2P	0.19	1.4	-
PP Stacking[(c)]	Various	0.21	1.4	Or 0.1 g/s for $U_{10,KA}$ < 2 m/s
PP Transfers inloading	Various	0.14	1.4	-
PP Reclaiming[(a)]	Various	0.29	1.4	Or 0.1 g/s for $U_{10,KA}$ < 2 m/s
PP Transfers outgoing[(b)]	Various	0.045	1.4	Or 0.1 g/s for $U_{10,KA}$ < 2 m/s

[(a)] Note that this is averaged from EA and SKM (2007) monitoring – see Appendix 4.
[(b)] Emission function from SKM (2007).
[(c)] Note that this is averaged from EA and SKM (2007) monitoring – see Appendix 5.

7.1.2 Conveyors

5E Conveyor top strand

Wind generated PM10 from the 5E conveyor top strand was estimated using the results from additional monitoring in 2004 (EA 2005):

$$Q_{PM10} = 0.00084U_f^3(1-(5.4^2/U_f^2))$$ **Equation 7**

Where-

U_f = the "forcing" wind speed – ie. net wind speed between the actual wind speed at conveyor height and the belt speed (m/s) (ie also taking into account the wind direction and orientation of the conveyor).

Operational area conveyors

The upgrade works have progressively involved the replacement of the original conveyors at Parker Point that have belt widths of 1500mm with slower conveyors having belt widths of 1800 mm. The dust emission benefits of the 1800 mm conveyors can be estimated theoretically.

Top strand dust emission rates are proportional to the ore surface area and net velocity of the exposed ore against the prevailing wind (U_f). For a relative comparison of 1800 mm belts and 1500mm belts (ie meteorological parameters the same), U_f is directly proportional to the belt speed.

The relative benefit of the 1800 mm conveyors is related to the change in these parameters in relation to ore transfer rate. Assuming that dust emissions are linearly proportional to ore surface area and conveyor belt speed (only ie. other dust controls are the same), the relationship for comparing relative PM10 emission rates per unit of conveyor length is:

$$Q'_{PM10,w} \alpha f(SA' \times Ub / C) \qquad \textbf{Equation 8}$$

Where-

$Q'_{PM10,w}$ = PM10 emission rate for belt of width “w”.

SA’ = unit surface area (m^2/m of belt).

Ub = belt speed (m/s).

C = conveyor ore transport capacity (g of ore transported/s).

The bottom stand emission rates can be estimated similarly except that the surface area term is simply the width of the belt (assuming that belt cleaning efficiencies are the same).

The table indicates that there is about a 9.3% emission benefit (per tonnes of ore transported) for the 1800 mm conveyors compared to the 1500 mm conveyors.

Table 13 Dust emission benefit of 1800 mm conveyors compared to 1500 mm conveyors

Upgrade Phase[(a)]	Nominal total Port capacity (PP + EII)	PP conveyor[(a)]	Capacity (t/hr) [(a)]	Width (mm) [(a)]	Average surface area (m2/m of belt) [(a)]	Relative PM10 emission rate for top strand (m2/g of ore transported)	Relative PM10 emission rate for bottom strand (m2/g of ore transported)	Average of relative PM10 emission rates for top and bottom strands (m2/g of ore transported)
Pre - Phase A	65 Mtpa	1P	7500	1500	1.08	1.78	2.47	2.57
		2P	7500	1500	1.08	1.78	2.47	
		3P	7500	1500	1.08	2.81	3.89	
		4P	7500	1500	1.08	2.81	3.89	
		5P	9000	1500	1.08	2.34	3.24	
		6P	12500	1500	1.08	1.68	2.33	
		7AP	10600	1500	1.08	1.62	2.24	
		10P	7500	1500	1.08	1.78	2.47	
		12P	2000	1500	1.08	3.55	4.91	
		18P	11400	1500	1.08	1.85	2.56	
		29P	11000	1500	1.08	1.74	2.41	
Phase A	95 Mtpa	3P	12000	1500	1.08	1.75	2.43	2.07
		4P	12000	1500	1.08	1.75	2.43	
		5AP	11400	1500	1.08	1.71	2.37	
		18P	11400	1500	1.08	1.85	2.56	
		101P	10000	1800	1.30	2.10	2.92	
		102P	10000	1800	1.30	1.82	2.53	
		103P	10000	1800	1.30	1.79	2.49	
		104P	10000	1800	1.30	1.77	2.45	
		106P	10000	1800	1.30	1.77	2.45	
		107P	12000	1800	1.30	1.79	2.48	
		108P	12000	1800	1.30	1.79	2.48	
		109P	11400	1800	1.30	1.58	2.19	
		110P	11400	1800	1.30	1.88	2.60	
		111P	11400	1800	1.30	1.60	2.22	
		112P	11400	1800	1.30	1.55	2.15	
Phase A	120 Mtpa	114P	11400	1800	1.30	1.57	2.18	
		115P	11400	1800	1.30	1.55	2.15	
		116P	11400	1800	1.30	1.55	2.15	
		121P	10000	1800	1.30	1.82	2.53	
Upgraded Phase B	145 Mtpa	201P	10800	1800	1.30	1.95	2.70	
		210P	11400	1800	1.30	1.88	2.60	
		212P	11400	1800	1.30	1.55	2.15	
		214P	11400	1800	1.30	1.57	2.18	
		215P	8000	1800	1.30	2.21	3.06	
		216P	11400	1800	1.30	1.55	2.15	
		3P	12000	1800	1.30	1.79	2.48	
		4P	12000	1800	1.30	1.79	2.48	
		5AP	11400	1800	1.30	1.58	2.19	
		18P	11400	1800	1.30	1.55	2.15	

[(a)] Data from P Ricciardello email 12/1/2006 modfied by K Buddle 18/9/2006.

7.1.3 Car Dumpers

Car dumper emissions estimates assumed a fixed emission of 0.35 g/s (when operating) based on a dust emissions concentration of 5 mg/m^3 when the dumper was operating. Measured emissions concentrations from car dumper 3 were 0.59 mg/m^3, <DL, 0.37 mg/m^3 (SKM 2006) hence 5 mg/m^3 is an upper estimate (Ref: SKM, 2006, “Design Transmittal no DPU-DT-09420”, 13/2/2006).

7.2 OPERATING FREQUENCIES

The emissions estimation approach incorporated the times of the actual activity of each stage of the ore handling operation (eg car dumping, stacking, reclaiming etc).

The operating frequencies for 2005 – nominally 95 Mtpa, were determined from the Port Process Analysis (PPA) data base. An example of the daily operating times over 2005 for the EII ship loader is shown in Figure 4. It is interesting that all of the ore handling equipment is subject to periodic stoppages throughout each day.

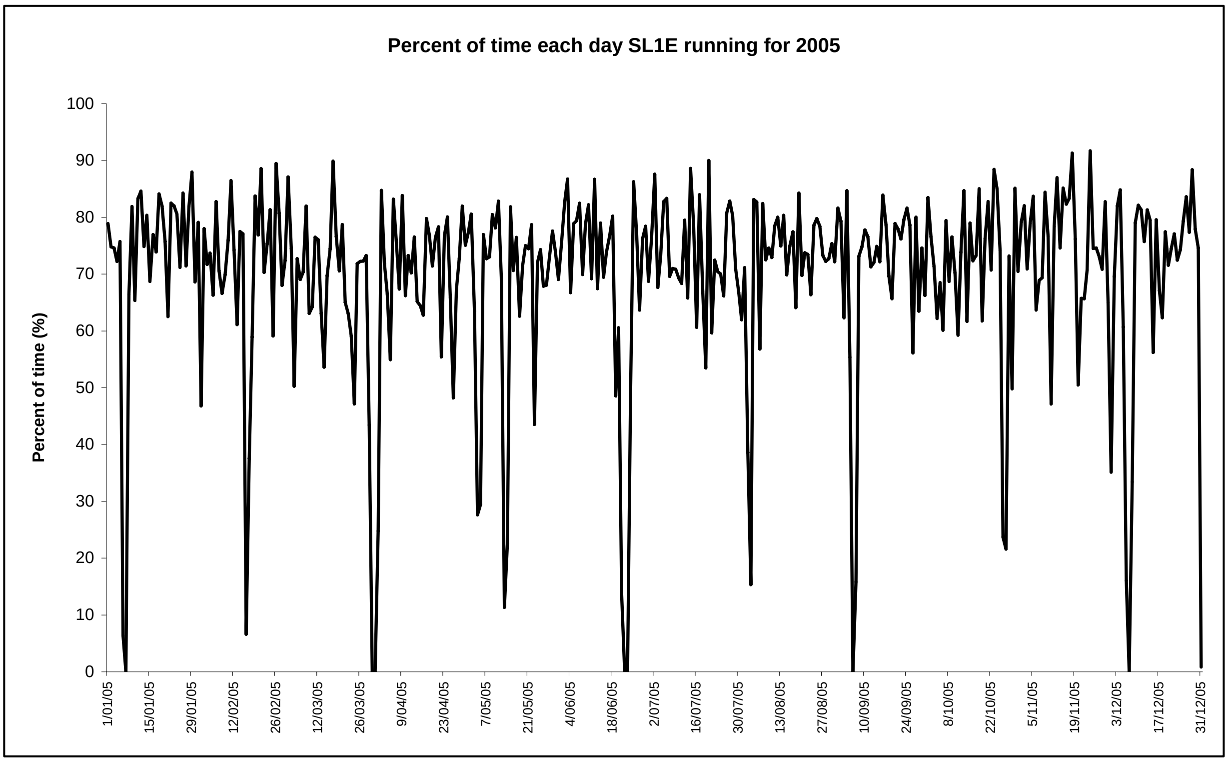

Figure 4 Percent of time each day EII shiploader running for 2005

The increases in Dampier Ports ore throughput capacity for 145 Mtpa is summarised in Table 14.

Table 14 Changes in total ore handling capacity of PI Dampier Ports

Combined ore handling capacity of both PI Dampier Ports	EII	PP
75 Mtpa	45 Mtpa	30 Mtpa
95 Mtpa	45 Mtpa	50 Mtpa
120 Mtpa	45 Mtpa	75 Mtpa
145 Mtpa	45 Mtpa	100 Mtpa

For example, references in this document to a total throughput (of both Ports) of 145 Mtpa imply a throughput of 100 Mtpa for the PP Port.

The estimation of emissions for the proposed increase in capacity at PP for 145 Mtpa ideally required hourly simulation data at that capacity to provide a realistic correlation in time between the emissions of the different ore handling activities. PI were unable to provide this type of data, however it was advised that the current ore handling operation at EII would be the best available approximation. This is because the 2005 throughput at EII was 45 Mtpa which is a close match to the two “trains” at PP when operating at 100 Mtpa (ie 50 Mtpa each train).

For 145 Mtpa, the hourly operating factor for EII over 2005 was therefore multiplied by 1.11 (=50/45). This becomes a little unrealistic for hours when the equipment is already operating for 100% of the hour (ie it’s not really possible to run for more than one hour within an hour).

Also for 145 Mtpa, the EII operating profiles for 2005 were followed for the CD3P and CD4P circuits at the same time, and for the SL2P and SL3P circuits at the same time. In other words, both car dumpers at PP and their associated equipment were assumed to be operating in synchronisation; similarly, both ship loaders at PP and their associated equipment were assumed to be operating in synchronisation. This could lead to an overestimate of the highest predicted dust levels because it is more likely that the CD3P and CD4P circuits will operate independently of each other and similarly for the SL2P and SL3P circuits.

The operating frequencies for 95 Mtpa and 145 Mtpa are summarised in Table 15.

Table 15 Use of operational parameters to estimate equipment emissions

Primary equipment for which operation periods data obtained	Ore	Associated equipment in use at the same time	Source Code	Percentage of time operating at 95 Mtpa - 2005 (%)	Percentage of time operating at 145 Mtpa (%)
CD1P (95 Mtpa only) or CD4P (145 Mtpa only)	Incoming ores	CD1P (95 Mtpa) or CD4P (145 Mtpa) Inloading transfers PP Stacker	CD1 (95 Mtpa) or CD4 (145 Mtpa) PXFIN PSTK	47.6	96.6[(a)]
CD3P	Incoming ores	CD3P Inloading transfers PP Stacker	CD3 PXFIN PSTK	22.1	96.6[(a)]
SL1P(95 Mtpa only) or SL3P (145 Mtpa only)	Exported products	Reclaimer Outloading transfers from Live Stockpiles to SH1P (95 Mtpa) or SH3P (145 Mtpa) Conveyor(incl transfers) from to SH1P to SL1P (95 Mtpa) or SH3P to SL3P (145 Mtpa) SL1P (95 Mtpa) or SL3P (145 Mtpa)	PRCL PXFOU PP7P SL1P (95 Mtpa) or SL3P (145 Mtpa)	57.4	76.6[(a)]
	Exported Lump (in addition to above)	SH1P (95 Mtpa) or SH3P (145 Mtpa) Returning fines Stacker	SH1P (95 Mtpa) or SH3P (145 Mtpa) PSTK	25.3	21.0[(a)]
SL2P	Exported products	Reclaimer Outloading transfers from Live Stockpiles to SH2P Conveyor(incl transfers) from SH2P to SL2P SL2P	PRCL PXFOU PP7P SL1P	8.2	76.6[(a)]
	Exported Lump (in addition to above)	SH2P Returning fines Stacker	SH2P PSTK	0.3	21.0[(a)]
CD2E	Incoming ores	CD2E 1/4-5E Transfer Point 5E Conveyor Inloading transfers EII Stacker	CD1E 145EXF 5ECR EXFIN EIISTK	79.8	79.8
SL1E	Exported products	Reclaimer Outloading transfers from Live Stockpiles to SH1E Conveyor (incl transfers) from SH1E to SL1E SL1E	EIIRCL EXFOU EI18E EIISHP	69.6	69.6
	Exported Lump (in addition to above)	SH1E Returning fines Stacker	SH1E EIISTK	19.1	19.1

[(a)] Calculated from 110% of EII throughputs (at 45 Mtpa) for 2005.

8. DUST EMISSIONS FROM OPEN SOURCES

This Section described the equations and supporting data used to estimate dust emissions from "Open" sources. A diagram outlining the emissions estimation steps is shown in Figure 5.

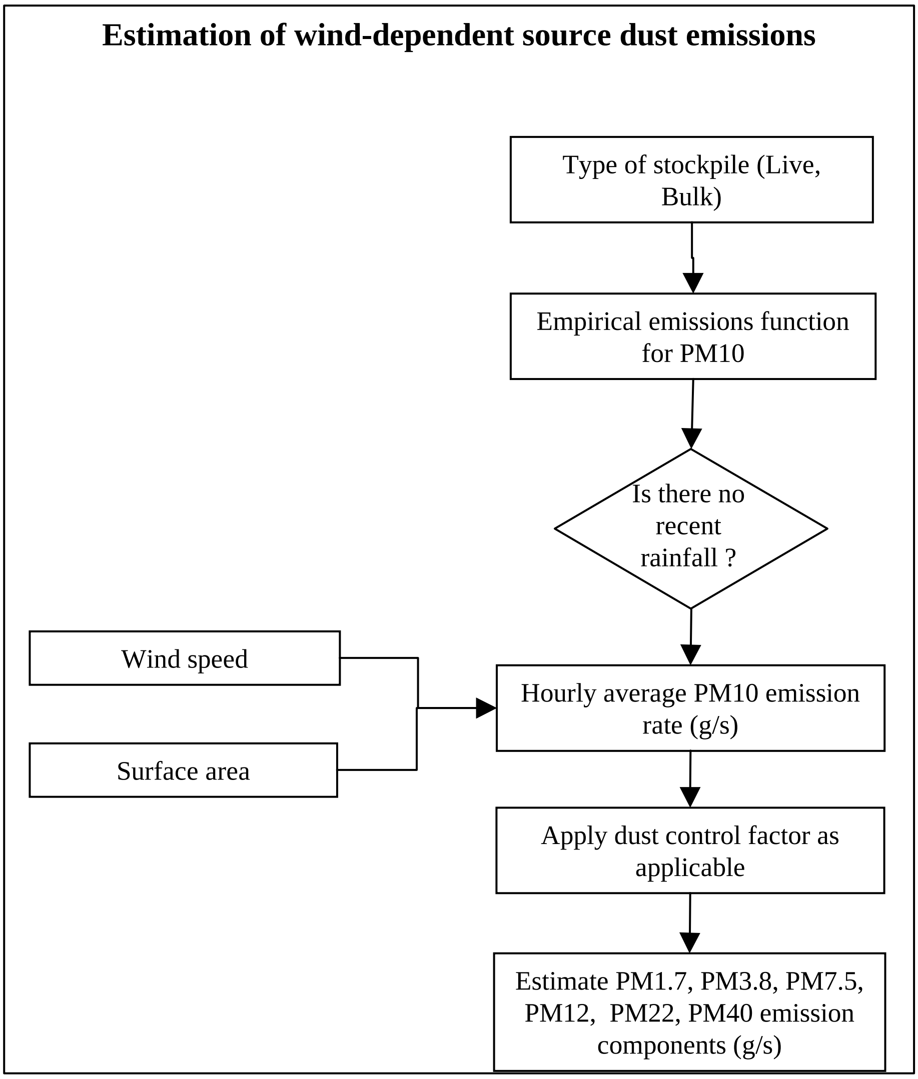

Figure 5 Outline of steps for estimating dust emissions from open sources

The form of the function used to estimate wind-generated PM10 emissions from "open" sources was as follows:

$$Q_{PM10,a} = K_{s,a} U_{10,KA}^{3} \left(1 - \frac{U_{t,10,KA}^{2}}{U_{10,KA}^{2}}\right) \quad (U_{10,KA} > U_{t,10,KA}) \qquad \textbf{Equation 9}$$

$$Q_{PM10} = Q_{PM10,a} x A \qquad \textbf{Equation 10}$$

where-

$Q_{PM10,a}$ = PM10 unit area emission rate (g/s/m^2).

$K_{s,a}$ = Site specific empirical constant ($g.s^2/m^5$).

$U_{10,KA}$ = Wind speed measured at 10 m at Karratha Airport (m/s).

$U_{t,10,KA}$ = Wind speed threshold for lift off of the material expressed in terms of wind speed measured at 10 m (m/s).

A = Source surface area (m^2).

The values of $K_{s,a}$ and $U_{t,10,KA}$ for the major wind-dependent dust sources are shown in Table 16. The application of the wind-generated function using these constants is illustrated in Figure 6.

Table 16 Unit area empirically derived parameters for wind generated dust lift-off

Open Source	$K_{s,a}$ ($g.s^2/m^5$)	$U_{t,10,KA}$ (m/s)
EII Live Stockpiles & Roads	5.2×10^{-7}	6.0[c]
PP Live Stockpiles & Roads	5.2×10^{-7}	7.5
PP Bulk stockpiles	5.2×10^{-7}	7.5
EII Bulk fines stockpile South and EII bulk stockpile North	8.9×10^{-7}	5.4
EII/PP Screening Buildings wind erosion	9.7×10^{-7}	5.4
EII conveyor from Screening Building to shiploader jetty (18E)[b]	9.7×10^{-7}	5.4
PP conveyor from SH1P to SL jetty (7P) [b]	9.7×10^{-7}	5.4
PP MMF Live Stockpiles (if required)[a]	20.2×10^{-7}	5.4

[a] Based on wind tunnel testing of dustiness assuming no water cannon dust suppression (SKM 2003 *pers com*).
[b] Source added following field sampling May 2004 (EA 2004).
[c] Emission function from SKM (2007).

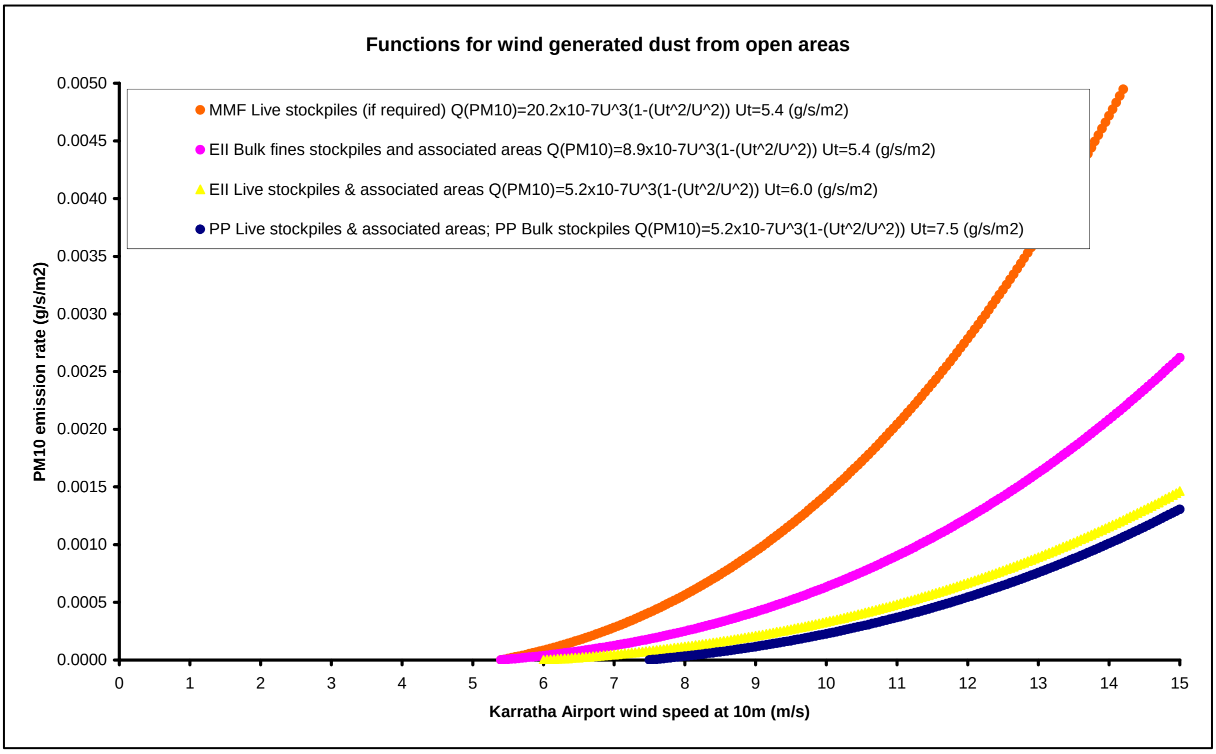

Figure 6 Wind generated PM10 emissions

The dimensions of the area sources are shown in Table 17.

Table 17 Areas of open sources

Open Source	95 Mtpa		145 Mtpa	
	Surface area (m^2)	% coverage for 2005	Surface area (m^2)	% coverage for 2005
EII Bulk fines stockpile South	14000	100	14000	100
EII Bulk stockpile North	27000	100	27000	100
EII Live Stockpiles & Roads	353000	100	353000	100
EII/PP Screening Buildings wind erosion	21600	100	21600	100
PP Live Stockpiles & Roads	426000	40	426000	65
PP Eastern Bulk stockpile	61500	7.5	61500	80
PP Northern (sea wall) Bulk stockpile	-	-	62500	95
PP North-eastern Bulk stockpile	-	-	20000	70

9. ADJUSTMENT FOR ORE DUSTINESS

The emissions estimation approach used for modelling dust for the 2005 year and for the proposed upgrade to 145 Mtpa also incorporated varying the real-time emissions estimate based on the dustiness of the ore being handled.

A considerable effort was undertaken by PI to measure dustiness from a variety of different ores. The method and results of this work are described in more detail in Appendix 2.

In theory, the relative in-field dustiness from different ores can be estimated from the dustiness/moisture relationship from dustiness testing and the actual ore moisture content. There are historical ore moisture measurements from ex the minesites and pre-shiploading. These data were reviewed but were not considered adequately representative of the ores as they are being handled through the Port. For example, the pre-shiploader moisture measurements at Parker Point are made immediately downstream of a manually operated water spray. The purpose of the measurement is to determine moisture levels of ore on the ship for commercial reasons.

Also, in-field moisture levels of the exposed ore vary considerably through the various stages from dumping, conveying to stockpiles, storage, reclaiming/conveying from the stockpiles (with screening as required) prior to shiploading. Moisture is added at various stages for dust control purposes, and lost through evaporation. A proper simulation of ore moisture changes during this cycle is complex. While important for accurate dust emissions modelling particularly for short timescales, this task is beyond the scope of what can be achieved at present.

In the absence of reliable in-field data of ore moistures, the "dustiness potentials" of various ores was assumed to be indicated simply by the ore Dust Extinction Moistures (DEMs) from the dustiness testing, as shown in Figure 7 and Figure 8 respectively for 95 Mtpa and 145 Mtpa ores.

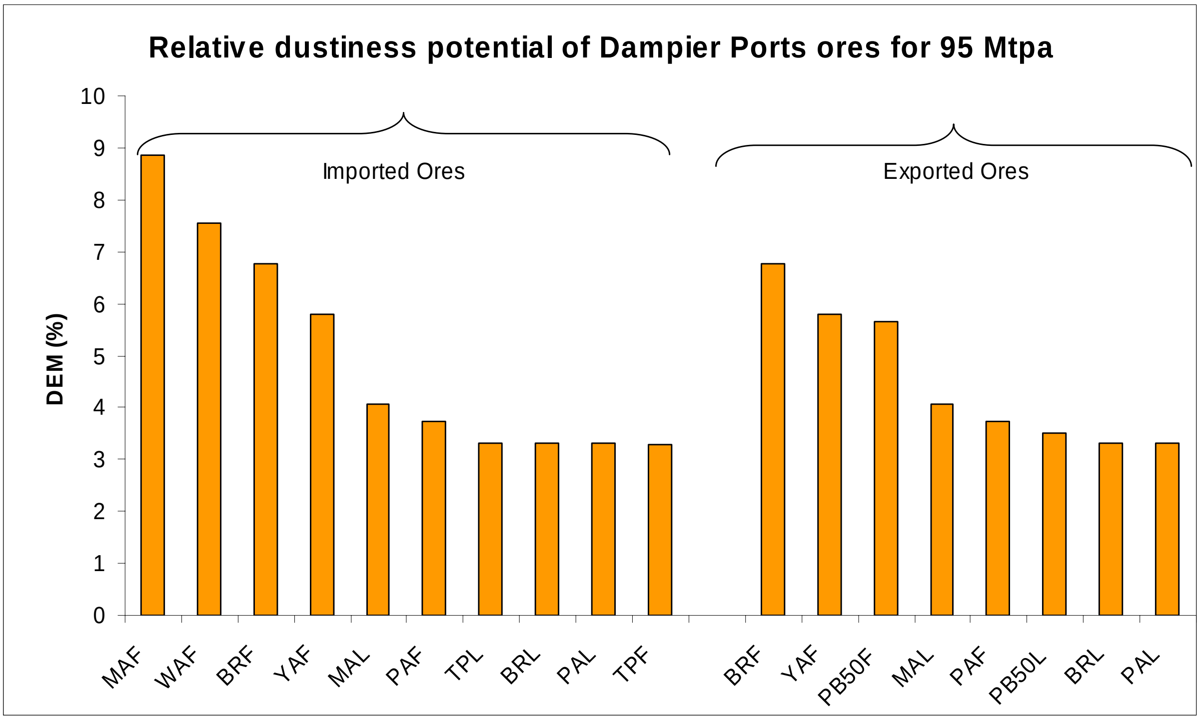

Figure 7 Relative dustiness potential of Dampier Ports ores for 95 Mtpa

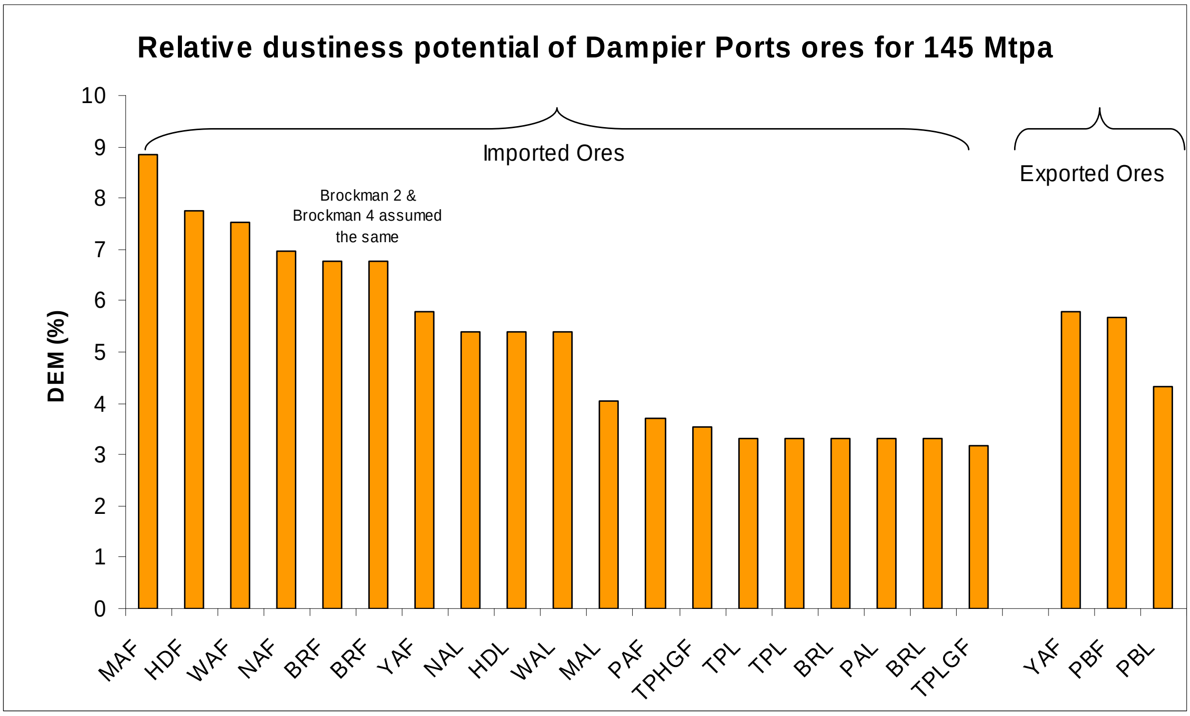

Figure 8 Relative dustiness potential of Dampier Ports ores for 145 Mtpa

For the modelling, a relative dustiness factor for each ore was calculated using the ore Dust DEM together with a small empirical adjustment[4] to ensure the annual average emission rate with the adjustments included was the same as when the adjustment was not included. This was to maintain the consistency with the previous modelling which showed that statistically, the modelled PM10 predictions compared quite reasonably with measured ambient concentrations. The relative adjustment factors used are illustrated in Figure 9.

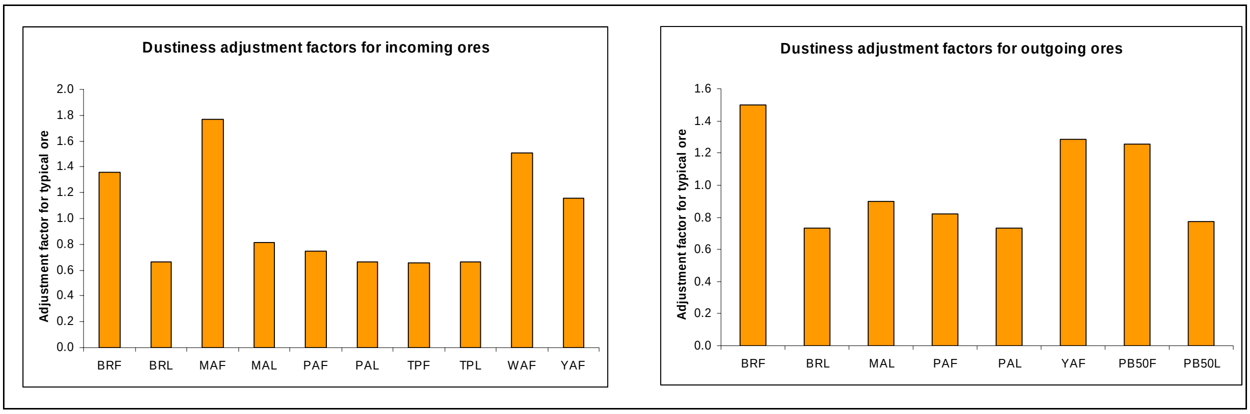

Figure 9 Dustiness adjustment factors

4 As it happened, this turned out to be very close to 1 in any case.

The ratio of the DEMs for the most dusty ore to the least dusty ore, is about three times. This is probably too low given that actual ore moisture levels also vary. This may cause an underestimation of the peak predicted dust levels over a year although this effect will be lessened to some extent in that dust criteria are 24-hour average concentrations (rather than based on a shorter averaging time). Predictions of annual average dust concentrations will not be affected.

Knowing the type of ore being processed by each item of equipment at any time enabled modelling of the emissions to be varied accordingly (ie on an hour-by-hour basis) by adjusting the emission rate relative to a “typical” ore upon which the empirical functions are based using the relative adjustment factors in Figure 9. It should be noted that these adjustments really relate more to dustiness during ore handling than to wind-generated dust.

It needs to be emphasised that this approach is very much a preliminary step towards accounting for changes in short-term dust emissions from ore type and it would be preferable to know or be able to estimate in-field ore moisture levels at each stage of handling and storage.

A moisture analyser was installed in the PP Car Dumper 3 in late 2005. Another moisture analyser was installed at the EII car dumper in August 2006. These will provide data on incoming ore moistures on a more consistent basis than previously. The use of this data should allow a more rigorous estimate of the variability of incoming ore dustiness than was possible using 2005 ex-minesite measurements.

It would be desirable to:

- Better understand the changes in ore moisture levels through the handling/storage process as water is added for dust control and lost through evaporation;
- Undertake more on-site source emissions testing to directly verify estimates and indeed confirm that the data from rotating drum dustiness test can be meaningfully applied in the real-world situation; and
- Further investigate the possible use of measured moisture levels of the ore prior to shiploading for estimating upstream and downstream ore moistures.

10. EFFECT ON AVERAGE DUSTINESS FROM CHANGE IN ORE COMPOSITION FOR 145 MTPA

There will be changes to the incoming ore composition when operating at 145 Mtpa since the market specifications will be changing and additional minesites will be contributing to the Port throughputs.

Since the dust emissions functions were determined empirically from a different ore composition, an assessment was undertaken on the potential effect on dustiness from the new composition.

The actual time-varying profiles for incoming and exported ores at 145 Mtpa are not known. Therefore, the dustiness potential of ores at 145 Mtpa throughput compared to 95 Mtpa were estimated using the weighted dustiness's of all ores for 95 Mtpa and 145 Mtpa (Table 18 and Table 19 respectively).

Table 18 Ore throughputs and DEMS for Dampier Port 2005 (95 Mtpa)

Ore type	Ore	Abbrev	% throughput for Dampier ports 2005	DEM (%)	Weighted DEM for throughput (%)	Weighted Avg DEM (%)
Incoming ores						
Brockman ores (mostly hematite)	Tom Price Lump	TPL	11	3.3	0.4	**4.9**
	Brockman Lump	BRL	5	3.3	0.2	
	Paraburdoo Lump	PAL	12	3.3	0.4	
Marra Mamba ores (mostly goethite)	Marandoo Lump	MAL	8	4.1	0.3	
Brockman ores (mostly hematite)	Tom Price Fines	TPF	9	3.3	0.3	
	Brockman Fines	BRF	11	6.8	0.7	
	Paraburdoo Fines	PAF	12	3.7	0.4	
Marra Mamba ores (mostly goethite)	Marandoo Fines	MAF	9	8.9	0.8	
	West Angelas Fines	WAF	0	7.5	0.0	
Channel Iron Deposit ores (pisolites)	Yandi Fines	YAF	23	5.8	1.3	
Exported products						
Brockman ores (mostly hematite)	Brockman Lump	BRL	1	3.3	0.0	**4.5**
	Paraburdoo Lump	PAL	20	3.3	0.7	
Marra Mamba ores (mostly goethite)	Marandoo Lump	MAL	0	4.1	0.0	
Hematites and goethites	Pilbara Blend 50 Lump	PB50L	14	3.5	0.5	
Brockman ores (mostly hematite)	Brockman Fines	BRF	1	6.8	0.0	
	Paraburdoo Fines	PAF	21	3.7	0.8	
Hematites and goethites	Pilbara Blend 50 Fines	PB50F	18	5.7	1.0	
Channel Iron Deposit ores (pisolites)	Yandi Fines	YAF	25	5.8	1.4	

Table 19 Ore throughputs and DEMS for Dampier Port at 145 Mtpa

Ore type	Ore	Abbrev	% throughput for Dampier ports predicted for 2007-8	DEM (%)	Weighted DEM for throughput (%)	Weighted Avg DEM (%)
Incoming ores						
Brockman ores (mostly hematite)	Tom Price HG	TPL	8	3.3	0.3	**5.4**
	Tom Price LG	TPL	2	3.3	0.1	
	Brockman 2/fines	BRL	2	3.3	0.1	
	Paraburdoo (wet), Eastern Range, Channar	PAL	6	3.3	0.2	
	Brockman 4	BRL	1	3.3	0.0	
Marra Mamba ores (mostly goethite)	Marandoo	MAL	4	4.1	0.2	
	Nammuldi	NAL	1	5.4	0.1	
	Hope Downs	HDL	4	5.4	0.2	
	West Angelas	WAL	9	5.4	0.5	
Brockman ores (mostly hematite)	Tom Price HG	TPHGF	7	3.6	0.2	
	Tom Price LG	TPLGF	2	3.2	0.1	
	Brockman 2/fines	BRF	4	6.8	0.2	
	Paraburdoo (wet), Eastern Range, Channar	PAF	9	3.7	0.3	
	Brockman 4	BRF	1	6.8	0.1	
Marra Mamba ores (mostly goethite)	Marandoo	MAF	6	8.9	0.6	
	Nammuldi	NAF	2	7.0	0.1	
	Hope Downs	HDF	6	7.8	0.5	
	West Angelas	WAF	14	7.5	1.0	
Channel Iron Deposit ores (Pisolites)	Yandi	YAF	10	5.8	0.6	
Exported products						
Hematites and goethites	Pilbara Blend	PBL	39	4.3	1.7	**5.2**
Hematites and goethites	Pilbara Blend	PBF	51	5.7	2.9	
Channel Iron Deposit ores (Pisolites)	Yandi	YAF	10	5.8	0.6	

The weighted average dustiness potential of ores at 95 Mtpa is about 4.7% (average of 4.9% and 4.5%). The weighted average dustiness potential of ores at 145 Mtpa is about 5.3% (average of 5.4% and 5.2%).

This implies that on a per tonne basis, ore handling will be on average, about 13% more dusty for 145 Mtpa than 95 Mtpa.

Consequently, for the modelling of dust emissions for 145 Mtpa, the emissions estimated from the empirical dust emission functions described in the previous Sections were also increased by a factor of 1.13[5]. Although the basis of this adjustment is ore handling dustiness, this factor was applied across all dust sources (ie including wind-generated) for 145 Mtpa. This assumption effectively implies that the ore moisture contents at 145 Mtpa will not be less than the ore DEM minus 0.4% (on average). These are shown in Table 20.

Table 20 Ore moisture assumptions for 145 Mtpa

Ore type	Ore	Abbrev	DEM (%)	Minimum moisture content (%)
Incoming ores				
Brockman ores (mostly hematite)	Tom Price HG	TPL	3.3	2.9
	Tom Price LG	TPL	3.3	2.9
	Brockman 2/fines	BRL	3.3	2.9
	Paraburdoo (wet), Eastern Range, Channar	PAL	3.3	2.9
	Brockman 4	BRL	3.3	2.9
Marra Mamba ores (mostly goethite)	Marandoo	MAL	4.1	3.7
	Nammuldi	NAL	5.4	5.0
	Hope Downs	HDL	5.4	5.0
	West Angelas	WAL	5.4	5.0
Brockman ores (mostly hematite)	Tom Price HG	TPHGF	3.6	3.2
	Tom Price LG	TPLGF	3.2	2.8
	Brockman 2/fines	BRF	6.8	6.4
	Paraburdoo (wet), Eastern Range, Channar	PAF	3.7	3.3
	Brockman 4	BRF	6.8	6.4
Marra Mamba ores (mostly goethite)	Marandoo	MAF	8.9	8.5
	Nammuldi	NAF	7.0	6.6
	Hope Downs	HDF	7.8	7.4
	West Angelas	WAF	7.5	7.1
Channel Iron Deposit ores (Pisolites)	Yandi	YAF	5.8	5.4
Exported products				
Hematites and goethites	Pilbara Blend	PBL	4.3	3.9
Hematites and goethites	Pilbara Blend	PBF	5.7	5.3
Channel Iron Deposit ores (Pisolites)	Yandi	YAF	5.8	5.4

[5] In addition to other adjustments for operating frequency, dust control improvements etc.

11. ADJUSTMENTS TO EMISSIONS ESTIMATES FOR KARRATHA WIND SPEED AND RAINFALL

11.1 WIND SPEED ADJUSTMENT FOR DPS

The SKM (1998) wind-generated dust emissions functions were based on winds measured at the Karratha airport. For the purpose of estimating emissions from operations and open sources using these functions, the DPS wind speed was increased by 1.3, as in the previous assessment for 95 Mtpa (SKM 2003). This is the average ratio of wind speeds greater than 5 m/s at the Karratha Airport to those measured at the DPS site.

11.2 RAINFALL

The hourly emissions were adjusted for rainfall by setting them to zero if the 1-hour rainfall exceeded 0.1 mm based on a rolling 24-hour average. This effectively allowed for a delayed onset of dusty conditions after heavy rainfall. This is more realistic than the US EPA (2003 Ch 13.12.2) approach for unpaved roads of setting a day's emissions to zero based on daily rainfall exceeding 0.254 mm. A lower value of 0.1 mm was, however, used to indicate the return of dust emissions after rainfall since sources such as roads and some stockpiles may have their surfaces disturbed.

12. CHANGES TO DUST SOURCES FOR 145 MTPA

12.1 ADDITIONAL DUST CONTROLS

The key additional dust controls for which an estimated dust control improvement has been incorporated into the modelling are:

Source	Dust Control
• 5E conveyor and causeway	The conveyor will be covered (the previously installed water sprays will be retained). The causeway will be kerbed and the sealed section widened. A new, larger road sweeper will be purchased.
• EII Live Stockpiles	Installation of 140 water cannons in stockyard at EII with associated pump stations to maintain delivery and water pressure. Also, chemical dust suppressant dosing is being added to stackers at EII to coat stockpile crests.
• EII roads	Sealing of additional roads at EII (eg eastern and western sides of EII causeway, and 5E/6E area) and between six live stockpiles.
• Water cannons at PP	Installation of 221 water cannons in live stockpile area at PP with associated pump stations to maintain delivery and water pressure.

Other additional dust controls which have not been incorporated into the modelling are:

- Chemical dosing capability is being added to standpipes at EII and PP for water truck application on roads (via spray bars) and stockpiles (via water truck mounted cannon); and
- Road sealing at PP.

12.2 QUANTIFIED CHANGES IN EMISSION RATES

It needs to be acknowledged that quantifying the dust control benefit of the improvements is a difficult task. For this study, the control factors provided in NPI (2001) have been used as the primary basis of these estimates. In some cases, estimates of control benefits are from test-work. Ultimately, the estimation of the emissions reduction benefits from the dust control improvements has been made by PI.

A summary of the estimated dust emissions for each source at 95 Mtpa and 145 Mtpa throughput, together with the additional controls and effectiveness assumptions is shown in Table 21 and Figure 10. From Table 21, the average TSP emissions rate for the proposal is estimated to increase from 160 g/s (actual for 2005) to 196 g/s.

The major changes are for 145 Mtpa compared to 95 Mtpa are:

- The 145 Mtpa emissions estimates for all sources include an additional 13% for increased dust potential from the changes to incoming ores and operating frequencies for a 145 Mtpa throughput rate;
- Dust from the 5E conveyor and road is reduced from 5.1 g/s to 1.2 g/s due to the construction of a cover;
- Wind generated dust from the EII Live stockpiles is reduced from 39.6 g/s to 19.5 g/s due to the installation of water canons;
- The actual PP throughput for 2005 was 37 Mtpa. For an increased throughput at PP to 100 Mtpa, the emissions from each PP activity sources will increase by an additional 100/37 = 2.7 times;
- The PP eastern bulk stockpile coverage for 2005 was only 7.5% (4,600 m^2). The total surface area of the PP bulk stockpiles at 145 Mtpa is 120,500 m^2, which is a considerable increase.
- The wind generated dust from the bulk stockpiles at PP increases by about 8.0 g/s due to the increase in the number of bulk stockpiles. Note that this increase is exaggerated by the very small bulk stockpile inventory actually held for 2005;
- Dust emissions from the PP bulking operations increases by about 11 g/s due to a three and one-half times increase in activity levels of bulking activity proposed for 145 Mtpa compared to the actual level of bulking for 2005; and
- The increase in dust emissions from the “activity” sources at PP are approximately a pro rata increase in emissions for the amount of ore handled.

Table 21 Changes to PI sources and emissions resulting from proposed expansion to 145 Mtpa

Source	Code[d]	95 Mtpa (PP=50 Mtpa)			145 Mtpa (PP=100 Mtpa) [a]		
		Dust controls at 95 Mtpa	**Effectiveness Assumptions**	**Avg emis rate 2005 data (g/s)**	**Dust control modifications**	**Effectiveness Assumptions**	**Avg emis rate[b] (g/s)**
EII Car Dumper	EICD2	Internal water sprays and baghouse	Assume 5 mg/m^3 TSP emission based on CD3 stack tests[c].	0.3	Assuming 5 mg/m^3 TSP emission	-	0.3
1-4E to 5E Transfer	145XEF	Enclosure	Emission function modified after Dec 2005 monitoring.	1.0	No change		1.1
5E Conveyor and Road Vehicles	5ECRX	EII Car Dumper fitted with moisture monitoring and sprays. Water sprays fitted along the conveyor. High pressure, low volume sprays, belt scraper and conveyor drying system installed on return side of conveyor. Road sweeper shared between EII and PP.	Emissions estimated from monitoring program described in EA (2005).	5.1	Covering of conveyor, Improved return strand cleaning mechanism (reduces accumulation of spilt material underneath conveyor), Sealing sides of causeway, Kerbing & dimple strip on western side, New larger road sweeper.	NPI (2001) gives 50% control for windbreaks and 100% control for enclosure. Testing of the new scrapers only (ie without wash box) gave 67% reduction in dust on return belt (SF, 4/9/06). Assume 80% reduction in emissions.	1.2
EII Stacking	EIISTK	Wind shielding fitted to stacker boom discharge sprays.	Incorporated into emissions function.	1.9	No change		2.6
EII Live Stockpiles & Roads – wind	EILSRW	Water cannon on SW face Road wetting	50% effective for 1/26th of total stockpile area Incorporated into emissions function.	39.6	Water canon coverage extended to cover entire stockpile area. Water applied when winds > 20 km/hr and 248-314° (Dmpr). Crusting agent to be added on final stockpile ridges (±10m). Ability to add water (or crusting agent) to all EII stockpiles.	NPI (2001) gives 50% control for water sprays. Wind tunnels tests indicate water sprays are 90% effective – SF 4/9/06). Assume 40% effective when operating. . Wind tunnels tests indicate agent 91-96% effective – SF 4/9/06). Assumed 40% effective.	19.5
EII Reclaiming	EIIRCL	-	Incorporated into emissions function.	5.4	Water reelers and sprays to be fitted to the three bridge reclaimers. Automatically controlled - will be used when moisture content of the ore requires use	NPI (2001) gives 50% control for water sprays. Assume 30% effective.	4.5

Source	Code[d]	95 Mtpa (PP=50 Mtpa)			145 Mtpa (PP=100 Mtpa) [a]		
		Dust controls at 95 Mtpa	Effectiveness Assumptions	Avg emis rate 2005 data (g/s)	Dust control modifications	Effectiveness Assumptions	Avg emis rate[b] (g/s)
EII bulking operations	EIHB95	Water sprays fitted to dump hopper. Water sprays from water truck used on bulking areas	NPI (2001) gives 50% control for water sprays Assumed 30% effective.	13.6	No change	-	15.3
EII Bulk Stockpiles – wind	EIIBW	-	Incorporated into emissions function.	9.7	No change	-	11.0
EII Screening Building	EIISB	-	Incorporated into emissions function.	10.0	No change	-	11.4
EII Screening Building – wind	EIISBW	-	Incorporated into emissions function.	5.6	Improved sealing between vibration feeder and belt and around screens to reduce spillage.	Not quantified.	6.3
EII operational areas Vehicles	EIIV	Road wetting.	As per Table 6	5.5	Road sealing of 15% of EII roads. New, larger road sweeper. Use of dust retardant on unpaved roads,	Overall dust control benefit = 14%	5.5
EII Transfers Outgoing + Ingoing	EXF	Enclosures.	Incorporated into emissions function.	3.5	No change	-	4.0
EII Conveyors from Screenhouse 1 to SL1E (incl 20E/21E)	EI18E	Wetted at Screen House	Based on monitoring of PP7P x 3.	4.0	Improved belt cleaner (5E design) and dust de-ionising scrubber (removed fine dust from top of belt after transfer point).	Tests indicate belt cleaner removes 67% of dust from return strand. Assume 67% effective.	1.5
EII Ship Loading	EIISHP	Boom control.	Incorporated into emissions function.	3.6	Fitted with boom sprays (separate project but similar timing). Also improved transfer belt design to reduce spillage.	Assumed 30% effective.	2.4
PP Car Dumper 1	CD1P	Internal water sprays.	50 mg/m^3 TSP emission[c].	0.2	-	Decommissioned	-
PP Car Dumper 3	CD3P	Internal water sprays, Baghouse.	Emission rate revised based on 5 mg/m^3 TSP emission after stack testing 2006.	0.1	No change	-	0.3
PP Car Dumper 4	CD4P	As for CD3P.	As for CD3P.	-	No change	-	0.3

Source	Code[d]	95 Mtpa (PP=50 Mtpa)			145 Mtpa (PP=100 Mtpa) [a]		
		Dust controls at 95 Mtpa	Effectiveness Assumptions	Avg emis rate 2005 data (g/s)	Dust control modifications	Effectiveness Assumptions	Avg emis rate[b] (g/s)
PP Live Stockpiles & Roads	PPLS95	For existing product range, 21 stockpiles are non MMF Stockpile sprays on north side of 3P/5P and eastern end – covers total of 9 of these stockpiles. 3 stockpiles are MM with water cannon.	Use of water sprays not yet implemented. No special MMF stockpiles. 40% capacity for 2005.	10.8	Total stockpiles=24. Only one lump (PBL) two fines (PBF & YF) products produced. Water canon coverage extended to cover entire stockpile area. Water applied when winds > 20 km/hr and 0 – 72° (Dmpr) and winds > 11 m/s 180 – 360° (King Bay). Average stockpile area utilisation is 65%.	NPI (2001) gives 50% control for water sprays. Assume 40% effective when operating.	19.2
PP Stacking	PPSTK	Manually operated water sprays on stackers.	Incorporated into emissions function.	5.8	No change	-	15.0
PP Reclaiming	PRCL[e]	-	Incorporated into original function	7.5	No change	-	19.0
PP Screen House	SH1P	-	Emission function modified after Dec 2005 monitoring.	4.6	-	Decommissioned	-
PP Screen House wind dust	SH1PW	-	Incorporated into original function	4.9	-	Decommissioned	-
PP Screen House 2	SH2P	Improved efficiency of materials transfers within structure reduces localised dust deposition.	Assumed to be 0.5 of SH1P emission rate (after SH1P doubled after Dec 2005 monitoring)	0.0	No change	-	2.5
PP Screen House 2 wind dust	SH2PW	-	Same wind dust function as PPSBW	-	Improved efficiency of materials transfers within structure reduces localised dust deposition. New, larger road sweeper.	50% reduction	2.8
PP Screen House 3	SH3P	New for 145 Mtpa	-	-	As for SH2P.	As for SH2P.	2.5
PP Screen House 3 wind dust	SH3PW	New for 145 Mtpa	Same wind dust function as PPSBW	-	As for SH2PW	50% reduction	2.8
PP operational areas Vehicles	PPV	Road wetting	As per Table 6	5.5	Minor (est 10% increase in traffic). Extra road sealing. New, larger road sweeper.	No change	6.2

Source	Code[d]	95 Mtpa (PP=50 Mtpa)			145 Mtpa (PP=100 Mtpa) [a]		
		Dust controls at 95 Mtpa	**Effectiveness Assumptions**	**Avg emis rate 2005 data (g/s)**	**Dust control modifications**	**Effectiveness Assumptions**	**Avg emis rate[b] (g/s)**
PP Transfers Outgoing + Ingoing	PXF	Enclosures	Incorporated into emissions function.	3.1	Installation of water sprays and more effective enclosures. Improved return strand belt cleaners to reduce spillage.	NPI (2001) gives 50% control for water sprays and 100% control for enclosure. Assumed 30% effective.	6.7
PP Conveyor from Screenhouse 1 to Ship Loader 1 – wind	PP7P	Wetted at Screen House	Incorporated into emissions function.	1.8	New slower moving wider belt conveyors.	Assume [1 - (2.07/2.57)] x 100 = 19% effective.	4.1
PP Ship Loader	SL1P	Boom height control.	Incorporated into original function	2.9	Decommissioned	-	-
PP Ship Loader 2	SL2P	Boom height control. Fitted with boom sprays.	30% effective	0.5	No change	-	2.9
PP Ship Loader 3	SL3P	-	-	-	As for SL2P	Simulated using EII operations data for 2005 x 111%	2.9
PP Bulk Stockpiles – wind	PPBW		Incorporated into original function	0.3	Water sprays on Northern Bulk Stockpile stacker (note increase in stockpiles capacities).		8.3
PP Bulking operations	PPHB	Water sprays on dump hopper for loading into live stockpile area. Road wetting/haul truck emissions as per SKM functions in EA (2003).	30% effective	3.2	No change to existing dust controls (but increase in activity)	-	14.3
TOTAL				160			196

(a) All sources to have extra 13% dustiness factor added.

(b) All PP activity sources in each circuit have extra 10% of 2005 EII Car dumper and shiploader operating frequencies.

(c) The emissions rate assumption for CD1 and CD2 based on CD3 testing may not be appropriate since the latter has a baghouse for dust control while CD1 has a wet scrubber and CD2 has an older dust collector. However this will understate the benefit of CD1 (95 Mtpa) being replaced by CD4 (145 Mtpa).

(d) The "Code" is primarily for internal modelling use and referencing, and is not necessarily a PI equipment reference.

(e) An example calculation of the ratio of the emission increase for PP reclaiming is provide below:

PRCL_95 (g/s) = (SL1Pfrq x SL1Pdust +SL2Pfrq x SL2Pdust) x Fn(PP_RCL,DPS_WS)

where

SL1Pfrq = average frequency of SL1P operation for 2005 data

SL1Pdust = average dustiness factor for ores handled by SL1P for 2005

SL2Pfrq = average frequency of SL2P operation for 2005 data

SL2Pdust = average dustiness factor for ores handled by SL2P for 2005

Fn(PP_RCLDPS_WS) = wind speed dependent emission function for PP reclaimers (this is different than for EII reclaimers)

= (0.574 x 0.986) + (0.082 x 1.16) x Fn(DPS_WS)

= 0.661

PRCL_145 (g/s) =1.13 x (2 x SL1Efrq + SL1Edust x 1.11) x Fn(PP_RCL,DPS_WS)

where

1.13 = ore dustiness increase factor for 145 Mtpa ore mix compared to 95 Mtpa ore mix

SL1Efrq = average frequency of SL1E operation for 2005 data

SL1Edust = average dustiness factor for ores handled by SL1E for 2005

1.11 = ratio of 50 Mtpa/45 Mtpa (50 Mtpa is throughput for each PP circuit for 145 Mtpa capacity; 45 Mtpa is actual ore tonnage from EII for 2005)

= 1.13 x (2 x 0.695 x 1.04 x 1.11) x Fn(PP_RCL,DPS_WS)

= 1.81

PRCL_145 / PRCL_95 from above = 1.81/0.661 = 2.7

Ratio of actual emissions = 19.4/7.58 = 2.6

Note that a small difference is possible from different wind speeds occurring at different emission periods.

(Calculation based on data as at 28/11/2006)

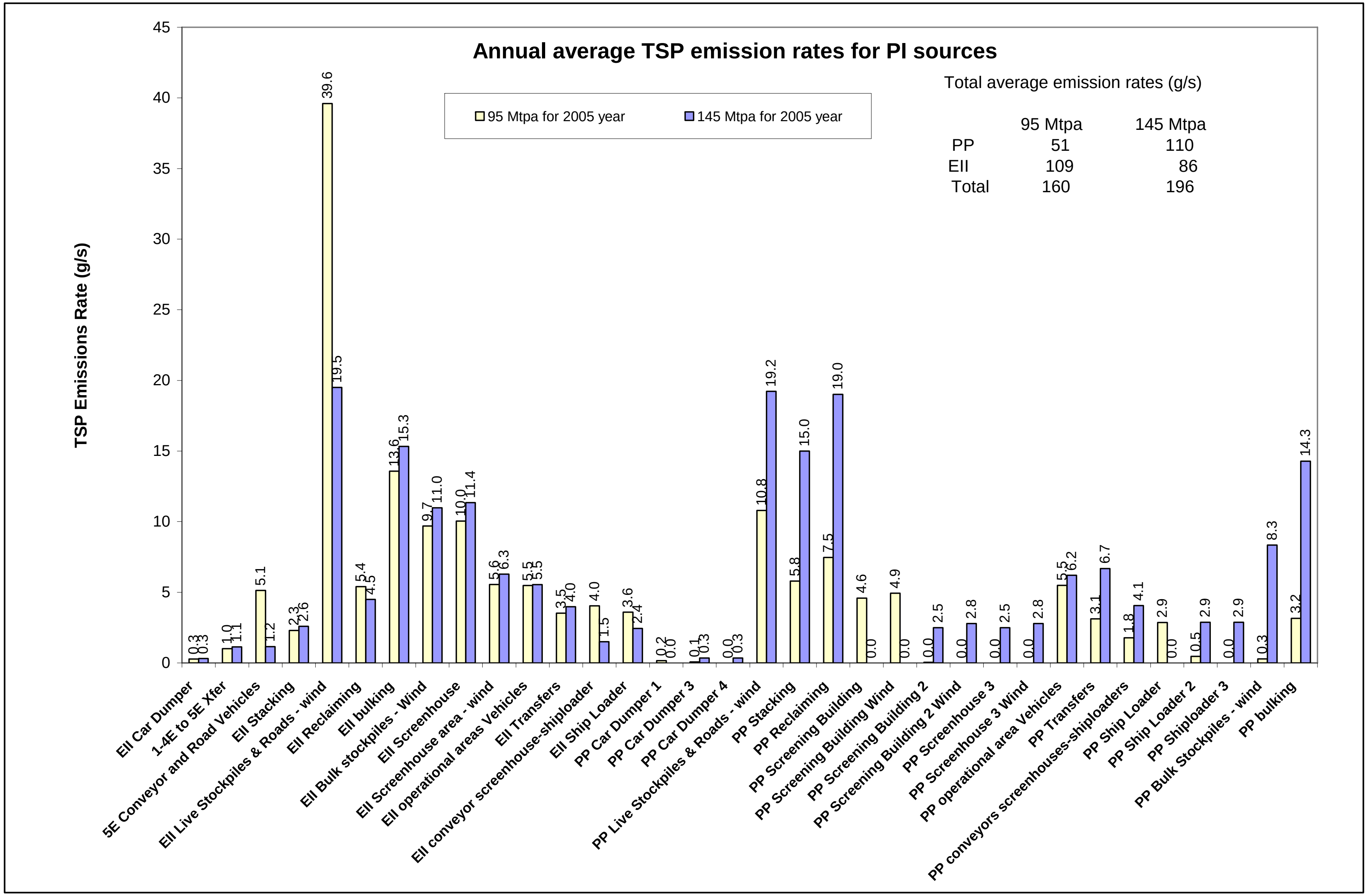

Figure 10 Annual average TSP emission rates for PI sources at 95 Mtpa and 145 Mtpa

13. REFERENCES

Air Assessments, 2005, "Cape Lambert - 2005 Dust Monitoring Review - Prepared for Pilbara Iron Company By Air Assessments", Draft, June 2005.

BHB Billiton Iron Ore, 2002, "Dust Management Program", April 2002.

Blockley, A., 2003, *pers com*, Ausplume meteorological file for Dampier 1999.

Department of Environment (DoE), 2004, "Pilbara Air Quality Summary Report", Technical Series Report 120, August 2004.

Department of Environment (DoE), 2005, "Western Australia Air Monitoring Report - Written to comply with the National Environment Protection Measure (Ambient Air Quality)", Technical Series 122, April 2005.

Department of Environment and Conservation NSW (DEC NSW), 2005, "Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales", 26 August 2005.

Environ, 2004, "Port Hedland Dust Modelling Assessment for Fortescue Metals Group Limited", 16 August 2004.

Environment Protection Authority of Victoria (EPAV), "Ausplume Gaussian Plume Dispersion Model - Technical User Manual", November 2000.

Environmental Alliances, 2004, "Hamersley Iron – Dampier Port Operations – Compliance with Dust Management Conditions in Ministerial Statement of Approval for 95 Mtpa Expansion", August 2004.

Environmental Alliances, 2005a, "Hamersley Iron – Dampier Port Operations – Monitoring Dust Emissions from the 5E Conveyor and Road", Prepared for Kellogg Brown & Root Pty Ltd, February 2005.

Environmental Alliances, 2005b, "Dust Dispersion Modelling for Hamersley Iron Dampier Port Expansion to 120 Mtpa", Version l, Prepared for Sinclair Knight Merz, April 2005.

Environmental Alliances, 2006a, "Dust Dispersion Modelling for Pilbara Iron Dampier Port Expansion to 145 Mtpa (Phase B) – Development of Dust Emissions Estimates", Prepared for Sinclair Knight Merz, November 2006.

Environmental Alliances, 2006b, "Dust Impact Assessment for Proposed Pilbara Iron Dampier Port Expansion to 145 Mtpa (Phase B) - Dispersion Model Set-Up and Assessment of Performance", Prepared for Sinclair Knight Merz, November 2006.

National Pollutant Inventory (NPI), 2001, "Emission Estimation Technique Manual for Mining Version 2.3", December 2001.

National Environment Protection Council (NEPC), 1997, "Draft National Environment Protection Measure and Impact Statement for Ambient Air Quality", 21 November 1997.

NEPC, 2002, "National Environment Protection (Ambient Air Quality) Measure Impact Statement for PM2.5 Variation Setting a PM2.5 Standard in Australia", October 2002.

Pacific Air & Environment, 2005, "Assessment of Dust Emissions from the Bauxite Residue Disposal Areas at Worsley Alumina Pty Ltd", 18 October 2005.

Sinclair Knight Merz (SKM), 1998, “Hamersley Iron Pty Limited – Dust Assessment – Dampier Operations”.

Sinclair Knight Merz (SKM), 2003, “Hamersley Iron – Dampier Port Upgrade to 95 Mtpa Capacity Environmental Protection Statement”, August 2003.

Sinclair Knight Merz (SKM), 2005, “Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques”, May 2005.

Sinclair Knight Merz (SKM), 2007, “Dust Emissions Inventory - Hamersley Iron Dampier Operations - Ministerial Statement 702, Condition 7-3”, March 2007.

U.S. Environmental Protection Agency, 1998, “Quality Assurance Handbook for Air Pollution Measurement Systems Vol II: Part 1 Ambient Air Quality Monitoring Program Quality System Development”, Research Triangle Park, North Carolina, August 1998.

U.S. Federal Register, 2001, “Part II Environmental Protection Agency 40 CFR Ch. I (7–1–01 Edition) Part 51, Appendix W —Guideline On Air Quality Models”.

United States Environmental Protection Agency (USEPA), 1999, Compilation of Air Pollutant Emissions Factors (AP-42), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

US EPA, 1999 ,Guideline on Air Quality Models, US EPA, 40 CFR Ch I (7-1-99 Edition).

14. GLOSSARY

General terms

[PM10], [TSP]	abbreviations for PM10 concentration and TSP concentration
$\mu g/m^3$	micrograms per cubic metre of air.
μm	microns or micrometers.
AB	PI Parker Point Administration Building – dust monitoring site.
BJ	Dampier Boat Jetty – dust monitoring site.
DoE	Department of Environment – formerly Department of Environmental Protection
DMP	PI's Dust Management Plan for its Dampier operations.
DPS	Dampier Primary School - dust and meteorological monitoring site.
E-BAM	Model of Beta Attenuation Monitor– instrument used for the continuous measurement of airborne particles.
EII	East Intercourse Island (operations).
equivalent aerodynamic diameter	the diameter of a particle which exhibits the same aerodynamic behaviour as a spherical particle with a density of 1000 kilograms per cubic metre.
g/cm^3	grams per cubic centimetre.
PI	Pilbara Iron Pty Limited.
HVAS	High volume air sampler
KEPP	Kwinana Environmental Protection Policy taken to jointly comprise the Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1992 and Environmental Protection (Kwinana) (Atmospheric Waste) Regulations 1992.
km	kilometres.
kt	kilotonnes
m	metres.
MMF	Marra Mamba Fines ore
m/s	metres per second.
Mtpa	Million tonnes per annum.
NEPM	National Environment Protection Measure for Ambient Air Quality dated 26 June 1998.
percentile	the division of a distribution into 100 groups having equal frequencies (calculated using MS Excel®)
PM10	Airborne particles with an equivalent aerodynamic diameter of less than 10 μm.
PM2.5	Airborne particles with an equivalent aerodynamic diameter of less than 2.5 μm.
PM50	Airborne particles with an equivalent aerodynamic diameter of less than 50 μm.
PP	Parker Point (operations).
TEOM	Tapered Element Oscillating MicroBalance – instrument used for the continuous measurement of airborne particles.
TSP	Total Suspended Particulates, for the purposes of this document,

	considered to be equivalent to PM50.

Wind direction references

NNE	north-north-east
NE	north-east
ENE	east-north-east
ESE	east-south-east
SE	south-east
SSE	south-south-east
SSW	south-south-west
SW	south-west
WSW	west-south-west
WNW	west-north-west
NW	north-west
NNW	north-north-west

PI sources at PP at 95 Mtpa or 145 Mtpa

CD1P	Car Dumper 1 – located at Parker Point (to be decommissioned and replaced by CD4P)
CD2E	Car Dumper 2 – located at East Intercourse Island
CD3P	Car Dumper 3 – located at Parker Point (part of 95 Mtpa expansion)
CD4P	Car Dumper 4 – located at Parker Point (part of 145 Mtpa expansion)
SH1E	Screenhouse 1 – located at EII
SH1P	Screenhouse 1 – located at Parker Point (to be decommissioned and replaced by SH3P)
SH2P	Screenhouse 2 – located at Parker Point (part of 95 Mtpa expansion)
SH3P	Screenhouse 3 – located at Parker Point (part of 145 Mtpa expansion)
SL1E	Ship Loader 1 – located at EII
SL1P	Ship Loader 1 – located at Parker Point (to be decommissioned and replaced by SL3P)
SL2P	Ship Loader 2 - located at Parker Point (part of 95 Mtpa expansion)
SL3P	Ship Loader 3 - located at Parker Point (part of 145 Mtpa expansion)
PPLS	PP Live Stockpiles & Roads – Wind-generated dust
PSTK	PP Stacking
PRCL	PP Reclaiming
SH1PW	PP Screening Building Wind generated dust from immediate surrounds
SH2PW	PP Screening Building 2 Wind generated dust from immediate surrounds
SH3PW	PP Screenhouse 3 Wind generated dust
PPV	PP operational area Vehicles
PXF	PP Transfers
PP7P	PP conveyors screenhouses-shiploaders
PPBW	PP Bulk Stockpiles - wind
PPHB	PP bulking (loading/unloading, haul trucks, dozing)

PI sources at EII at 95 Mtpa or 145 Mtpa

EICD2	EII Car Dumper
145EXF	1-4E to 5E Tansfer on mainland
5ECRX	5E Conveyor, Road and Vehicles
EIISTK	EII Stacking
EILSR	EII Live Stockpiles & Roads - Wind generated dust
EIIRCL	EII Reclaiming
EIHB	EII bulking (loading/unloading, haul trucks, dozing)
EIIBW	EII Bulk stockpiles - Wind
EIISB	EII Screenhouse
EIISBW	EII Screenhouse area - Wind generated dust from immediate surrounds
EIIV	EII operational areas Vehicles
EXF	EII Transfers
EI18E	EII conveyor screenhouse-shiploader
EIISHP	EII Ship Loader

Appendix 1 Results of source monitoring program 7-10/12/2005

Methodology

On-site dust monitoring to improve the emissions estimates from specific sources was undertaken over 7-10/12/2005.

Two types of techniques were used:

Profiling

Profiling involves taking continuous dust measurements while moving laterally through the plume. Ideally, locations for the start and end of each profile are where dust is at background levels so that the resultant profile resembles a gaussian shaped curve where the peak is the plume centre-line concentration and the outer extents either side of the "plume" curve are background concentrations. An average profile for up to one hour is obtained by averaging the dust measurements at each location from repeated profiles. This can also be used to refine the modelled source dimensions and initial plume dispersion spread parameters. For back-calculating the source emission rate, a number of discrete receptors are defined along the profile and the model's predictions at each receptor compared to the concentration at that location indicated by the measured profile curve.

When comparing the predicted profile to the measured profile, it is not particularly important that the profiles are a little horizontally off-set. This can result from a small misrepresentation of the actual wind direction has minimal effect on the expected correspondence of the profiles in other aspects.

The profiling method provides data which can be depicted in pictorial form which facilitates a review of the "reasonableness" of the data and that the measurements corrected targeted the required source. Profiling does however, require considerable work.

Stationary sampling

This involves simply monitoring downwind of the source for a period of time to determine the average concentrations at that location. The model's predicted concentrations at that location are simply compared to the measurements, and the source emission rate can be scaled accordingly. The problem with using a single measurement location to back-calculate a source emission is that it is difficult to know for sure the whereabouts of the sampling location along the cross-wind axis of the plume due to the uncertainty of the representivity of the wind direction. This can lead to very significant errors in the back-calculated source emission rate – particularly for narrow plumes, and is not a recommended approach.

Background concentration estimates

The background concentrations from profiling were estimated from the concentrations at the outer extent of the profile. Background concentrations from stationary monitoring were estimated from the 5th percentile of the sampled concentrations.

Meteorological data

The meteorological data set used for modelling was that developed using Calmet for annual modelling of the 2005 year. In this way, the adjustments to meteorological data itself, source configurations, local influences on dispersion etc are matched to the source configuration used to predict dust impacts over the course of the full year.

Form of exponent in wind-dependent source emission rate

For determining the emission rates of sources that do not have emissions functions from historical monitoring, sources that have emissions open to the exposed air (stackers, reclaimer etc) are assumed to have their emissions related to wind speed through a power law with an exponent of 1.4. For sources that more enclosed (eg transfer points, screening building etc), the exponent assumed is 0.5 (ie wind speed is likely to have a relatively lesser influence on the emission rate).

Results

The results for individual sources follow.

In the above and following profile Figures, the black line shows the measured PM10 concentration profile. The blue line shows the modelled profile based on previously assumed emissions function for the prevailing wind conditions, corrected for ore-specific dustiness. The green line shows the predicted concentrations using the revised emission function which adjusts the predicted concentrations half-way towards the measured concentrations.

The revised K factors for wind speeds referenced to the DPS site are shown in Table 23 at the end of this Section.

1/4-5E Transfer Point

The source is shown in Figure 11. The downwind cross-sectional profile of the dust plume from the source is shown in Figure 12. The revised emission rate is effectively 0.64 times the previous emission rate.

Figure 11 1/4-5E transfer point during downwind dust sampling

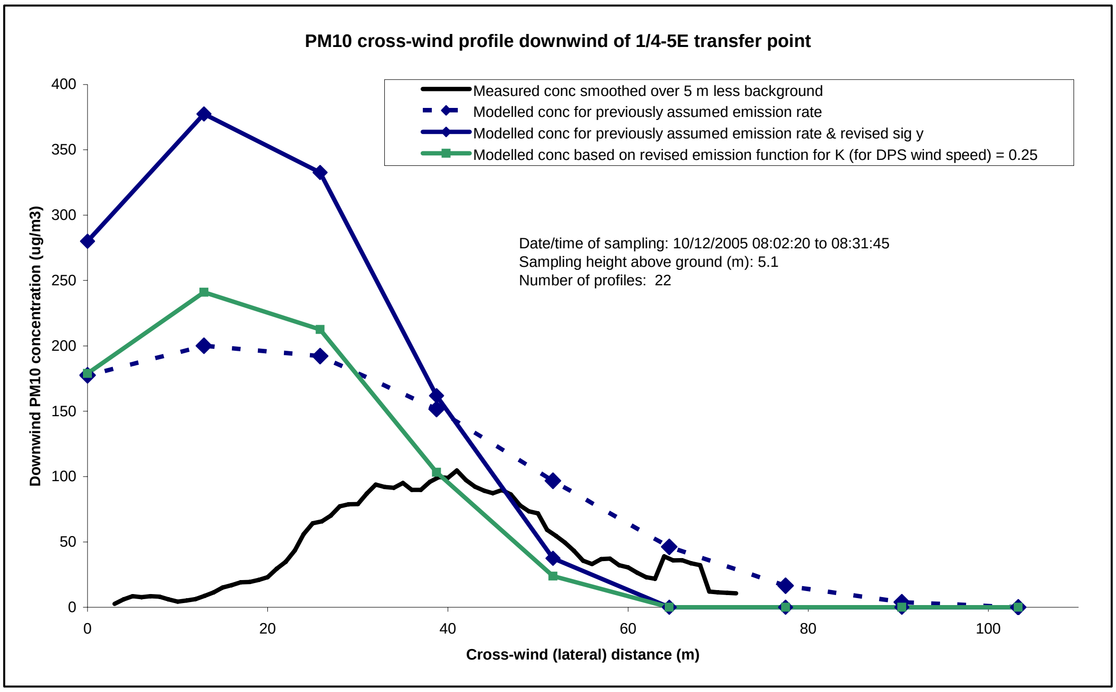

Figure 12 Downwind cross-sectional profile of dust plume from 1/4-5E transfer point

PP Stacker

The downwind cross-sectional profile of the dust plume from the source is shown in Figure 13. The revised emission rate is effectively 0.73 times the previous emission rate.

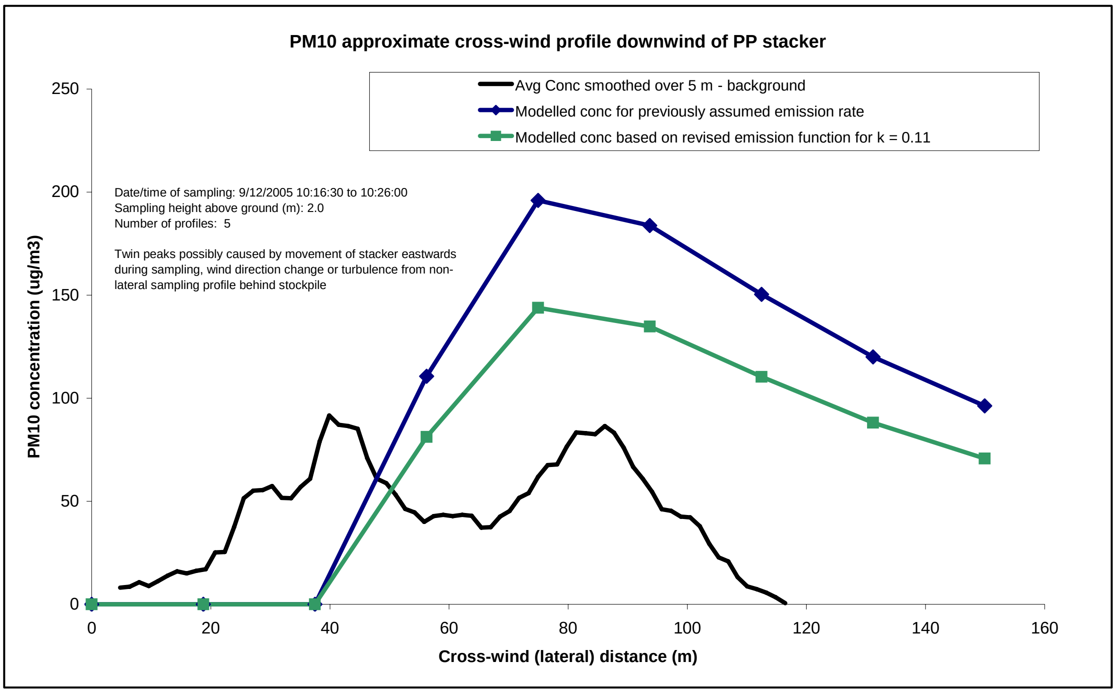

Figure 13 Downwind cross-sectional profile of dust plume from PP stacker

PP Reclaimer

The source during the initial stages of monitoring is shown in Figure 14, with little visible dust. The same source 18 minutes later is shown in Figure 15 after moving to a new bench. Visible dust emissions have increased considerably.

Figure 14 PP reclaimer during downwind dust sampling at 11:34

Figure 15 PP reclaimer during downwind dust sampling at 11:52

The downwind cross-sectional profile of the dust plume from the source is shown in Figure 16.

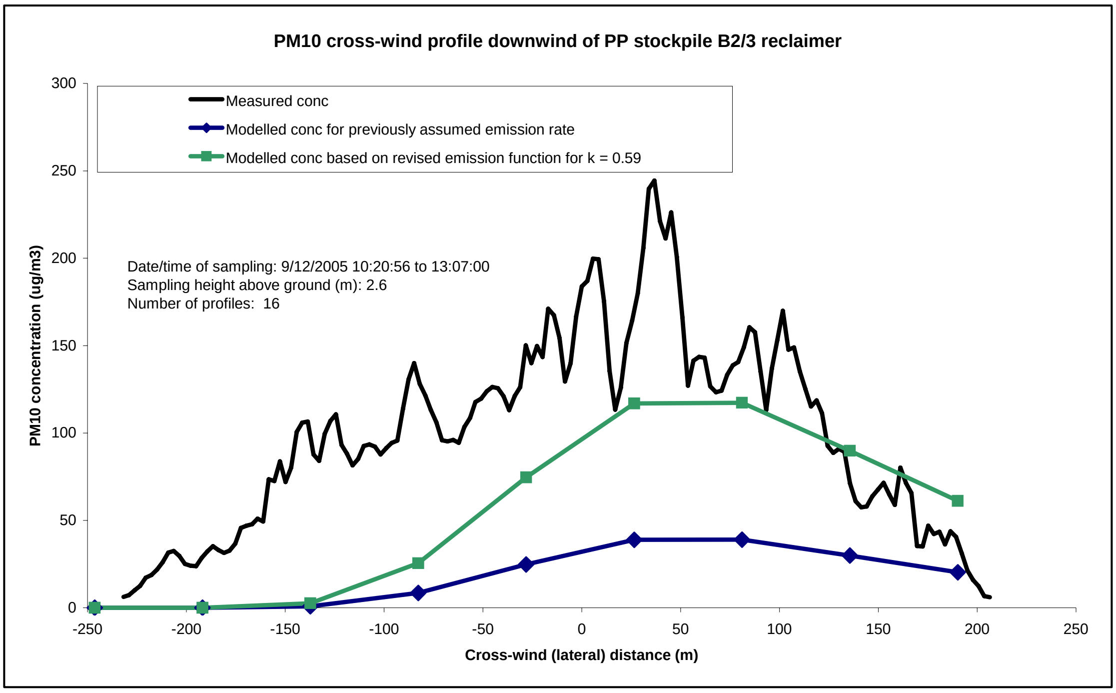

Figure 16 Downwind cross-sectional profile of dust plume from PP reclaimer

The revised emission rate is effectively 3 times the previous emission rate.

Differences between PP and EII reclaimers

The reclaimers at EII are of a different design to that at PP. At EII, a reclaimer or stacker can move to any pile. This is not the case at PP. The new PP reclaimers are the same as the old PP reclaimers due to the design of the stockyard. The emissions functions for the EII reclaimers have therefore not been altered based on the new functions for the PP reclaimers.

Figure 17 Photos of reclaimers at EII

PP Screenhouse SH1P

The source is shown in Figure 18. The downwind cross-sectional profile of the dust plume from the source is shown in Figure 19. Firstly, the predicted profile (dark blue dotted line) was far too broad compared to the measured profile. The initial sigma-y was changed from 80m to 20m. This resulted in a much better shaped profile (dark blue solid line). The revised emission rate is effectively 1.7 times the previous emission rate.

Figure 18 PP Screenhouse SH1P

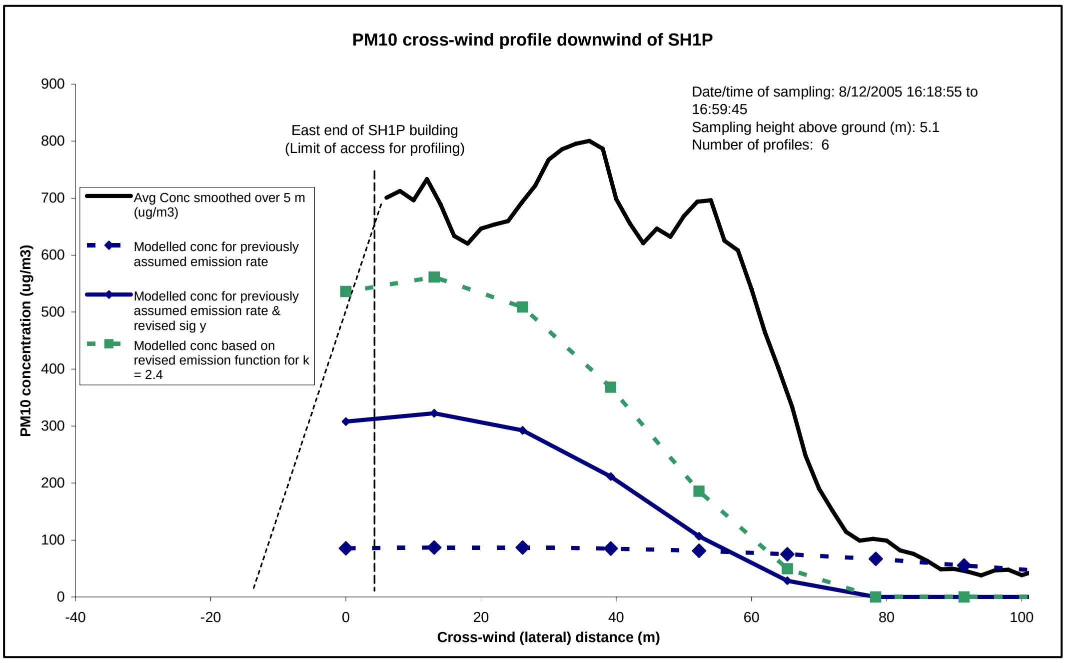

Figure 19 PM10 cross-wind profile downwind of SH1P

Outloading ore from Bulk Stockpile

The downwind cross-sectional profile of the dust plume from the source is shown in Figure 20.

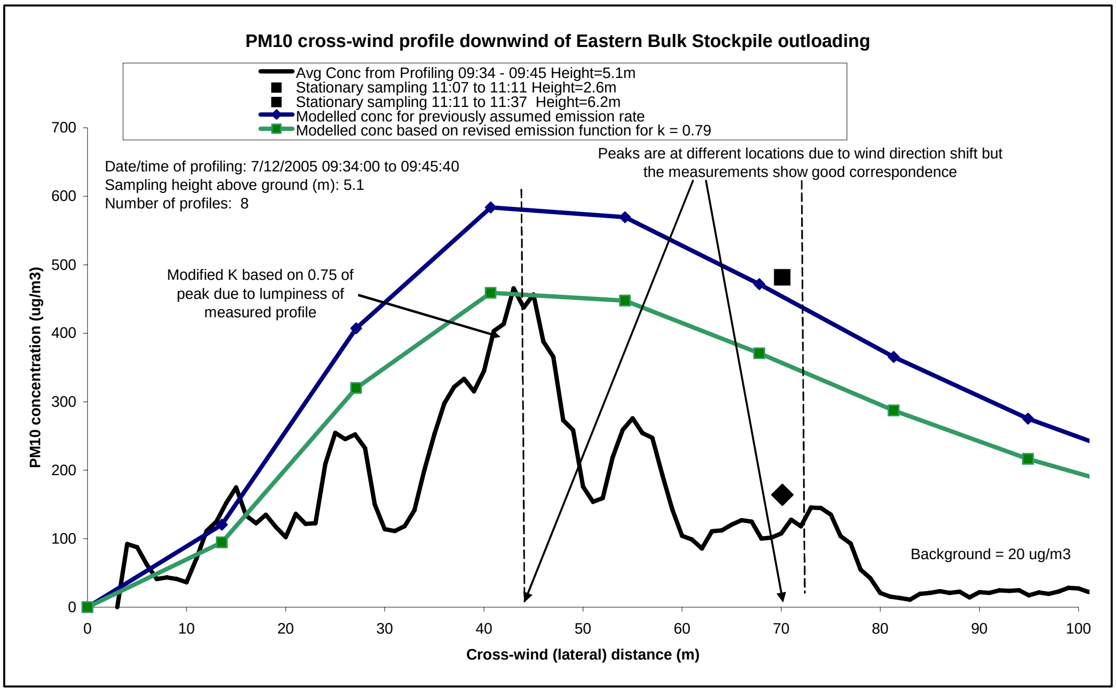

Figure 20 PM10 cross-wind profile downwind of Eastern Bulk Stockpile outloading

The initial equation was based on the NPI function for the estimate throughput rate and default moisture and silt values of 2% and 10% respectively. The previously assumed emission function is too high (by about 40% based on the peak). The measurements were undertaken only over a relatively short time period and hence should probably be smoothed a little more to allow for greater wind direction variability over an hour as modelled. This would reduce the peak concentrations further and lead to a larger adjustment (to a lower emissions level).

PP Conveyor to SL1P

A profile was taken of the air alongside the PP conveyor to SL1P. A plot showing 1 second measurements (in time only – not length) is shown in Figure 21.

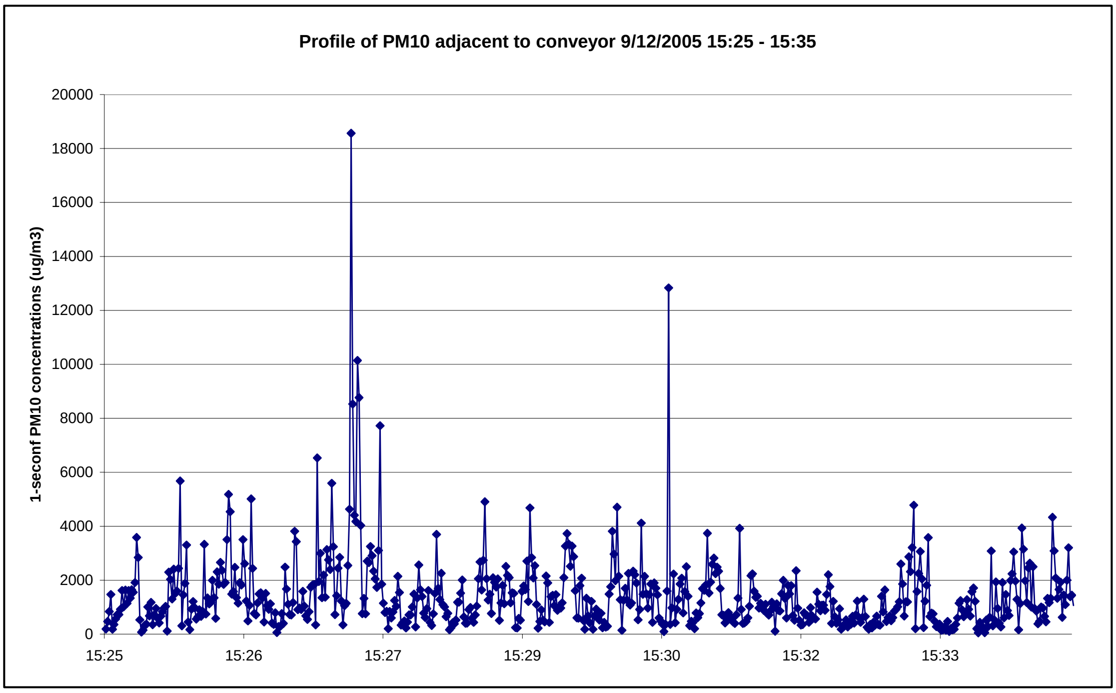

Figure 21 Profile of PM10 adjacent to conveyor

The calculated emission rate was used to develop K for the form of the equation used for semi-enclosed sources (see Table 22).

Table 22 Summary of conveyor monitoring results

Source parameters		Sampling parameters						
Conveyor	Ore type	Time period of sampling	Duration (hrs)	Horizontal dist monitored (m)	Number of profiles	Vertical ht of conveyor section (m)	PM10 concentration excl b/g ($\mu g/m^3$)	Wind velocity through conveyor (m/s)
7P (to SL1P)	HIP-F	15:25-15:35	0.2	360	2	2.2	1425	0.75

Cont.

Calculations				
PM10 emission rate (g/s/horizontal m)	DPS WS 10 (m/s)	DPS WD 10 (deg)	Dustiness factor from DEM	K (g/s per m length)
0.0023	3.0	352	0.82	0.0016

The resulting equation for PM10 from the narrow–belt conveyors is:

$$Q_{PM10} = K_s xLxU_{10,\text{Dmpr}}{}^{p}$$ **Equation 11**

Where-

Q_{PM10} = PM10 emission rate (g/s).

K_s = 0.0016 (g/s per m length).

$U_{10,Dmpr}$ = DPS wind speed at 10 metres (m/s).

L = length of conveyor (m).

p = 0.5.

As described previously, emissions from conveyors are also dependent on wind direction. This function was derived for winds at right angles to the conveyor and hence would cause emissions to be over-estimated for other wind orientations due to a reduced area of exposure. The emissions factor has therefore been reduced by 0.71 for annual modelling purposes.

Summary

A summary of changes to emissions functions from on-site monitoring is shown in Table 23.

Table 23 Summary of changes to emissions functions from on-site monitoring

Parameter/Emission Source	1/4-5E Transfer Point	PP stacker	PP stockpile B2/3 reclaimer	SH1P	Loading out from bulk stockpile[b]
Ore	HIY-F	HIY-F	PB50-F	PB50-L	PB50-F
Moisture ex-minesite (%)	7.43	7.77	N/a	N/a	N/a
DPS WS (m/s)	4.3	4.0	4.6	5.0	2.7
DPS WD (deg)	268	75	20	265	359
Original PM10 K for Karratha wind speed at 10m	0.35	0.108	0.14	1.2	N/a
Revised PM10 K for DPS wind speed[a] at 10m	0.25	0.11	0.59	2.4	0.36
Effective change in emissions estimate[a]	0.64	0.73	3.01	1.7	0.79

[a] Note that the emission functions which were previous based on Karratha Airport winds in SKM (1998) are progressively being redefined for DPS wind data, which will more representative of the area and more useful for PI's dust management purposes. The revisions to the K factor also incorporate this change.
[b] It was considered that more data is required before moving away from the existing NPI-based loading out function although it appear at this stage that the NPI function is reasonable – if anything, a little high.
[c] The power law exponents used for semi-enclosed sources is 0.5; for open sources is 1.4.

In summary, the emissions for the PP reclaimers and SH1P appear to have been under-estimated; the previously used emissions for the 1/4-5E transfer, stacking and bulk stockpile loading out appears to have been overestimated.

There has been a tendency during this monitoring program to target obviously dusty sources. A more widespread monitoring program would have to try and target a typical range of ores – from "dusty" to "not visually dusty".

At present, the inability to determine moisture levels of the ore being sampled means that the results have some uncertainties. The improvement of the dust emission functions without an accurate knowledge of moisture can only be done empirically by repeated sampling over a wide range of range of ore types and moistures.

Appendix 2 Effect of Ore moisture on dust emissions

The dust emitted from a given ore during a handling operation is considered to be primarily dependent on the actual moisture content and "inherent dustiness".

The inherent dustiness arises from a number of inter-related factors such as the particle size distribution, density (specific gravity) and shape of the particles, mineralogy of the ore and hygroscopicity.

Ore dustiness has historically been characterised using a rotation drum test designed to measure coal dustiness as defined by Australian Standard AS4156.6-2000.

The rotating drum test consists of a horizontally mounted drum. A moisture-conditioned 1 litre sample is placed inside the drum and the drum rotated for a fixed time. A constant stream of air is drawn through the drum and the generated dust (-150 micron) collected in a vacuum filter bag (see Figure 22). The weight of the filter bag is measured before and after the test to determine the quantity of dust collected.

	
Rotating drum test rig with drum having yellow band on right	End View of Rotating Drum

Figure 22 Rotating drum arrangement

A dust number, indicating relative dustiness, is obtained from:

Dust Number = $(Mb - Ma) / Ms \times 100,000$ **Equation 12**

Where:

Mb = Mass of filter bag and dust (grams)

Ma = Mass of filter bag (grams)

Ms = Mass of sample in drum (grams)

By repeating the test for different moisture levels in the same ore, a series of moisture and dust number paired data are obtained. These are plotted on a log linear graph (see Figure 23) where the line of best fit intersecting a dust number of 10 is deemed to be the "Dust Extinction Moisture"

(DEM). The slope of the line from right-to-left indicates the rate at which dustiness increases with decreasing moisture below the DEM and has been referred to as the “Moisture Change Sensitivity” (MCS):

$D = b \times e^{(MCS \times M)}$ **Equation 13**

Or, in the more familiar form for a straight line relationship,

$\ln(D) = (MCS \times M) + \ln(b)$ **Equation 14**

Where

D = Dustiness (Dustiness units)

M = Moisture (%)

MCS = Moisture Change Sensitivity (Dustiness units/%)

b = constant (Dustiness units)

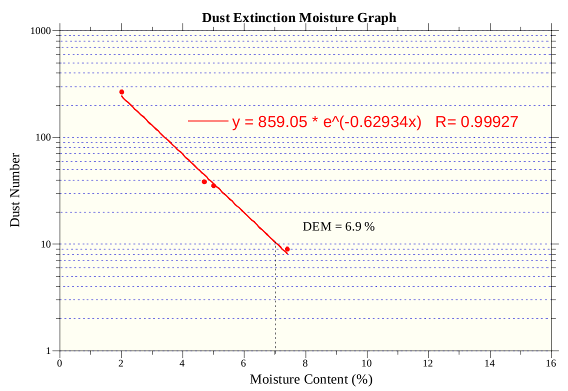

Figure A9.1 - Dust/Moisture Relationship Test
6650- Brockman Iron Ore

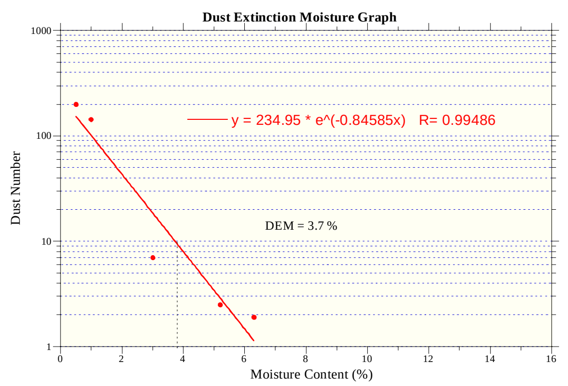

Figure A9.1 - Dust/Moisture Relationship Test
6650- Tom Price 48c Iron Ore

In the above example, Brockman ore requires 6.9% moisture to eliminate dust emissions, whereas Tom Price ore requires only 3.8%. Therefore, for the same moisture, Brockman will be dustier than Tom Price.

Figure 23 Example of moisture/dustiness relationships from rotating drum tests

In theory, it is therefore desirable at the operational level to keep the moisture level of any ore during handling just higher than its DEM value in order to minimise dust generation whilst also minimising water usage.

This implies a number of assumptions regarding the applicability of the test results to actual application:

- The air velocity through the ore particles is the same as used for the test – clearly actual wind velocities will vary.
- In real-world situations, ore drops are a fairly thick stream (eg 1m or so in diameter). Therefore the penetration of wind into the ore stream may be less than occurs in the test drum where the ore particles are well separated. This would lead to the test results over-estimating dust generation.
- The AS specifies that the material is screened to < 6.3 mm before testing. Fines ores are typically < 6.7 mm so this wouldn’t substantially change the ore sample, however lump ore samples will be considerably altered from the initial product by the screening.

Following a review of dustiness test reports provided by PI, it also became apparent that there are a number of variations that may be applied by different laboratories:

- Where the moisture of the ore sample needs to be lowered, either oven drying or air drying may be used.
- Where the moisture of the ore sample needs to be raised above the level as provided, the moisture tends to adhere to the fine fraction only and not be evenly distributed throughout. It was advised that a spray bottle is used and the ore gently agitated in a bag, however the skill of the analyst would appear to be important in obtaining an even distribution of moisture. It is preferable to get ores to be tested in a wet condition from the minesite.
- PI follow the ISO 3087:1998 Standard for the analysis of moisture in ore, however it is not clear what procedure is used by laboratories when undertaking dustiness tests.
- The AS specified that the moisture is measured prior to the test. The Standard optionally specifies a moisture measurement after the test as well, but does not specify it be used in determination of the actual test moisture. If there is some drying out of the sample during the test, the associated moisture will be over-estimated.
- Some laboratories may run the test for a period of 5 minutes with an air flow rate of 350 L/m as opposed to the Standard's specification of 10 minutes with an air flow rate of 170 L/m. This may be at the request of the client on the basis that the shorter duration and higher air flow rate is more representative of real-world situations.

Unfortunately, dustiness test results were not always accompanied by reports describing the details of the method used.

It is not known whether the issues described above are important in terms of affecting the usefulness of the results or not.

- In order to obtain more up-to-date and consistent data, PI arranged for further dustiness testing of existing fines ores and most of those proposed at the 145 Mtpa throughput level - strictly following AS 4156.6-2000 (noting the various vagaries in this Standard).
- For the ores not tested in the 2006 program, previous test data was used to estimate the parameters for the dust equations (see Table 24).
- The parameters for the moisture/dustiness relationships for 95 Mtpa and 145 Mtpa ores and products are shown in Table 25.

Table 24 Results from all known PI rotating drum dustiness tests

Ore Classification/Product	b (Dustiness units)	MCS (Dustiness units/%)	DEM (%)	Ref
Hematites Fines				
HIB Fines	6.6	-1.1	3.8	Dust Tests Data Base.xls
HIB Fines	7.0	-0.9	5.0	Dust Tests Data Base.xls
HIB Fines	4.9	-0.6	4.3	Dust Tests Data Base.xls
HIB Fines	8.3	-1.7	3.4	Dust Tests Data Base.xls
HIB Fines	10.3	-1.7	4.8	Dust Tests Data Base.xls
HIB Fines	9.5	-1.7	4.3	Dust Tests Data Base.xls
HIB Fines	3.8	-0.3	4.9	Dust Tests Data Base.xls
HIB Fines	2.8	-0.2	2.9	Dust Tests Data Base.xls
HIB Fines	5.2	-0.4	6.7	Dust Tests Data Base.xls
Brockman Fines	6.0	-0.6	6.3	Bkm Fines Production 23_09_03.doc
Brockman Fines	7.0	-0.7	6.8	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
HIP Fines	5.5	-0.5	6.1	Dust Tests Data Base.xls
HIP Fines	7.9	-1.3	4.2	Dust Tests Data Base.xls
Paraburdoo Fines	6.3	-1.1	3.7	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
Tom Price Fines 48c	5.5	-0.8	3.7	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
Tom Price 10 Fines	22.3	-5.6	3.6	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
Tom Price 44 Fines	9.9	-2.9	2.6	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
Average	**6.5**	**-0.9**	**4.9**	
Goethites Fines				
HIM Fines	6.5	-0.8	5.2	Dust Tests Data Base.xls
HIM Fines	7.3	-0.8	6.5	Dust Tests Data Base.xls
HIM Fines	6.6	-0.5	8.7	Dust Tests Data Base.xls
HIM Fines	7.2	-0.7	7.3	Dust Tests Data Base.xls
HIM Fines	7.2	-0.7	7.4	Dust Tests Data Base.xls
HIM Fines	13.3	-2.4	4.7	Dust Tests Data Base.xls
HIM Fines	6.5	-0.9	4.8	Dust Tests Data Base.xls
HIM Fines	7.3	-0.9	5.5	Dust Tests Data Base.xls
HIM Fines	7.5	-0.9	5.7	Dust Tests Data Base.xls
HIM Fines	7.5	-0.9	5.6	Dust Tests Data Base.xls
Marandoo Fines	9.6	-0.9	8.1	MARANDOO STOCKPILE TREATMENT ANALYSIS Email: David.B.Bennie@aus.dupont.com Our Ref.: 6564 From: Tobias Krull Your Ref.: DB3878 Subject: Stockpile Treatment Analysis (Wind Tunnel & DEM)
Marandoo Fines	17.0	-1.7	8.9	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
West Angelas fines	4.6	-0.3	6.8	Flow Properties of West Angelas Ores Report No 5613 June 1997 Client:Robe River Iron Associates
WA Zone D Fines	10.0	-1.1	6.9	SKM Cape Lambert
WA Fines	9.5	-0.8	9.6	SKM Cape Lambert
WA Fines	11.0	-1.1	8.1	SKM Cape Lambert
West Angelas Fines	12.3	-1.3	7.5	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
Hope Downs Fines	10.2	-1.1	7.5	Dustiness Testing of Hope Downs Iron Ores Report No 6086 Nov 2001 Client: Hope Downs Management Services
Hope Downs Fines	9.9	-0.9	8.0	Dustiness Testing of Hope Downs Iron Ores Report No 6086 Nov 2001 Client: Hope Downs Management Services
Nammuldi Fines	6.7	-0.6	7.0	TEST PROGRAM TO DETERMINE THE RELATIONSHIP BETWEEN DUSTINESS AND MOISTURE CONTENT FOR SELECTED TYPES OF IRON ORE CONDUCTED AT TUNRA BULK OLIDS HANDLING RESEARCH ASSOCIATES, UNIVERSITY OF NEWCASTLE Date: 30 August 2006 Introspec Consulting
Average	**9.0**	**-1.0**	**7.0**	
Pisolitic Fines				
Mesa J Fines	8.5	-0.6	10.0	SKM Cape Lambert
Mesa J Fines	11.3	-1.2	7.5	SKM Cape Lambert

Table 25 Parameters for moisture/dustiness relationships for 95 Mtpa and 145 Mtpa ores and products

Ore Classification/Product	Port throughput	Abrev	b (Dustiness units)	MCS (Dustiness units/%)	DEM (%)	Ref
Brockman Fines	95 Mtpa & 145 Mtpa	BRF	7.0	-0.7	6.8	Introspec Consulting 30 August 2006
Paraburdoo Fines	95 Mtpa & 145 Mtpa	PAF	6.3	-1.1	3.7	Introspec Consulting 30 August 2006
Tom Price Fines 48c	95 Mtpa & 145 Mtpa		5.5	-0.8	3.7	Introspec Consulting 30 August 2006
Tom Price 44 Fines	95 Mtpa & 145 Mtpa		9.9	-2.9	2.6	Introspec Consulting 30 August 2006
Tom Price LG Fines	145 Mtpa	TPLGF	7.7	-1.9	3.2	Average of TP LGs
Tom Price 10 Fines	145 Mtpa	TPHGF	22.3	-5.6	3.6	Introspec Consulting 30 August 2006
Avg Tom Price Fines	95 Mtpa	TPF	12.6	-3.1	3.3	Average of all TP fines
Marandoo Fines	95 Mtpa & 145 Mtpa	MAF	17.0	-1.7	8.9	Introspec Consulting 30 August 2006
West Angelas Fines	95 Mtpa & 145 Mtpa	WAF	12.3	-1.3	7.5	Introspec Consulting 30 August 2006
Yandicoogina Fines	95 Mtpa & 145 Mtpa	YAF	8.6	-1.1	5.8	Introspec Consulting 30 August 2006
Nammuldi Fines	145 Mtpa	NAF	6.7	-0.6	7.0	Introspec Consulting 30 August 2006
Hope Downs Fines	145 Mtpa	HDF	10.1	-1.0	7.8	Dustiness Testing of Hope Downs Iron Ores Report No 6086 Nov 2001 Client: Hope Downs Management Services
Pilbara Blend Fines	145 Mtpa	PBF	7.9	-1.0	5.7	Introspec Consulting 30 August 2006
Brockman Lump	95 Mtpa & 145 Mtpa	BRL	10.3	-2.4	3.3	Average of BLs
Marandoo Lump	95 Mtpa & 145 Mtpa	MAL	8.3	-1.5	4.1	Dust Tests Data Base.xls
Paraburdoo Lump	95 Mtpa & 145 Mtpa	PAL	10.3	-2.4	3.3	Average of hematites lumps
Tom Price Lump	95 Mtpa & 145 Mtpa	TPL	10.3	-2.4	3.3	
Nammuldi Lump	145 Mtpa	NAL	10.1	-1.5	5.4	Average of goethite lumps
Hope Downs Lump	145 Mtpa	HDL	10.1	-1.5	5.4	
West Angelas Lump	145 Mtpa	WAL	10.1	-1.5	5.4	
Pilbara Blend Lump - Avg Hematite/Geothite lumps	145 Mtpa	PBL	9.9	-1.9	4.3	Average of composites
Pilbara Blend 50 fines - Avg Hematite/Geothite fines	95 Mtpa	PB50F	10.7	-1.6	5.7	Average
Pilbara Blend 50 lump - Avg Hematite/Geothite lumps	95 Mtpa	PB50L	9.8	-2.2	3.5	Average

Appendix 3 Revisions to emissions estimates since draft report version 6b

A number of changes to the emissions estimates for the 145 Mtpa proposal have been made since the draft report version 6b (dated 28/11/2006) was provided to the EPA. The basis of the changes were:

- Revisions to dust emissions inventory

Pursuant to Condition:M7-3 of Ministerial Statement 734, SKM undertook an intensive on-site emission monitoring programme at Hamersley Iron's Dampier Operations in June and October 2006 to determine emission rates under various operational and meteorological conditions. Details of SKM's findings are provided in SKM (2007) which was submitted to the DEC on 29 March 2007. The changes to the emission function for the sources covered by the SKM program have since been included in this proposal.

- Changes to level of proposed bulking at PP

Pilbara Iron have revised downwards the level of bulking activity from 9 Mtpa in draft report version 6b to 5.5 Mtpa in 2008 and 5.9 Mtpa from 2009. The 5.9 Mtpa level has been assumed for modelling of the 145 Mtpa proposal.

- Use of water canon on PP Live Stockpiles for winds towards King Bay

Pilbara Iron now propose to apply water canons for winds in the direction of King Bay in excess of 11 m/s. During 2005, this occurred for 10 hours of the year.

The changes to the TSP emission rates from those reported in the draft report version 6b are summarised in Table 26 below.

Table 26 Revised emission rates

Basis of change	Sources affected	95 Mtpa		145 Mtpa	
		Previous annual TSP emissions (g/s)	Revised annual TSP emissions (g/s)	Previous annual TSP emissions (g/s)	Revised annual TSP emissions (g/s)
Revisions to dust emissions inventory	EII Reclaiming	1.5	5.4	1.3	4.5
	EII Stacking	1.9	2.3	2.1	2.6
	EII Transfers [a]	4.5	3.5	4.7	4.0
	PP Stacking[c]	2.2	5.8	8.0	15.0
	PP Reclaiming[b]	7.6	7.5	19.4	19.0
	PP Transfers [a]	4.1	3.1	8.6	6.7
	EII Live Stockpiles & Roads	22.0	39.6	10.1	19.5
Changes to level of proposed bulking at PP	PP Bulking	-	-	24.0	14.3
Use of water canon on PP Live Stockpiles for winds towards King Bay	PP Live Stockpiles & Roads	-	-	19.7	19.2

[a] Emissions shown are for in loading plus outloading.
[b] Slightly modified from SKM function as described in Appendix 4.
[c] Slightly modified from SKM function as described in Appendix 5.

Reference

Sinclair Knight Merz (SKM), 2007, "Dust Emissions Inventory - Hamersley Iron Dampier Operations - Ministerial Statement 702, Condition 7-3", March 2007.

Appendix 4 Comparison between EA (2006) and SKM (2007) emissions functions for PP Reclaimers

The emissions function determined for PP reclaimers from EA monitoring in 2005 was:

$$Q_{PM10} = (0.69x0.59)K_s U_{10,KA}^{\ 1.4}$$ **Equation 15**

Where 0.69 = $(1/1.3)^{1.4}$ which adjusts the K constant from DPS winds to Karratha Airport winds.

The emissions function determined for PP reclaimers from SKM monitoring in 2007 was:

$$Q_{PM10} = 0.10_s U_{10,KA}^{\ 1.6}$$ **Equation 16**

These are plotted in Figure 24 below.

This shows that the emissions from the EA function are about three times higher than from the SKM function.

The SKM function was determined excluding a high outlier data point (see SKM 2007 page 32 Figure 4-13). Had this point been included in determined the emission function, it would have more resembled the EA function. This approach differs slightly from EA's sampling where "outlying" data are not excluded.

The EA emissions function was therefore essentially retained for modelling in this assessment except for a slight modification whereby the SKM approach of setting of a lower emission limit to avoid an unrealistic zero emission when the wind speed equals zero, was retained (ie. PM10 emission rate set to 0.1 m/s for wind speed < 2 m/s).

Actual emissions may be highly variable depending on the frequency of reclaiming the type of dusty ores that were measured in the SKM outlier.

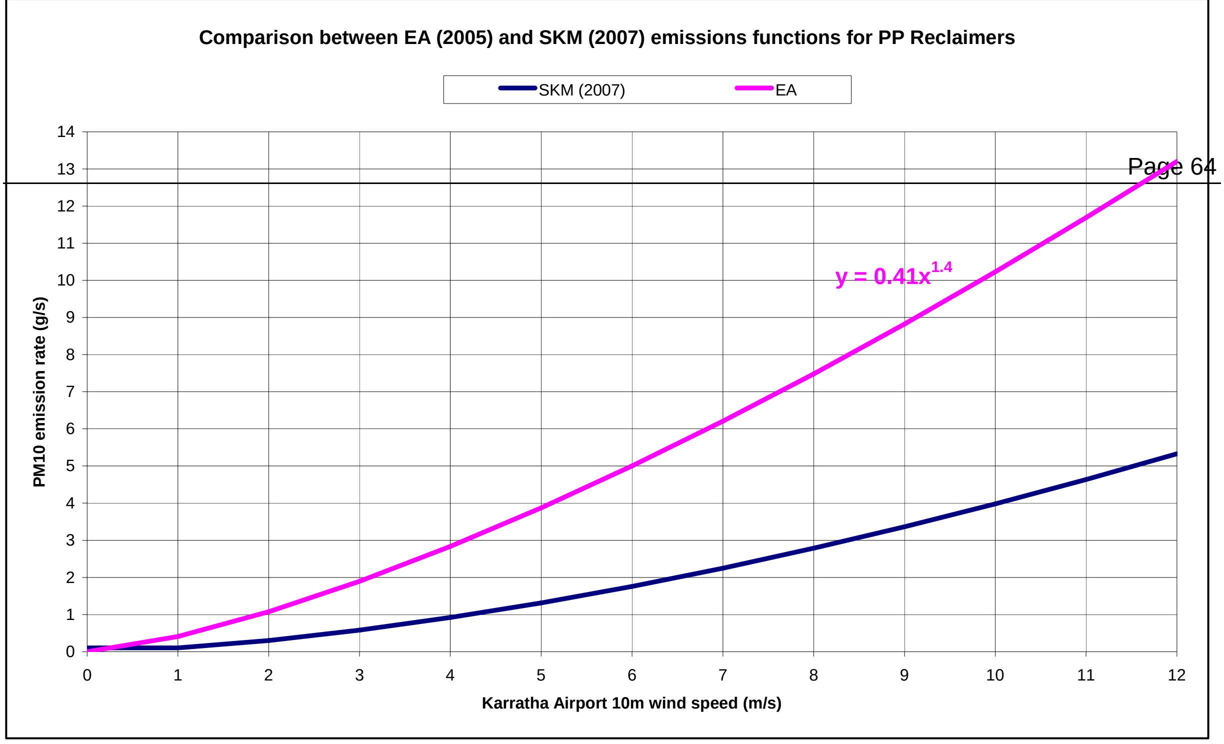

Figure 24 Comparison between EA (2006) and SKM (2007) emissions functions for PP Reclaimers

Appendix 5 Comparison between EA (2005) and SKM (2007) emissions functions for PP Stackers

The emissions function determined for PP stackers from EA monitoring in 2005 was:

$$Q_{PM10} = (0.69x0.11)K_s U_{10,KA}^{1.4}$$ **Equation 17**

Where 0.69 = $(1/1.3)^{1.4}$ which adjusts the K constant from DPS winds to Karratha Airport winds.

The emissions function determined for PP stackers from SKM monitoring in 2007 was:

$$Q_{PM10} = 0.35_s U_{10,KA}^{1.4}$$ **Equation 18**

These are plotted in Figure 24 below.

This shows that the emissions from the EA function are about three times lower than from the SKM function. The emissions function used for modelling in this assessment is the average of the EA and SKM functions. The SKM approach of setting of a lower emission limit to avoid a zero emission when the wind speed equals zero, which is unrealistic, was retained.

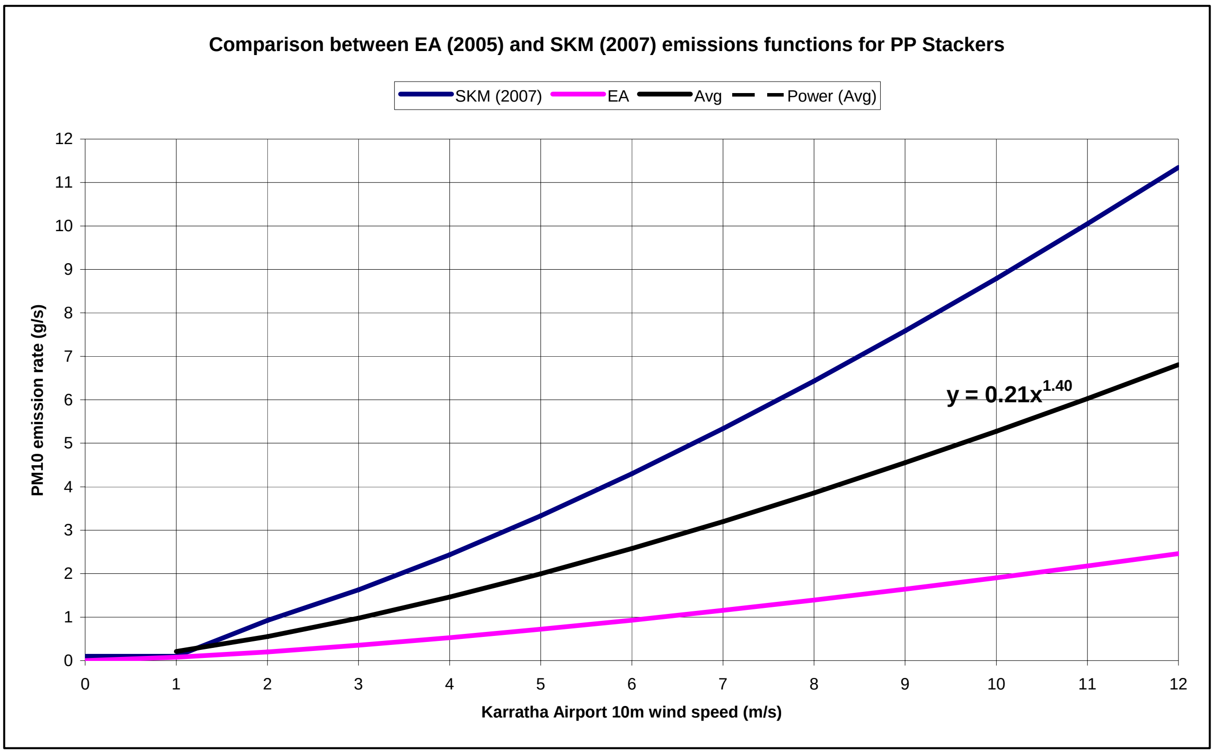

Figure 25 Comparison between EA (2005) and SKM (2007) emissions functions for PP Stackers