DUST DISPERSION MODELLING FOR PILBARA IRON DAMPIER PORT EXPANSION TO 145 MTPA (PHASE B)

Prepared for

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by

Environmental Alliances Pty Ltd

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1. INTRODUCTION

Pilbara Iron Pty Ltd (PI) operates iron ore receiving, processing, stockpiling and exporting facilities at Parker Point and East Intercourse Island, adjacent to the town of Dampier in the North West of Western Australia. The iron ore is sourced from a range of mine-sites in the Pilbara region (see Figure 1).

PI (Hamersley Iron at that time) was granted environmental approval in November 2003 to upgrade the Dampier Port Operations to 95 Mtpa. A subsequent environmental approval to increase iron ore throughput to 120 Mtpa was granted in 25 November 2005. The completion of the construction changes necessary to achieve a throughput capacity of 145 Mtpa is scheduled for mid-2007.

Operations from the Parker Point (PP) and East Intercourse Island (EII) operations generate dust that has the potential to impact the local environment and Dampier community.

This report assesses existing dust levels at the Dampier town-site and the change in dust levels predicted from the proposal. The approach taken is:

- Presentation of ambient dust criteria and review of the ambient monitoring data against the criteria;
- Identification of various sources of dust in PI's operations, and corresponding emission estimates;
- Approach to dispersion modelling and comparison of dust levels predicted by modelling of PI's current operations (based on assumptions for 95 Mtpa) with measured ambient data; and
- Predicted effect on ambient dust levels in Dampier and King Bay from the proposed operations at 145 Mtpa.

2. DUST CRITERIA

2.1 PARTICLE SIZES

Dust is generally assumed to comprise of fine, airborne particles of earth or pollen material. Monitors used to measure dust may also include in their measurement smoke particles, salt and other aerosols suspended in the air.

Dust or particle monitors have a cut-off for the size range of the particles they collect and measure. Three size ranges are commonly used: 50 μm, 10 μm and 2.5 μm and the particulate matter (PM) measured is abbreviated as PM50, PM10 and PM2.5 respectively. PM50 is also referred to as Total Suspended Particulates (TSP).

TSP measurements are associated with potential for nuisance or loss of amenity. PM10 and PM2.5 measurements are associated with the potential for health impacts because particles below these sizes may penetrate the nose and enter the lung.

2.2 ENVIRONMENTAL CRITERIA USED IN WESTERN AUSTRALIA

Environmental criteria for dust that may be used in Western Australia are outlined in Table 1.

Table 1 Criteria for airborne dust

Particle size	Averaging time	Concentration ($\mu g/m^3$)	Frequency	Reference
TSP	15 minutes	1000	Not to be exceeded	Kwinana EPP, Area C (residential) [(a)]
	24 hours	90	Desirable not to be exceeded	
	24 hours	150	Not to be exceeded	
PM10	24 hours	50	Not more than 5 days a year	NEPM for Ambient Air[(b)]
PM2.5	24 hours	25	Goal is to gather sufficient data nationally to facilitate a review of the Advisory Reporting Standards as part of the review of this Measure scheduled to commence in 2005	
	1 year	8		
Deposition	30 days	2 g/m^2/month[(c)]	Guideline	DEC NSW (2005)

(a) Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1992 and Environmental Protection (Kwinana) (Atmospheric Waste) Regulations 1992.
(b) National Environment Protection Council (NEPC), 1998, National Environment Protection Measure for Ambient Air Quality, 26 June 1998 and Variation dated 23 May 2003.
(c) Additional insoluble deposited dust assuming a background level of 2 g/m^2/month.

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

Consequently, in terms of implementing the NEPM in Western Australia, the Department of Environmental and Conservation (DEC)[1] has stated that:

It is proposed to implement the NEPM via a state-wide Environmental Protection Policy (EPP) which:

- *references the NEPM standards for general application in WA, but also;*
- *excludes application of the standards within industrial areas and residence-free buffer areas around industrial estates;*
- *for circumstances where the standards are not being achieved due to existing emissions, enables attainment and/or management programs to be established. (The NEPM goal envisages a 10 year period for attainment).*

Examples of issues which would need to be addressed via attainment and/or management programs are as follows:

...

- *Exceedences of dust standards in the Pilbara (often caused by natural events) are inevitable. Good dust management practices can form the basis for acceptable management programs for Pilbara industries.*

...(NEPC 1997).

1 DEC in this report refers to the current Department of Environment and Conservation or its predecessors.

An assessment of PM2.5 levels was initiated through the implementation of the Ministerial Conditions in "Hamersley Iron Port Upgrade to 95 Mtpa Capacity" (Assessment No 1489, Statement No 638) which PI was required to monitor PM2.5 from 2005. This requirement was subsequently superseded by Ministerial Statement No 702 through which PM2.5 monitoring was incorporated in the PI Dust Monitoring Plan. PM2.5 has therefore also been addressed in this report.

Dust deposition has been raised as an issue of concern to the community and hence has been addressed in this report. The determination of a criterion for acceptable levels of dust deposition is difficult. A comprehensive review of the subject is provided in Air Assessments (2005). The appropriateness of the DEC NSW criterion shown in Table 1 for Western Australia is therefore not straight-forward.

2.3 PI DUST PERFORMANCE TARGETS

The above criteria for TSP and PM10 have been reflected in the performance targets in PI's Dust Management Plan (DMP) for its Dampier operations. The DMP contains performance targets for PM10 and TSP as outlined below.

PM10 Target

Zero PM10 exceedences of 50 $\mu g/m^3$ over a 24 hour period as measured at the Dampier Primary School monitoring station, where there is a significant contribution by PI's operations.

The basis of this target is the National Environment Protection Council's PM10 standard of 50 $\mu g/m^3$, 24-hour average. The standard has a goal of no more than five exceedences per year of this concentration. It is understood that the DEC recognise that background levels of PM10 in the Pilbara can contribute substantially to measured levels, and that this needs to be considered in the application of the NEPM standard to the control of emissions from industrial sources in the region. The procedure for determining PI's contribution is based primarily on the analysis of the 10-minute average PM10, wind direction and wind speed data over each 24-hour period, measured at the Dampier Primary School.

TSP Target

Zero TSP exceedences of 90 $\mu g/m^3$ over a 24 hour period as measured at the Dampier Primary School monitoring station, where there is a significant contribution by PI's operations.

The basis of this target is the Kwinana Environmental Protection Policy (KEPP) residential standard for TSP of 90 $\mu g/m^3$. This is the only legislated TSP standard in Western Australia. The KEPP refers to the 90 $\mu g/m^3$ level as "desirable not to exceed" in residential areas.

The KEPP also refers to a TSP limit of 150 $\mu g/m^3$ which is not to be exceeded, therefore the use of 90 $\mu g/m^3$ as the basis of a performance target implies some conservatism.

As for PM10, background levels of TSP contribute to ambient measurements. Therefore, PI's TSP performance target is related to the level of contribution by PI's operations. The procedure for determining PI's contribution is based primarily on the analysis of the 10-minute average TSP, wind direction and wind speed data over each 24-hour period, measured at the Dampier Primary School.

3. DUST AND METEOROLOGICAL MONITORING NETWORK

3.1 AMBIENT MONITORING OBJECTIVES

PI has undertaken dust monitoring in the Dampier region since 1993. The number, types and locations of the monitors have varied over the years in response to changing demands and circumstances. There are numerous constraints which restrict the ability to monitor in any desired location which include for example, site ownership and access, security, noise impacts, the availability of power and the proximity of nearby potential sources of dust that could cause measurements to be unrepresentative of the locality in general. The broad objectives of the monitoring program are to:

- Determine long term trends in ambient dust levels;
- Determine TSP and PM10 concentrations at representative locations within Dampier for comparison to criteria levels;
- Determine the most appropriate options for dust control improvement projects;
- Determine PM10 concentrations at a nearby town (Karratha) that will have negligible impacts from Dampier operations and therefore be representative of a typical Pilbara coastal town; and
- Provide scientific data to the community.

3.2 LOCATIONS OF AMBIENT MONITORING SITES AND PARAMETERS MEASURED

Details of the current monitoring network are presented in Table 2 with locations of current monitoring shown in Figure 2.

Table 2 Dust and meteorological monitoring by Pilbara Iron in the Dampier and Karratha region

Site name	Location – GDA94 (m)		Parameter	Monitor		Period	Comments
	E	N					
Dampier Primary School (DPS)	469348	7715001	PM10	TEOM		13/4/2000-current	Ambient measurement in sensitive environment
			PM10	E-BAM	B2965	13/6/2004-17/6/2005	
			PM2.5	TEOM		24/10/2005-current	
			TSP	TEOM		23/2/2002-current	
			Met data (10m)	Various		24/02/1998-current	
EII – boat jetty near marine workshop (BJ)	468280	7713964	PM10	E-BAM	C1261	04/06/03-current	Ambient measurement with focus on EII and 5E sources
Parker Point – SKM offices	471596	7716659	Met data (4.5m)	Oregon Scientific WMR-968		26/8/2005-current	Installed to assist management of dust from construction activities.
King Bay	473525	7719352	PM10	E-BAM	B2965	26/8/2005-current	Ambient measurements with focus on PP operations contribution to King Bay
East Intercourse Island	466527	7715879	TSP	High Volume		3/10/1993-16/2/2003	Occupational health
Parker Point – north of main administration building (AB)	471544	7716333	PM10	E-BAM	C1263	03/06/03-5/12/2005	Ambient measurement with focus on PP sources
Karratha Water Corp Pump station	485417	7708000	TSP	High Volume Air Sampler		4/5/1996-16/2/2003	Ambient measurement in a similar environment to Dampier away from Port operations impacts
			PM10	TEOM		22/2/2002 –current	
			PM2.5	TEOM		1/9/2005-current	
			Met data (5m)	Various		22/2/2002-current	

E-BAM continuous PM10 monitors were installed at the EII Marine Workshop near the water-front, just north of where the 5E conveyor reaches the mainland, and Parker Point Administration Building (AB) in mid-2003. The locations of these were selected on the basis of being at the "coal-face" between the PI operational areas and the Dampier township.

An E-BAM continuous PM10 monitor was also installed in August 2005 on the Dampier Port Authority site in King Bay, immediately behind the rock wall. This location was selected to enable the dust contributions in the King Bay area from the PP operational area to be determined, in view of the potential for expanding iron ore throughput at PP.

The measurement of PM2.5 also commenced in October 2005 at the DPS site and in September 2005 at the Karratha site. The same type of monitor (TEOMs) was used to ensure comparability of the data.

A proposed upgrade of the ambient dust monitoring program is described in Section 6.

Wind data used to assist the interpretation of ambient dust levels at Dampier are sourced from the Dampier Primary School (DPS) anemometer. Summary specifications of the anemometer are shown in Table 3.

Table 3 DPS anemometer specifications

Parameter	Specification
Model	RM Young Model 05103
Accuracy	Speed: +/- 0.3 m/s, Direction: <3 deg
Thresholds	Speed: 1.0 m/s, Direction: 1.1 deg

A full compliance assessment of the anemometer is described in EA (2004). The compliance assessment finding was that the anemometer was suitable for wind measurements in the Pilbara environment for the purpose of dust impact assessment (noting that the anemometer needed to be adequately robust to withstand periodic cyclones).

Data collected up to 31/12/2006 have been used for the purposes of this report.

3.3 AVERAGE DUST CONCENTRATIONS

Annual average dust concentrations measured at each of the PI ambient monitoring sites in the Dampier/Karratha region are shown in Table 4.

It should be noted that a valid comparison of annual dust data from different sites ideally requires that data is collected over the same (or very similar) time periods – otherwise seasonal differences may confound their interpretation. For this reason, the data recoveries are also shown in Table 5.

DPS PM10 and Karratha PM10

The monitoring at the Karratha site[2] which is unaffected by dust from PI's operations at Dampier is intended to provide comparative data against the DPS measurements where PI's dust does contribute.

[2] About 15 km from Dampier.

Up until 2006, the Karratha monitoring site was probably influenced by dust emissions from vacant land to the west and north. The land to the west has since been redeveloped for housing however, there the bare land to the north remains. On one hand, these data could be interpreted as representative of background dust levels since there is nothing unique about vacant land in the Pilbara. Airborne particle levels in mid-suburban areas where the surrounding land has been more stabilised could, however, be lower – assuming no localised influences from nearby vehicles, unpaved driveways or similar sources.

The Karratha data indicates that that year-to-year variability can be substantial due to both climatic variability and the nature of surrounding urban activity.

For 2003, the annual average PM10 measured at Karratha was 40% higher than measured at Dampier. This seems to have been something of an aberration. For all of the other years, the annual average PM10 measured at Karratha was within ±10% of that measured at Dampier.

DPS PM2.5 and Karratha PM2.5

Over the first full year of monitoring – 2006, the PM2.5 concentration at the DPS was 3.1 $\mu g/m^3$ which was lower than the 4.3 $\mu g/m^3$ measured at the Karratha monitor. Both of these are well below the NEPM Advisory Reporting Standard of 8.0 $\mu g/m^3$.

Trends from 2006 measurements

For 2006 at the DPS:

- The average PM10 concentration of 21.2 $\mu g/m^3$ was about 9% less than the 2001 to 2005 average of 22.8 $\mu g/m^3$.
- The average TSP concentration of 27.9 $\mu g/m^3$ was about 11% less than the 2003 to 2005 average of 30.6 $\mu g/m^3$.

This indicates that dust levels at the DPS over 2006 were lower than the "long term" average. At Karratha however, the average PM10 concentration of 19.3 $\mu g/m^3$ was about 25% less than the 2003 to 2005 average of 25.6 $\mu g/m^3$. Changes in the nature of land uses around the monitors probably have an influence – for example, the paving of the car park adjacent to the DPS monitor in 2005 and the stabilisation of land west of the Karratha monitor for housing development. Therefore the reduction in the 2006 dust levels at Dampier and Karratha may have been assisted by these changes along with possibly lower naturally-occurring levels than previously.

The data recovery at the BJ and AB sites for 2006 was too poor to enable a meaning assessment of dust trends. This issue is being addressed as discussed in Section 6.

Table 4 Average concentrations of airborne particles at PI monitoring sites in the Dampier region

Area	Non-residential locations			Residential locations					
Monitoring site	Boat Jetty	Admin Building	King Bay	DPS			Dampier (DoE)	Karratha	
Parameter/ Instrument	PM10 - EBAM	PM10 - EBAM	PM10 - EBAM	PM2.5 - TEOM	PM10 - TEOM	TSP - TEOM	PM10 - TEOM	PM2.5 - TEOM	PM10 - TEOM
Year	Average concentration ($\mu g/m^3$)								
1998							15.9 [h]		
1999							17.9		
2000							22.4		
2000	-	-	-	-	23.4 [a]	-	-	-	-
2001	-	-	-	-	21.3	-	-	-	-
2002	-	-	-	-	25.8	32.3 [b]	-	-	24.3 [c]
2003	26.3 [d]	25.7 [e]	-	-	24.4	31.9	-	-	34.6
2004	29.8	31.3	-	-	20.6	30.4	-	-	19.4
2005	27.1	24.6	23.1 [f]	7.6[e]	22.3	29.4	-	4.6[g]	22.7
2006	23.7	15.2	20.0	3.1	21.2	27.9	-	4.3	19.3

Table 5 Data recoveries for airborne particles at PI monitoring sites in the Dampier region

Area	Non-residential locations			Residential locations				
Monitoring site	Boat Jetty	Admin Building	King Bay	DPS			Karratha	
Parameter/ Instrument	PM10 - EBAM	PM10 - EBAM	PM10 - EBAM	PM2.5 - TEOM	PM10 - TEOM	TSP - TEOM	PM2.5 - TEOM	PM10 - TEOM
Year	Annual data recovery (%)							
2000	-	-	-	-	67.4 [(a)]	-	-	-
2001	-	-	-	-	96.3	-	-	-
2002	-	-	-	-	98.6	82.6 [(b)]	-	57.2 [(c)]
2003	45.8 [(d)]	46.5 [(e)]	-	-	95.4	93.9	-	92.6
2004	55.4	50.4	-	-	87.2	94.7	-	95.2
2005	66.7	72.0	27.9 [(f)]	18.3[(e)]	99.3	98.8	29.5[(g)]	63.2
2006	53.1	8.5[(i)]	50.4	91.0	82.3	82.7	95.4	94.6

(a) 13/3/2000 to 31/12/2000 only. (b) 1/3/2002 to 31/12/2002 only. (c) 1/6/2002 to 31/12/2002 only. (d) 4/6/2003 to 31/12/2003 only.
(e) 28/10/2005 to 31/12/2005 only. (f) 27/8/2005 to 31/12/2005 only. (g) 1/9/2005 to 31/12/2005 only. (h) Less than full year. (i) Decommissioned 7/6/2006.

Comparison with other Pilbara dust measurements

A summary of average dust levels measured at other Pilbara sites is shown in Table 6.

Table 6 Long term average dust levels at Dampier compared to other Pilbara sites

Site	Period of data	PM10 concentration (μg/m^3)
Boodarie [(a)]	1998 to 2000	19.5
Cape Lambert [(b)]	2001	22.0
	2002	22.2
	2003	21.6
	2004	21.2

[(a)] DoE 2004 "Pilbara Air Quality Study Summary Report", Technical Series Report No 120, August 2004.
[(b)] Monitor is located south-east of Robe River iron ore outloading operations at Cape Lambert – about 50 kms east of Dampier [3].

The monitoring data from Boodarie (DoE 2004) (19.5 μg/m^3) should be indicative of background dust levels in the Pilbara. The 2001 – 2006 average PM10 concentration measured at the DPS site of 22.6 μg/m^3 is 15% above Boodarie.

3.4 24-HOUR AVERAGE DUST CONCENTRATIONS

Health-related dust impact criteria are mostly based on 24-hour averages.

Dampier trends

Time series plots of 24-hour average PM10 and TSP concentrations are presented as follows:

- Figure 3 24-hour average PM10 concentrations measured at DPS site for 2001-06
- Figure 4 24-hour average PM10 concentrations measured at BJ site for 200
- Figure 5 24-hour average PM10 concentrations measured at AB site for 2004
- Figure 6 24-hour average PM10 concentrations measured at King Bay site for 2005-06
- Figure 7 24-hour average PM10 concentrations measured at Karratha site for 2003-06
- Figure 8 24-hour average Total Suspended Particulate concentrations measured at DPS site for 2003-06

These all show a general seasonal trend, with higher particle levels being measured during summer.

The 24-hour average PM2.5 concentrations measured at DPS and Karratha are shown in Figure 9. The measurements are all below the advisory reporting criterion. The measurements also appear to fairly closely follow each other. This may indicate that PM2.5 emissions from the Port operations are negligible, and/or that PM2.5 emission rates from PI sources tend simply to follow that from crustal sources.

[3] As advised by Air Assessments 17/5/2007.

Comparison with other sites

There is a common misperception that dust levels at Dampier are similar to those at Port Hedland where iron ore handling is also undertaken. A summary of the annual exceedences of PM10 target levels at monitoring sites at Dampier, Karratha, Port Hedland, Perth and Bunbury is shown in Table 7. For PM10, this shows that on average, the 24-hour concentration of 50 $\mu g/m^3$ is exceeded only a little more at the DPS than at the Karratha site. The number of exceedences of the target level at the DPS site:

- on average, are at least three times less than at the Port Hedland sites; and
- from 2004 onwards, are comparable to the Bunbury Metropolitan site and a little higher than for the Perth Metropolitan sites.

A summary of the annual exceedences of TSP target levels at monitoring sites at Dampier is shown in Table 8. These show a similar reduction to PM10 for 2004 onwards compared to preceding years.

It should be noted that the interpretation of monitoring results can be influenced by the number of days during which data was collected if less than over a full year. For reference, these are shown in Table 9.

Table 7 Annual exceedences of PM10 target levels at monitoring sites

Region	Port Hedland[h]			Dampier			Karratha	Perth Metropolitan[f]			Bunbury Metropolitan[f]
Locality	**Non-residential**	**Residential**		**Non-residential**		**Residential**	**Residential**	**Residential**			**Residential**
Site	**Boodarie**	**Townsite**	**Port Hedland Hospital**	**Boat Jetty**	**Admin Building**	**DPS**	**Karratha**	**Caversham**	**Duncraig**	**South Lake**	**Bunbury**
Year	**Number of times per year 24-hour average PM10 concentration of $\geq$50 $\mu g/m^3$ was exceeded**										
1996	-	42	29	-	-	-	-	-	-	-	-
1997	9	41	42	-	-	-	-	-	4	-	-
1998	7	40	40	-	-	-	-	-	1	-	-
1999	6	88	56	-	-	-	-	-	0	-	0
2000	22	60	61	-	-	10[a]	-	-	0	0	0
2001	7	93	39	-	-	7	-	-	1	1	1
2002	-	99	61	-	-	13	5[c]	-	1	2	0
2003	-	121	62	4[d]	12[d]	14	18	-	1	0	1
2004	-	-	-	15	23	3	2	1	0	1	4
2005	-	-	-	21	20	4	2	1[g]	1[g]	3[g]	3[g]
2006[i]	-	-	-	13[m]	-	4	4	-	-	-	-
Instrumentation	HVAS[e]	HVAS[e]	HVAS[e]	E-BAM	E-BAM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM

[a] 13/4/2000 to 31/12/2000 only.
[b] 1/3/2002 to 31/12/2002 only.
[c] 1/6/2002 to 31/12/2002 only.
[d] 4/6/2003 to 31/12/2003 only.
[e] Note that data from Port Hedland indicates that PM10 measurements made using high volume air samplers may be higher than those made using TEOMS (DoE 2004).
[f] Data from DoE (2005).
[g] Data from DEC http://portal.environment.wa.gov.au/portal/page?_pageid=54,66336&_dad=portal&_schema=PORTAL
[h] Data from DoE (2004).
[i] Data analysis incomplete at time of writing.
[m] Note that data recovery was only 52%.

Table 8 Annual exceedences of TSP target levels at monitoring sites

Year	Number of exceedences of 24-hour averages	Year	Number of exceedences of 24-hour averages
	DPS [TSP] ≥ 90 μg/m³		DPS [TSP] ≥ 90 μg/m³
1996	-	2002	6[(b)]
1997	-	2003	7
1998	-	2004	3
1999	-	2005	2
2000	-	2006	3
2001	-		
Instrumentation	TEOM	Instrumentation	TEOM

[(b)] 1/3/2002 to 31/12/2002 only.

Table 9 Percentage data recoveries for measurement of annual exceedences of target levels of airborne particles at monitoring sites

Year	Annual percentage data recoveries (%)							
	Boodarie [PM10] [(b)]	Port Hedland Townsite [PM10] [(b)]	Port Hedland Hospital [PM10] [(b)]	DPS [PM10] [(a)]	DPS [TSP] [(a)]	DPS [PM2.5] [(a)]	Karratha [PM10] [(a)]	Karratha [PM2.5] [(a)]
1996	-	43.2	45.4	-	-	-	-	-
1997	55.9	46.6	57.8	-	-	-	-	-
1998	61.6	58.4	66.3	-	-	-	-	-
1999	59.7	51.8	66.3	-	-	-	-	-
2000	47.3	35.2	55.5	66.9	-	-	-	-
2001	53.4	61.6	64.9	94.5	-	-	-	-
2002	-	85.8	76.7	98.6	82.7	-	57.3	-
2003	-	81.1	78.4	94.8	93.2	-	92.1	-
2004	-	-	-	87.2	94.7	-	95.2	-
2005	-	-	-	99.3	98.8	18.3	63.2	29.5
2006	-	-	-	82.3	82.7	91.0	94.6	95.4

[(a)] 24-hour average recoveries based on > 67% data recovery for the 24-hour period.
[(b)] Data modified from DoE (2004).

Note also that "-" indicates data not available or not analysed.

Source contributions indicated by polar plots

Airborne particles are ubiquitous in the environment. Ambient particle monitors measure crustal dust from land sources, salt aerosols from the ocean, smoke particles during wild fires in addition to any dust originating from the PI operational areas. These factors highlight some of the difficulties in determining sources of airborne aerosols and trends in measured airborne particle concentrations.

Notwithstanding, correlating short-term dust measurements with wind direction provides an indication of the bearing to the likely sources of the dust being measured.

A polar plot showing the average PM10 concentrations correlated with wind direction is shown in Figure 10. For the DPS site, the 2006 data (green) is compared against the "historic" average concentrations measured from 2001 to 2005 (pink). The 2006 data illustrates:

- Increased average PM10 from around the NNW, indicating PP operations;
- Decreased average PM10 from around the east, indicating reduced contributions after paving the adjacent car park; and
- A possible reduction from around the SW, which would indicate reduced dust emissions from the 5E conveyor and road.

For the BJ and AB and KB sites, only the average of all PM10 concentration data is shown since these sites have not been in operation long enough, and the data recovery has been too patchy, to undertake meaningful year-to-year comparisons.

The BJ plot clearly indicates elevated concentrations from the 5E conveyor and road, and EII operational area generally.

The AB plot also indicates elevated concentrations from EII and PP operational areas. The EII impacts appear to be higher than from PP although it should be noted that the data recovery for the AB monitor over 2006 was only 8.5% hence the contour really reflects impacts up to 2005.

The KB plot also indicates elevated concentrations from the PP operational area direction, although also from the NW and north. The latter could be from ship emissions while berthed at the container jetty.

It is noteworthy that background PM10 from the NW to NNW (about 23 $\mu g/m^3$) – originating over the ocean, are higher than background levels from the south-east (about 15 $\mu g/m^3$) – originating over the land. This trend was also evident from the DEC monitoring over 1998 to 2000. The DEC data (DoE 2004, Figure 4.7) indicated that background PM10 from the ocean was nearly 20 $\mu g/m^3$, which was higher than background PM10 from the land (up to 10 $\mu g/m^3$).

4. ESTIMATING PI'S CONTRIBUTION TO 24-HOUR AVERAGE PM10 CONCENTRATIONS AT AMBIENT MONITORS

In order to fairly evaluate the impact of PI's operations and PI's dust control performance against targets, estimates must be made of PI's contribution to the measured ambient particle levels without contributions from background and other dust sources. This is also required for assessing the predictive performance of the dispersion modelling of dust from PI's sources against measured ambient data.

The bearings of the PI operations to the ambient monitors are shown in Table 10.

Table 10 Bearings of Pilbara Iron operations to ambient monitoring sites at Dampier

Source	Wind direction bearing from (°)			
	DPS monitoring site	Boat Jetty monitoring site	PP Admin Building monitoring site	King Bay monitoring site[(b)]
Ocean ("background")	305 - 18	338 - 30	275 - 329	249 - 0
PP operational area	18 - 59	30 - 57	329 - 59	198 – 249[(a)]
Land ("background")	59 - 201	57 - 152	59 - 223	0 - 198
EII operational area including 5E Conveyor and Road	201 - 305	152 - 338	223 - 275	-

[(a)] Includes EII operational area.
[(b)] Bearings actually used to determine PI contribution was 180 – 360 deg due to noisy wind direction measurements.

The PI operations areas are within a few kilometres of the monitors. It is therefore reasonable to assume that dust levels measured while winds are within the arcs shown in Table 10 originate predominantly from the respective PI operations areas, or are "background" either from the ocean or the land respectively.

The procedure for estimating PI's contribution to measured 24-hour average particle levels for performance indicator and model validation purposes[4] is that used previously for the 120 Mtpa upgrade assessment (EA 2005), as follows:

- The bearings assumed between the DPS site and the PI operational sources shown in Table 10 (above) were increased by 25° to allow for lateral plume spreading due to wind direction swings. This was based on an analysis of 10-minute average sigma thetas measured at the DPS site.
- A background concentration of 11 μg/m^3 is subtracted from the measured 10-minute average concentrations while winds are from the PI operation area arcs. (This choice for background is described in detail in the 120 Mtpa assessment). A check is also applied to ensure no single resultant 10-minute average concentration becomes negative.
- The modified 10-minute average concentrations while winds are from the PI operation area arcs are then used to calculate the 24-hour average concentrations attributed to PI sources.
- For evaluating compliance with the performance targets in the Dust Management Plan (DMP), if the weighted average concentration from all of the PI source arcs defined in Table 10 exceeds 50% and other atypical background sources (eg wildfire smoke, dust storms) can be discounted as significant contributors, PI records that its operations significantly contributed to that exceedence.

[4] TEOM negative dust concentrations: Unfortunately, this source identification routine can still lead to anomalous results when the TEOM records negative dust concentrations. For the processing of TEOM data, negative 10-minute average concentrations are limited to –50 μg/m^3. It is understood that this is consistent with the DEC's treatment of such data from TEOMs. In the calculation of longer term average concentrations, the negative TEOM data are probably legitimate data. However, when TEOM data are used for short-term investigations, such as daily PI contribution to measured ambient dust levels, the negative concentrations can lead to probably erroneous results (eg an EII contribution could be 10 μg/m^3 and PP contribution could be –10 μg/m^3 both over 1 hour, therefore the average PI contribution is calculated as zero). It would be possible for such analyses to limit negative concentrations to zero, however this ultimately leads to inconsistencies between the longer term calculated average concentrations from short time-scale analyses compared to those directly from longer time-scale analyses. (For example, the sum of the PI contributions and background derived from the short time-scale analysis does not equal the total concentration derived directly from the measured ambient data over a longer time-scale). At this stage, it has been decided to preserve the consistency of calculated results even if occasionally, the short time-scale analysis of the data for source reconciliation purposes may give erroneous results.

Table 11 Exceedences of [PM10] target at DPS

Year	Date	As measured		Estimated PI contribution using revised method		
		[PM10] 24h ($\mu g/m^3$)	**Total number of [PM10], 24 hr > 50 $\mu g/m^3$ for year**	**[PM10] 24h from PI ($\mu g/m^3$)**	**% of measured [PM10]**	**Number of times PI contribution > 50% of measured (PI DMP)**
2000	26/07/00	122	10	1	1	8
	11/09/00	62		37	**61**	
	20/10/00	75		44	**59**	
	21/10/00	62		51	**82**	
	30/11/00	59		26	45	
	5/12/00	58		44	**76**	
	6/12/00	83		52	**63**	
	7/12/00	56		33	**58**	
	8/12/00	57		41	**73**	
	21/12/00	63		42	**66**	
2001	14/02/01	59	6	0	0	4
	15/02/01	94		69	**73**	
	16/02/01	72		43	**60**	
	5/11/01	65		54	**83**	
	6/12/01	50		32	**63**	
	7/12/01	80		37	47	
2002	2/02/02	84	13	65	**77**	10
	15/02/02	56		45	**80**	
	17/03/02	110		100	**91**	
	16/09/02	53		23	43	
	17/09/02	79		28	35	
	18/09/02	52		30	**57**	
	29/09/02	53		35	**66**	
	9/10/02	53		4	8	
	23/10/02	55		42	**77**	
	19/11/02	54		43	**80**	
	10/12/02	152		124	**82**	
	18/12/02	69		43	**63**	
	19/12/02	57		38	**66**	

Year	Date	As measured		Estimated PI contribution using revised method		
		[PM10] 24h (μg/m³)	Total number of [PM10], 24 hr > 50 μg/m³ for year	[PM10] 24h from PI (μg/m³)	% of measured [PM10]	Number of times PI contribution > 50% of measured (PI DMP)
2003	8/01/03	93	14	70	**75**	8
	9/01/03	67		43	**64**	
	10/01/03	52		40	**76**	
	14/01/03	99		45	45	
	15/01/03	65		36	**56**	
	21/01/03	56		36	**64**	
	22/01/03	68		15	22	
	16/04/03	51		4	8	
	12/06/03	64		4	6	
	19/10/03	56		42	**75**	
	9/11/03	60		46	**76**	
	12/12/03	55		28	50	
	19/12/03	51		40	**78**	
	3/012/03	63		20	31	
2004	30/08/04	58	3	4	7	0
	21/11/04	57		24	42	
	21/12/04	91		41	46	
2005	31/01/05	70	4	59	**84**	3
	1/02/05	61		50	**82**	
	5/03/05	55		30	**54**	
	9/08/05	57		27	48	
2006	15/11/06	68	4	40.8	60	3
	10/12/06	54		42.1	77	
	25/12/06	82		39	47	
	26/12/06	61		35	57	

Table 12 Exceedences of [TSP] target at DPS

Year	Date	As measured		Estimated PI contribution using revised method		
		[TSP] 24h (μg/m^3))	Total number of [TSP], 24 hr > 90 μg/m^3 for year	[TSP] 24h from PI (μg/m^3)	% of measured [TSP]	Number of times PI contribution > 50% of measured (DMP PI)
2002[(a)]	16/09/02	100	6	46	46	3
	17/09/02	151		57	38	
	9/10/02	128		6	4	
	23/10/02	102		88	86	
	10/12/02	269		228	85	
	18/12/02	92		62	68	
2003	8/01/03	136	7	105	77	3
	9/01/03	98		68	69	
	14/01/03	141		63	45	
	21/01/03	96		63	66	
	22/01/03	96		27	28	
	16/04/03	133		15	11	
	12/06/03	112		7	6	
2004	30/08/04	106	3	12	11	0
	21/11/04	99		41	42	
	21/12/04	180		86	48	
2005	31/01/05	112	2	101	90	2
	9/08/05	110		57	52	
2006	25/11/06	122	3	91	74	3
	25/12/06	122		66	54	
	26/12/06	92		60	65	

[(a)] Data from 1/3/2002.

Using the method described above, an assessment of PI's dust impacts against the PM10 performance target is shown in Table 11 and against the TSP performance target in Section Table 12. This shows that PI significantly contributed to three PM10 and three TSP events during 2006.

The continuous measured data during which PM10 exceeded the 24-hour average target levels of 50 μg/m^3 at the DPS monitoring over the 1 June 2004 to 31 December 2006 period have also reviewed to assist the interpretation of contributing sources. The results are shown in Appendix 1. This more detailed review of the data supports the quantitative outcomes using the automated method, although this should probably be expected since both rely primarily on wind direction and corresponding dust concentration measurements to indicate sources. As far as can be interpreted, PI's contribution to high dust events over the 2004 to 2006 period has reduced from the preceding four years.

5. PREDICTED DUST CONCENTRATIONS FROM PROPOSED EXPANSION TO 145 MTPA

5.1 METHODOLOGY FOR PREDICTING DUST IMPACTS

The proposed upgrade will see the approved capacity of the PP operations increase from 75 Mtpa (120 Mtpa total Dampier Ports capacity) to 100 Mtpa (145 Mtpa total Dampier Ports capacity). Details of the proposed 145 Mtpa upgrade are provided in the Environmental Protection Statement (SKM 2007).

Prediction of dust impacts for the proposed increase in Port capacity to 145 Mtpa were made by estimating the changes to dust emissions compared to current operations at 95 Mtpa, then using the

CALPUFF dispersion model to predict resulting ambient concentrations using meteorological data for the 2005 year.

The reasons for comparing dust impact at 145 Mtpa to those at 95 Mtpa rather than comparing to the currently approved capacity of 120 Mtpa are:

- The general basis of the EPA's approvals for the expansions to both 95 Mtpa and 120 Mtpa is that dust impacts are not significantly increased above previous levels; and
- It would be very unreliable comparing impacts for 145 Mtpa against 120 Mtpa because both scenarios cannot be verified with ambient monitoring. Using 95 Mtpa as the basis for assessing impacts at 145 Mtpa allows the former to be verified against ambient monitoring data. This means the predicted dust impacts for 145 Mtpa can be determined as the difference above the existing, "known" level of impacts.

The derivation of the dust emission estimates for each PI source at EII and PP is described in detail in EA (2007a).

The dispersion model set-up and assessment of model performance at 95 Mtpa throughput is described in detail in EA (2007b).

The main indicators used to assess the change to dust levels for the proposed expansion are:

- the 6^{th} highest 24-hour PM10 concentrations. The NEPM goal requires this to be less than 50 $\mu g/m^3$;
- the 6^{th} highest 24-hour TSP concentrations. Using the Kwinana EPP as a guide, reasonable goals may be for this not to exceed 90 $\mu g/m^3$ [5] at Dampier and 150 $\mu g/m^3$ [6] at King Bay; and
- the average PM10 and TSP concentrations.

This section describes the results of the dispersion modelling using the above indicators.

5.2 MONITORING SITES

A summary of the impacts of the proposed expansion at the DPS and King Bay monitoring sites is shown in Table 13.

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[5] That is, interpreting the 90 $\mu g/m^3$ Kwinana Area C (residential) TSP standard which is "desirable not be exceeded" as the 6^{th} highest 24-hour average.

[6] That is, interpreting the 150 $\mu g/m^3$ Kwinana Area A (industrial) TSP standard which is "desirable not be exceeded" as the 6^{th} highest 24-hour average.

Table 13 Summary of changes in dust levels for proposed upgrade

Location	Parameter	Criterion	Concentration (μg/m³) 95 Mtpa: Contribution from PI (All days[d])	95 Mtpa: Background and other sources	95 Mtpa: Total	145 Mtpa: Contribution from PI (All days[d])	145 Mtpa: Background and other sources	145 Mtpa: Total	Change in Totals from 95 Mtpa to 145 Mtpa: Relative[b] (%)	Change in Totals from 95 Mtpa to 145 Mtpa: Absolute [c] (μg/m³)
Dampier township (DPS site)	**6th highest 24-hr avg [PM10]**	**50**	22.5	24.6	**47.1**	23.0	24.6	**47.6**	1.0	0.5
	Annual avg [PM10]	**-**	6.8	15.5	22.3	5.6	15.5	21.1	-5.7	-1.3
	6th highest 24-hr avg [TSP]	**90**	32.6	44.1	**76.7**	29.2	44.1	**73.3**	-4.4	-3.4
	Annual avg [TSP]	**-**	10.0	19.5	29.5	8.1	19.5	27.6	-6.4	-1.9
	6th highest 24-hr avg [PM2.5]	**25**	10.6	7.9	**18.5**	11.6	7.9	**19.6**	5.7	1.1
	Ann avg [PM2.5]	**8**	3.0	4.5	**7.6**	2.5	4.5	**7.1**	-6.5	-0.5
King Bay (monitor site)	**6th highest 24-hr avg [PM10]**	**-**	30.4	12.8	43.2	57.1	12.8	69.9	61.9	26.7
	Annual avg [PM10]	**-**	8.6	9.2	17.8	15.0	9.2	24.3	36.3	6.5
	6th highest 24-hr avg [TSP]	**150**	49.6	23.0	**72.5**	84.7	23.0	**107.7**	48.4	35.1
	Annual avg [TSP]	**-**	12.5	11.6	24.1	21.7	11.6	33.3	38.1	9.2
Location	**Parameter**	**Criterion**	**Deposition (g/m²/month)**						**Relative (%)**	**Absolute (g/m²/month)**
Dampier township (DPS site)	**Annual average**	**2**[a]	0.46	-	-	0.34	-	-	-26	-0.12
	Maximum monthly	**-**	0.91	-	-	0.54	-	-	-41	-0.37

[a] Criterion for additional insoluble deposited dust from PI operations only – ie. excluding background.
[b] Calculated from (Total_145 / Total_95 x 100) - 100
[c] Calculated from Total_145 -Total_95.
[d] Note that the "Contribution from PI (All days)" is the modelled/predicted contribution from modelling all days in the 2005 year.

"Background" levels in this Table were estimated by comparing the predicted concentrations for 95 Mtpa to the measured concentrations for 2005 at the monitoring sites for the days during which the monitoring data was actually available. The "background" levels are actually the difference between:

- the measured concentration, which included contributions from regional background and localised sources near the monitor, and
- the modelled/predicted concentration, which are from PI operations only,

for each ranked pair of measured and modelled/predicted 24-hour average concentrations – or for the measured and modelled/predicted annual average concentrations, as relevant to the concentration statistic (percentile or annual average) being compared.

A reason for using this approach is that the highest dust levels may occur on windy days when background dust levels may also increase along with PI's contribution to ambient dust levels. If, for 145 Mtpa, a constant "average" background dust level was added to PI's modelled/predicted contribution for high dust-event days, it may under-estimate the total dust level.

The definition of "background" also inherently implies that the under-prediction in the modelled concentrations compared with the PI contribution to the measured concentrations that was estimated from the monitoring data as described in the modelling verification report (EA 2007b), is less likely to compromise the validity of the modelled predictions for 145 Mtpa.

For parameters where there was substantially less than a full year's monitoring data available[7], the 6th highest 24-hour average concentrations could be underestimated because the days during which the highest dust impacts occurred may not have been measured. To try and minimise the effect of this problem, the (modelled) "Contributions from PI (All days)" are for all days in the year and the "Total concentrations" are the addition of this modelled concentration and the "background" concentration as described above. The 6th highest "Total concentration" is therefore the best estimate of the 6th highest concentration that may have occurred during the year irrespective of the number of days in the year the monitoring was actually working.

Further details in the predicted change in the highest PM10 concentrations is given in Table 14 which shows the top six 24-hour average concentrations for 95 Mtpa and 145 Mtpa. For 95 Mtpa, the NEPM 24-hour average concentration of 50 $\mu g/m^3$ was exceeded four times in the year. For 145 Mtpa, this concentration is predicted also to be exceeded four times per year (when background concentrations are also considered).

[7] For King Bay, there were only 111 days of measured PM10 data for 2005. Similarly for PM2.5 measured at the DPS where only 53 days of data were available. It is possible that the 6th highest background concentrations are under-estimated because less than a full year's data are available.

Table 14 Change in top 24-hour average PM10 concentrations at DPS site

Rank	24-hour average PM10 concentration over 2005 year ($\mu g/m^3$)					
	95 Mtpa			145 Mta		
	As measured by TEOM	As modelled/ predicted for 95 Mtpa from PI	"Background" (ie difference between modelled/ predicted from PI, and measured)	"Background" - as for 95 Mtpa	As modelled/ predicted for 145 Mtpa from PI	Total modelled/ predicted for 145 Mtpa
1st	69.6	31.0	38.6	38.6	26.8	65.4
2nd	60.9	30.1	30.8	30.8	25.5	56.3
3rd	56.9	28.4	28.5	28.5	25.4	53.9
4th	55.1	24.6	30.5	30.5	24.5	55.0
5th	48.0	24.3	23.7	23.7	23.9	47.6
6th (NEPM reference)	**47.1**	**22.5**	**24.6**	**24.6**	**23.0**	**47.6**

The distribution of predicted 24-hour average concentrations at DPS over a full year is shown in Figure 11. In this plot, the 24-hour average concentrations predicted for 145 Mtpa ordered from highest to lowest are plotted against the 24-hour average concentrations predicted for 95 Mtpa ordered from highest to lowest. This illustrates that for 145 Mtpa, most 24-hour average concentrations are less than for 95 Mtpa except for the top seven days of PM10.

5.3 SOURCE CONTRIBUTIONS

5.3.1 Highest 24-hour average concentrations

The contributions of each source to the predicted top six 24-hour PM10 concentrations at the DPS for 95 Mtpa are shown in Figure 12 to Figure 17. These indicate that EII sources are the dominant contributors to all of these events.

The contributions of each source to the predicted top six 24-hour PM10 concentrations at the DPS for 145 Mtpa are shown in Figure 18 to Figure 23. These indicate that PP sources are the dominant contributors to the top event with either EII or PP sources, or a combination of the two being the dominant contributors for the 2nd to 6th highest events.

The dispersion-related issue that has arisen with the proposed increased throughput at PP is:

- There are now more activity sources emitting at night-time due to the increased utilisation of these sources. To some extent, this includes PP bulking which was assumed to occur only during day-time for 95 Mtpa whereas for 145 Mtpa, bulking starts to also occur during the night-time.
- The trajectory from PP operations to Dampier is across land. During night-time, stable atmospheric conditions lead to less dispersion than would otherwise occur during the daytime.
- Consequently, night-time impacts at Dampier from activity-generated dust at PP has increased for 145 Mtpa.

The change in the 6th highest 24-hour average concentrations for 145 Mtpa is probably over-estimated for several reasons:

- As described in the source emissions estimation report (EA 2007a), for 145 Mtpa, the operating profiles for the CD3P/SL2P and CD4P/SL3P circuits were assumed to be synchronous. This is probably unrealistic and will over-estimate the maximum emissions from the PP operational area, and consequently the highest predicted dust levels where PP sources contribute.
- For the DPS site and the Dampier township region, the estimation of "background" concentrations at 95 Mtpa inherently includes the modelling prediction "shortfall" - in addition to true background contributions. The shortfall component is indicated in the assessment of modelling performance report (EA 2007b) and is thought to be due to the underestimation of the EII emissions for 95 Mtpa throughput. No such similar underestimation of PP emissions was, however, identified, since the model's predictions at King Bay (for 95 Mtpa) were good. The inclusion of the shortfall component in the "background" for relatively high dust events where PP sources dominate will lead to an overestimation of concentrations.
- If the modelling underprediction at the DPS site for 95 Mtpa is due to EII sources, for which improvements are to be implemented for 145 Mtpa, then the benefit of those improvements at 145 Mtpa would also be underestimated.

5.3.2 Average concentrations

The source contributions to the annual average PM10 concentrations at DPS for 95 Mtpa and 145 Mtpa are shown in Figure 24. There are obvious reduction in dust contributions from the 5E conveyor/road and EII live stockpiles. The sources contributing most to increased average dust levels are PP reclaiming and PP bulking.

5.4 CONTOUR PLOTS

Contours of the modelling predictions with some brief comments on the results are given as follows:

PM10 concentrations

- Figure 25 Predicted 6th highest 24-hour average PM10 concentrations for 95 Mtpa from PI sources
- Figure 26 Predicted 6th highest 24-hour average PM10 concentrations for 145 Mtpa from PI sources

  The comparison between the above two Figures indicates changes in dust levels caused by PI's operations.
- Figure 27 Predicted 6th highest 24-hour average PM10 concentrations for 95 Mtpa including background
- Figure 28 Predicted 6th highest 24-hour average PM10 concentrations for 145 Mtpa including backgroundFigure 28 Predicted 6th highest 24-hour average PM10 concentrations for 145 Mtpa including background

  This Figure shows that the NEPM criterion of 50 μg/m^3 is exceeded on the coastal and northern parts of the Dampier township, but met elsewhere.

TSP concentrations

- Figure 29 Predicted 6th highest 24-hour average TSP concentrations for 95 Mtpa from PI sources
- Figure 30 Predicted 6th highest 24-hour average TSP concentrations for 145 Mtpa from PI sources
- Figure 31 Predicted 6th highest 24-hour average TSP concentrations for 95 Mtpa including background

- Figure 32 Predicted 6th highest 24-hour average TSP concentrations for 145 Mtpa including background

  This Figure shows that the Kwinana EPP criterion of 90 μg/m^3 is predicted to be met within most of the Dampier township except for the northern-most portion.

- Figure 33 Predicted annual average TSP concentrations for 95 Mtpa from PI sources
- Figure 34 Predicted annual average TSP concentrations for 145 Mtpa from PI sources

PM2.5 concentrations

- Figure 35 Predicted 6th highest 24-hour average PM2.5 concentrations for 95 Mtpa from PI sources
- Figure 36 Predicted 6th highest 24-hour average PM2.5 concentrations for 145 Mtpa from PI sources
- Figure 37 Predicted annual average PM2.5 concentrations for 95 Mtpa from PI sources
- Figure 38 Predicted annual average PM2.5 concentrations for 145 Mtpa from PI sources

Deposition

- Figure 39 Predicted average dust dry deposition for 95 Mtpa from PI sources
- Figure 40 Predicted average dust dry deposition for 145 Mtpa from PI sources
- Figure 41 Predicted maximum monthly dust dry deposition for 95 Mtpa from PI sources
- Figure 42 Predicted maximum monthly dust dry deposition for 145 Mtpa from PI sources

5.5 SUMMARY

5.5.1 Dampier

For the key criteria used to assess dust impacts – which for concentrations include contributions from background and other sources, the predictions for the proposed throughput at 145 Mtpa are as follows:

- The NEPM 6th highest 24-hour PM10 concentration goal of 50 μg/m^3 is predicted to be met at the DPS site although exceeded in the northern part of the Dampier township. This is similar to the present situation.
- Similarly, the Kwinana EPP residential 6th highest 24-hour TSP concentration of 90 μg/m^3 is predicted to be met at the DPS although exceeded in the northern part of the Dampier township. This is similar to the present situation.
- The predicted average dust deposition in the Dampier township for both 95 and 145 Mtpa is within NSW dust deposition criterion of 2 g/m^2/month with a 26% reduction being predicted for 145 Mtpa.
- The maximum monthly dust deposition for both 95 and 145 Mtpa exceeds the NSW dust deposition criterion in the northern-most part of the Dampier township, however it is slightly reduced for 145 Mtpa.

In summary, the predicted changes to Dampier's dust levels from the increased throughput to 145 Mtpa are minor compared to the existing situation and most likely within the bounds of emissions estimation and modelling uncertainties.

5.5.2 King Bay

King Bay is an industrial area and therefore considered less sensitive to dust levels than the Dampier township.

From Table 13, the Kwinana EPP industrial 6th highest 24-hour TSP concentration of 150 $\mu g/m^3$, is predicted to be met at the King Bay monitoring site with a reasonable margin. Note that the contour plot in Figure 32 shows higher concentrations than this, but this is because the higher DPS "background" of 44.1 $\mu g/m^3$ has been included, which is more relevant for Dampier rather than a "background" of 23.0 $\mu g/m^3$ which would have been more appropriate for King Bay.

The predicted increases in dust levels at King Bay are more extreme than for the Dampier township because of the substantial measures to reduce dust emissions from EII which mostly benefit Dampier and the fewer such measures that can be practically implemented at PP designed to reduce impacts at King Bay.

6. PROPOSED ADDITIONAL AMBIENT DUST MONITORING

Continuous ambient monitoring is the best way to determine actual levels of dust at sensitive locations. The extent of the ambient monitoring network at Dampier has been progressively upgraded over the last three years and will continued to be upgraded for the 145 Mtpa capacity increase:

- The PM10 TEOM at the DPS will be fitted with a Filter Dynamics measurement System (FDMS) inlet with the objective of reducing the artefacts in the measurements associated with sea salt spray and humidity changes.
- Three additional PM10 TEOM stations will be installed in Dampier during 2007.
- The service intervals of the E-BAMs at the Marine Shed ("Boat Jetty") and King Bay sites will be upgraded to monthly to improve reliability and data recovery. (Note that the PP Admin Building EBAM has been decommissioned).
- Nine E-scans (nepholometry-based dust monitors) will be commissioned. These have been specially designed for PI's requirements with a solar power supply and built onto a portable (3.6 tonne) concrete base to permit significant flexibility in location selection. At least three of these units will be located in PI's EII and PP operational areas with alarms to indicate elevated dust levels. The remaining units will be located throughout Dampier and elsewhere with their locations to be determined following community input.
- The continuous dust monitors will continue to be supported by the dust deposition bottle and gloss monitoring networks.

7. OVERVIEW AND RECOMMENDATIONS

The proposed upgrade of the Dampier Port operations entails considerable increases in dust emissions from PP and at the same time, decreases of emissions from key EII sources due to the inclusion of substantial dust controls. These include covering of the 5E conveyor and using a dust suppressant on the EII live stockpiles ridges when finished off. It is considered that these types of measures are approaching the best that can be realistically achieved without "step changes' in the nature of the operation.

There is an increasing emphasis for the 145 Mtpa upgrade on controlling dust emissions through management processes – that is, the implementation of additional source controls to prevent dust impacts specifically at Dampier. These entail a more efficient use of water since it is used only when really needed, but have the potential disadvantages of:

- being based on manual interventions – for example, for sealing of roads to be effective, the roads must be regularly cleaned of dust which accumulates from nearby sources (ie occur before the onset and windy conditions); and
- implying an acceptance of higher visual dust emissions when winds are away from sensitive areas.

The assessment of ambient dust impacts from the proposed upgrade to 145 Mtpa has been undertaken through a dispersion modelling study. Uncertainties in various aspects of modelling have been noted. It is considered that estimates of dust emissions remains the largest area of uncertainty. These include uncertainties in the physics underlying emissions, underlying emissions parameters (source height/areas, operating frequencies, ore dustiness etc) and the effectiveness of proposed control options. This does not imply that predictions of dust impacts are necessarily under-estimated. Numerous ongoing "minor" dust control improvement measures were considered too difficult to quantify and therefore have not included in the modelling.

The general predictions from the modelling work for this proposal are:

- a reduction in average dust concentrations and deposition in the Dampier township;
- no change to the highest 24-hour average dust levels although an increasing contribution to these from PP operations rather than EII operations; and
- the northern portion of the Dampier township being subject to relatively higher dust levels than the southern portions (ie higher gradient of change from south-to-north) due to the former's closer proximity to PP and higher prevailing wind direction frequencies from EII.

The role of expanding the ambient monitoring network to include a monitor in the northern Dampier township area is critical to the demonstration that dust impacts from this proposal are acceptable. PI have recognised that the past reliability of parts of the ambient dust monitoring network has been poor and are implementing monthly servicing to rectify this.

A further improvement would be to establish data collection and management systems that provide an audit trail of the implementation of dust controls leading to publicly reported performance indicators. Examples could be:

- records of application times and volumes of water/suppressants used at the various water application stations (PIs: water application rate per unit surface area or tonne of ore); and
- GPS and water useage tracking of water trucks (PIs: roads surface area treated per hour; average water application rate per unit area).

Apart from demonstrating adequate dust control, such systems can provide valuable data for the optimisation of water usage.

It is understood that process control systems associated with the Port upgrade include improved water usage data collection.

As a part of PI's Dust Management Plan, the causes of high dust events are investigated. The outcome of these investigations and/or specific actions resulting from them does not appear to be reported externally. This process may occur in a general sense as the Dust Management Plan is regularly reviewed, however it would be more desirable to specifically document and report actions resulting from the investigation of each event.

The apparent lack of accurate record keeping of the timing of bulking activities is difficult to understand given that this activity has consistently been identified as a significant dust source. If the causes of high dust events as indicated from ambient monitoring, are to be properly investigated, better records of bulking activities are essential.

Some years ago, PI investigated – but did not proceed with, the use of continuous photography to provide a visual record of dust events. The technology has improved considerably since then and it would be worthwhile establishing some kind of visual dust surveillance system. This can be an invaluable aid for investigating the causes of high dust events.

On a strategic level, the largest potential dust control improvement is considered to be through the addition of adequate moisture to the ores prior to leaving the minesites. The rotating drum tests have shown that even the dustiest ores can be handled with minimal dust generation if moisture is maintained at greater than the Dust Extinction Moisture level.

Other strategic dust control improvements could include:

- reducing or eliminating ore bulking;
- direct ship-loading from the car-dumpers – the practicality of which would be enhanced if off-site ore blending was possible;
- clean-ups or stabilisation of areas adjacent to sources where fine dust deposits during light winds but is lifted off during subsequent stronger winds;
- wind shielding of dusty sources; and
- perimeter tree areas to enhance dust deposition.

It is considered that the results of the modelling in-as-much as marginal changes in dust concentrations at Dampier are predicted, should be interpreted as “prima facie” evidence that dust from the 145 Mtpa upgrade can be managed to acceptable levels if:

- the anticipated/quantified emission benefits from dust control improvements are realised; and
- protective and reactive strategies to reduce dust impacts continue to be developed.

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9. 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

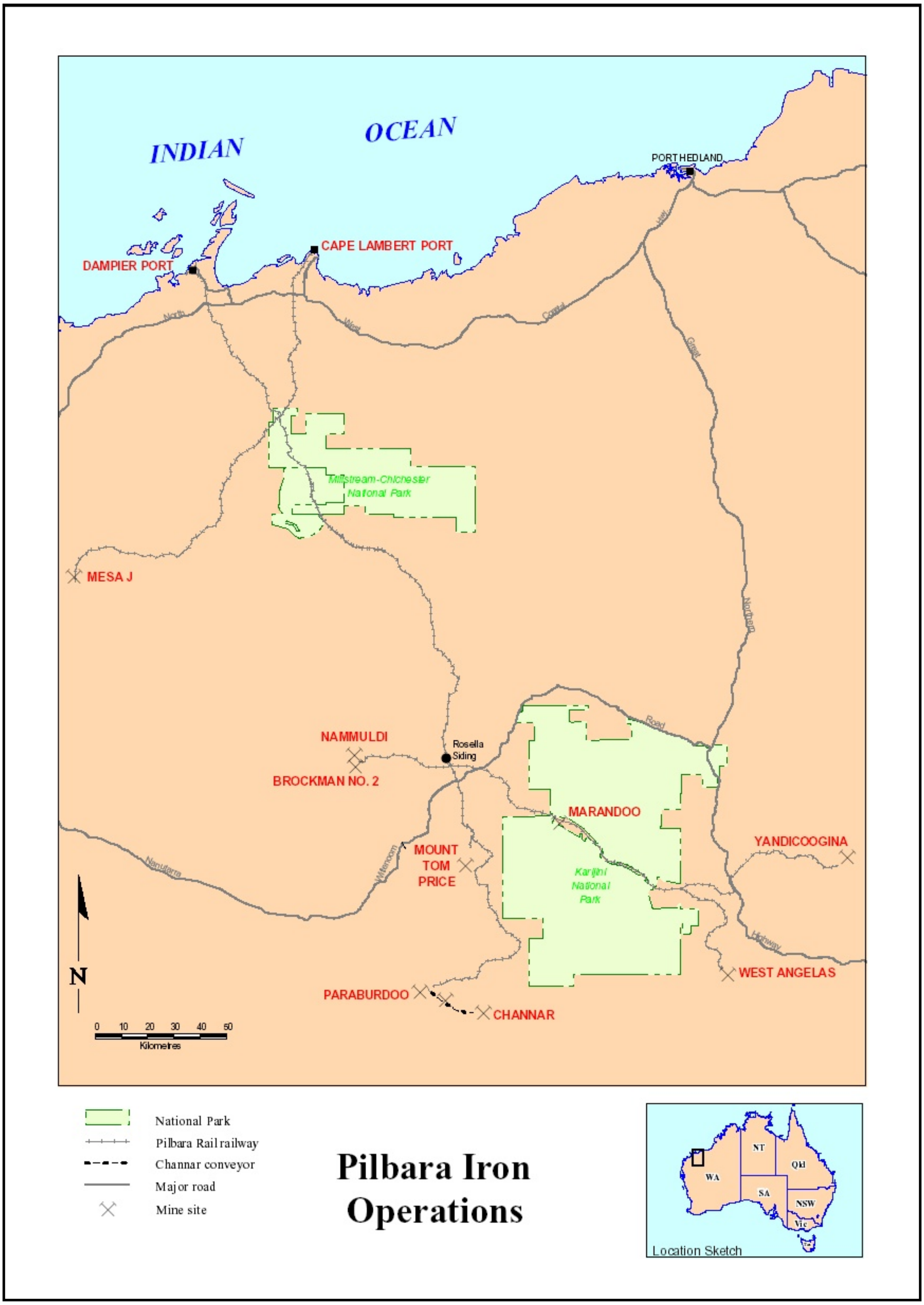


Figure 1 Location of Pilbara Iron mining operations in Western Australia

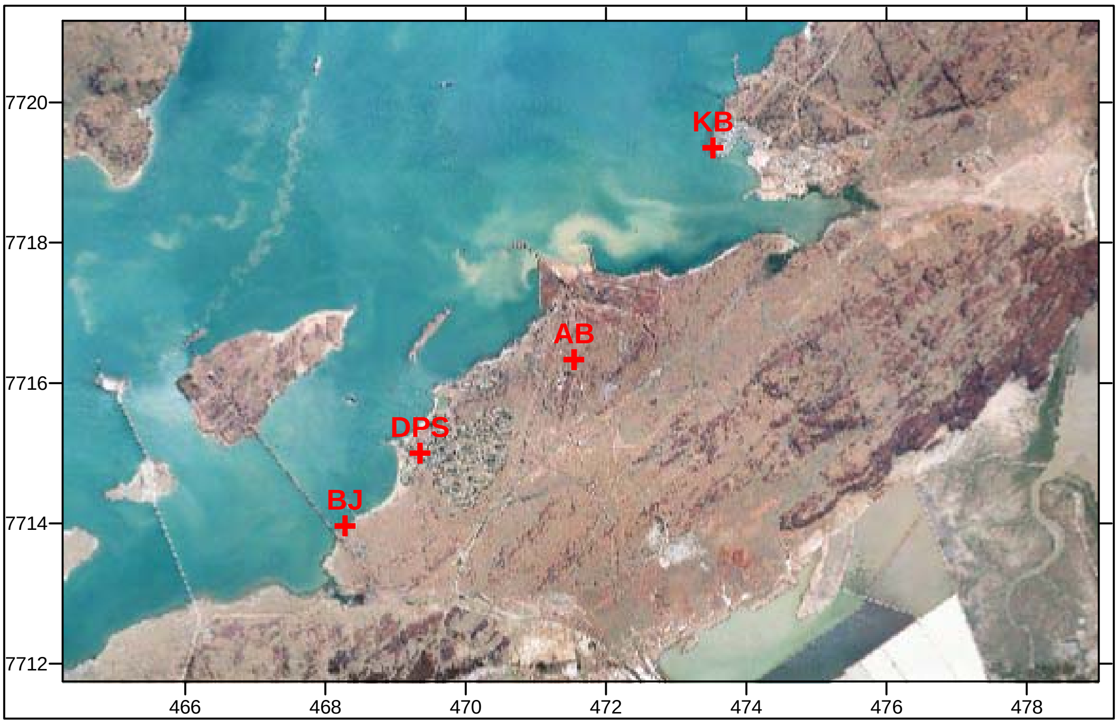


Figure 2 Locations of current dust and meteorological monitoring network at Dampier

(SKM PP offices and Karratha monitoring site not shown).

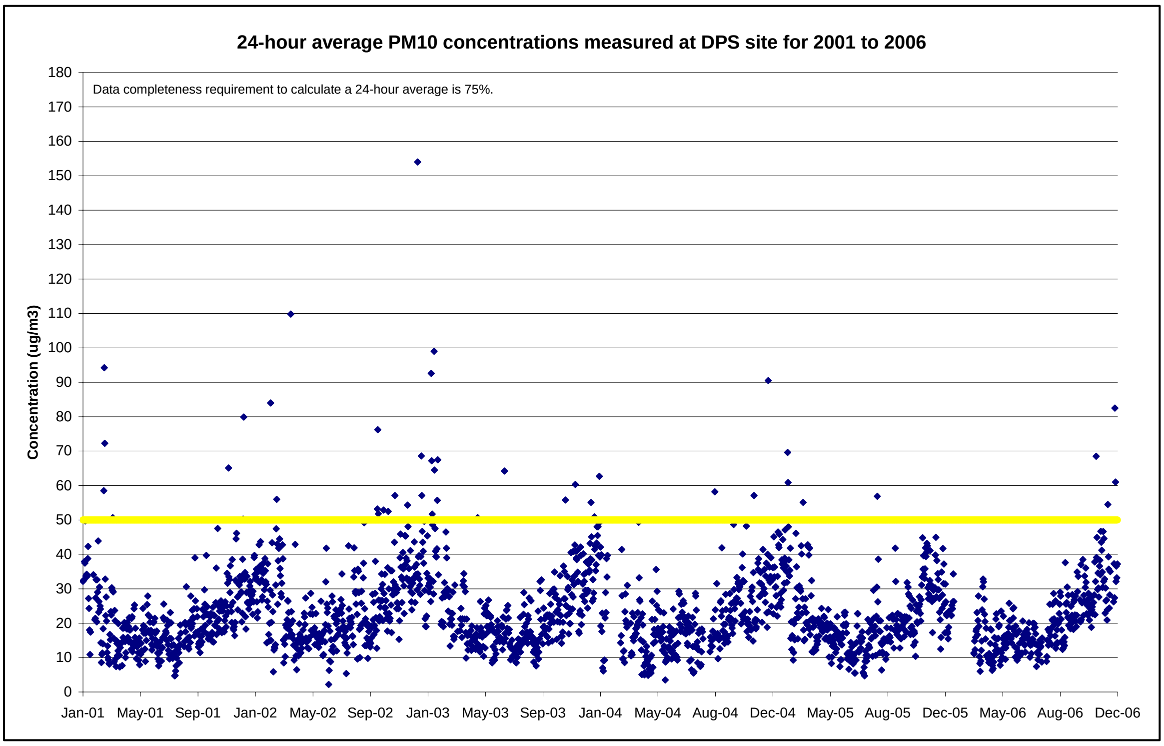


Figure 3 24-hour average PM10 concentrations measured at DPS site for 2001-06

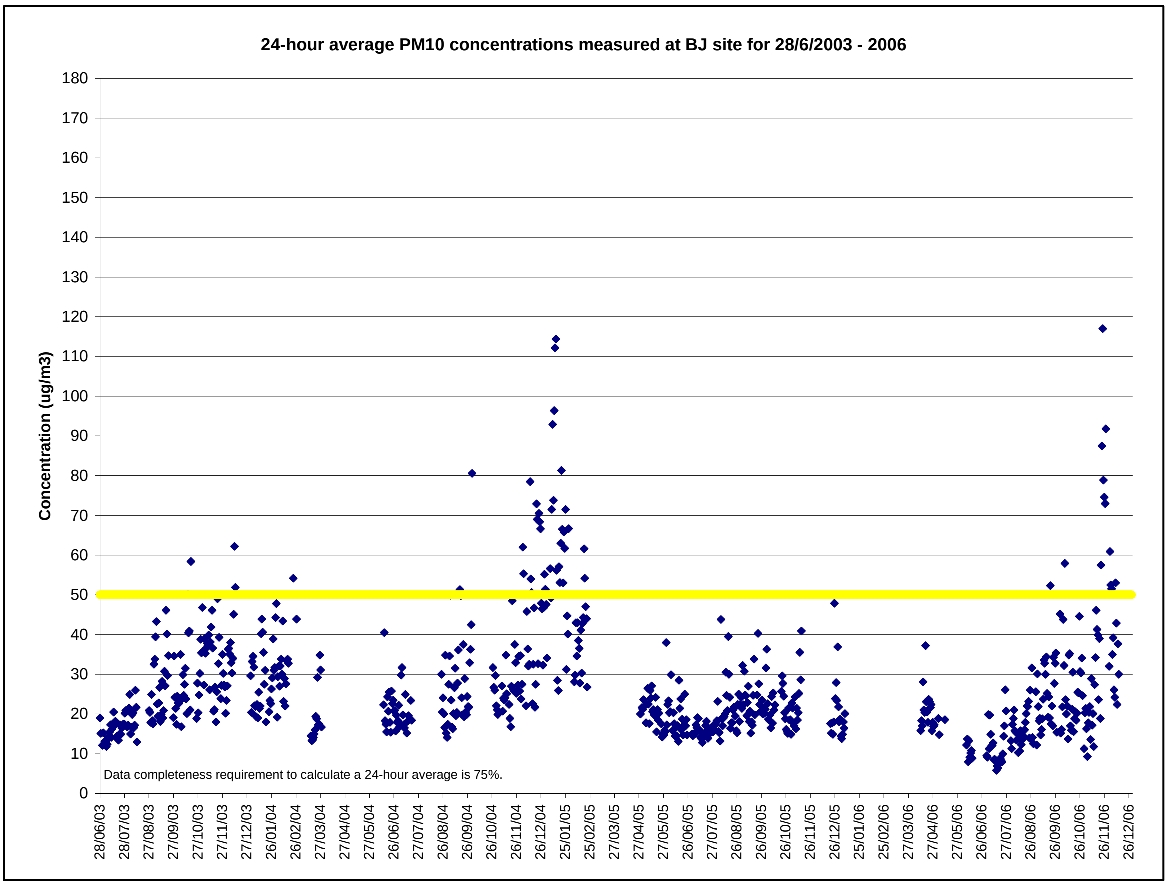


Figure 4 24-hour average PM10 concentrations measured at BJ site for 2003-06

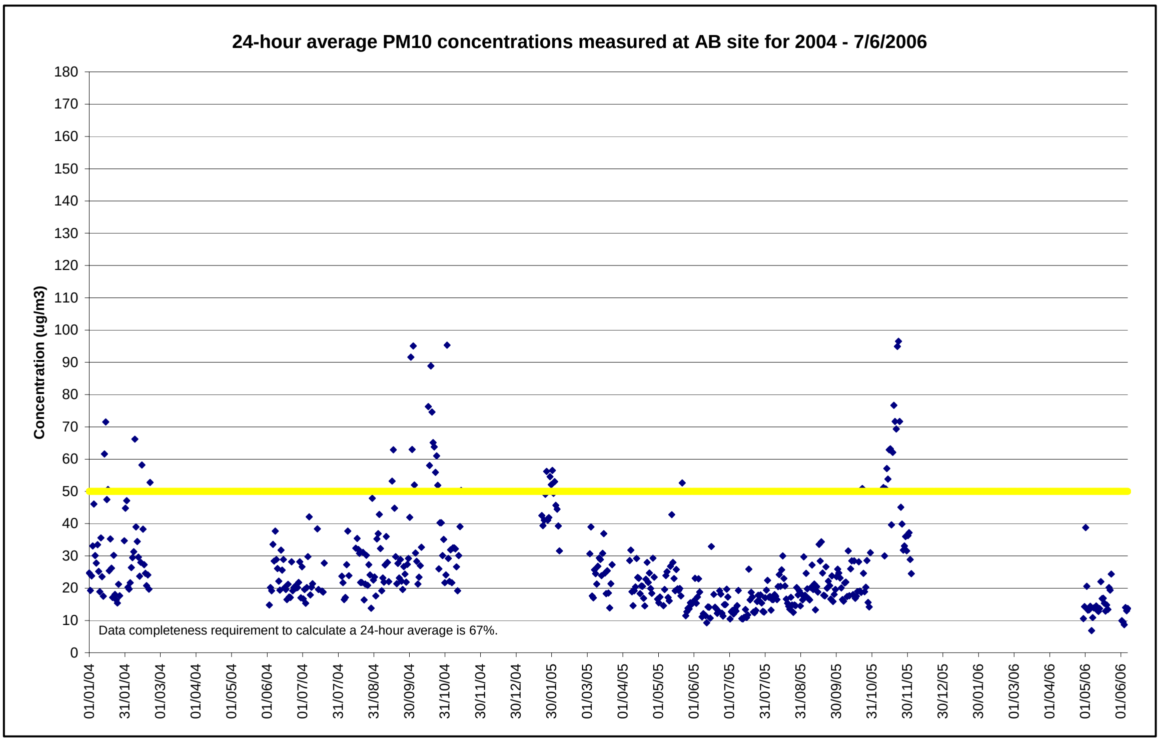


Figure 5 24-hour average PM10 concentrations measured at AB site for 2004-06

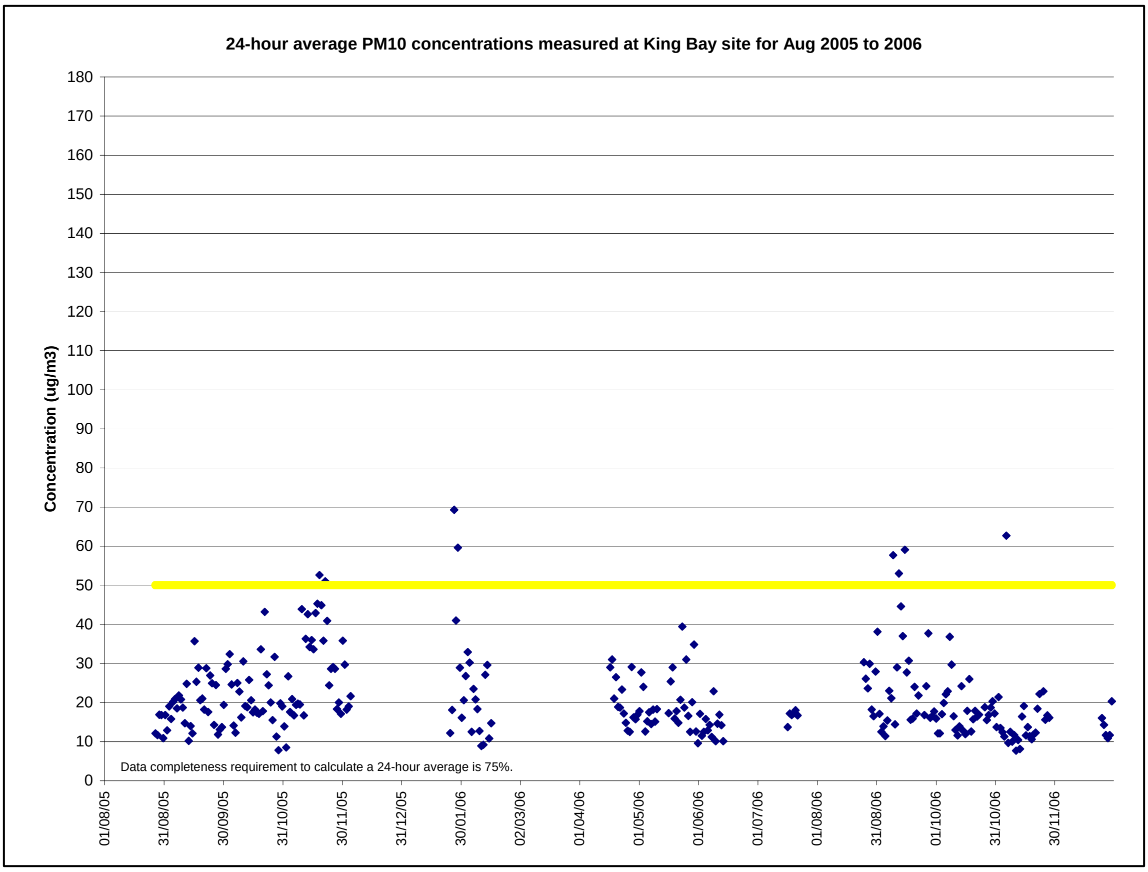


Figure 6 24-hour average PM10 concentrations measured at King Bay site for 2005-06

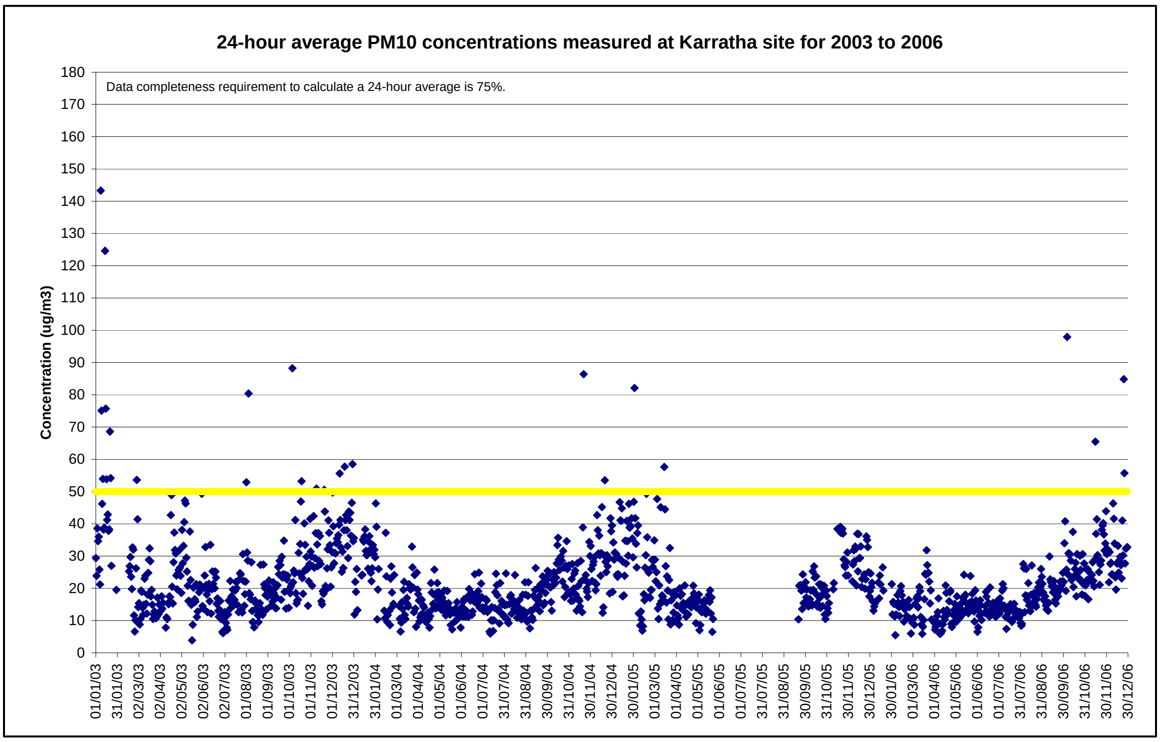


Figure 7 24-hour average PM10 concentrations measured at Karratha site for 2003-06

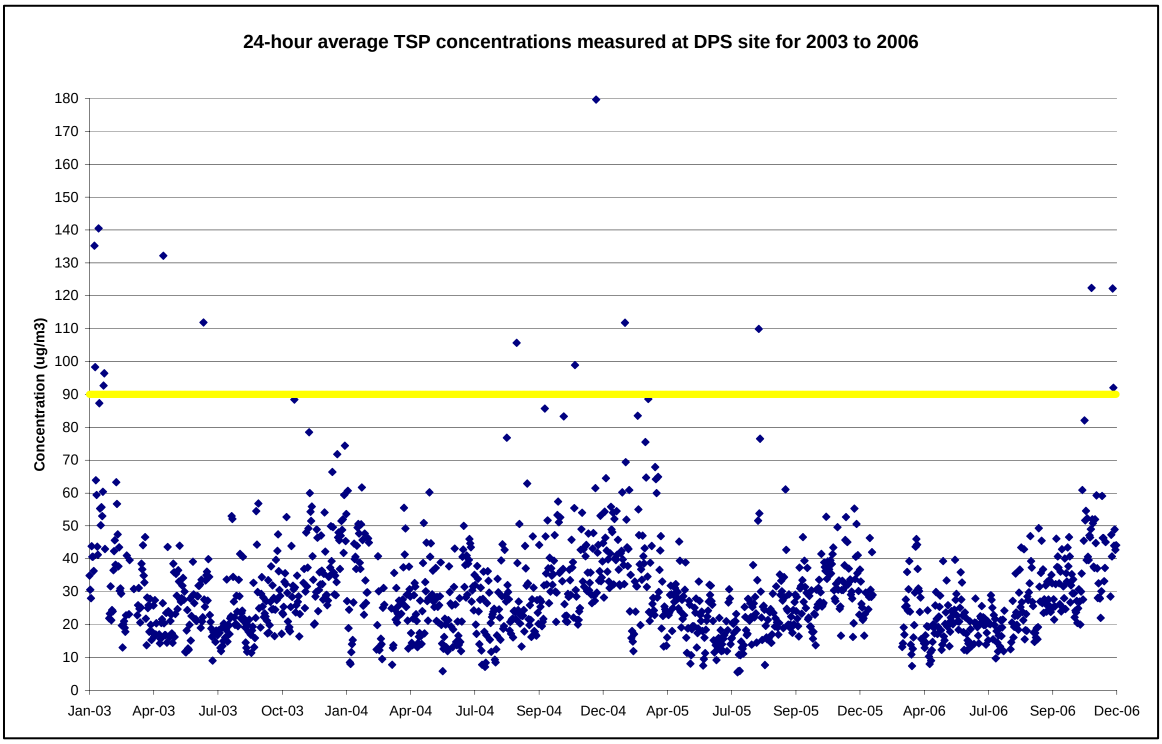


Figure 8 24-hour average Total Suspended Particulate concentrations measured at DPS site for 2003-06

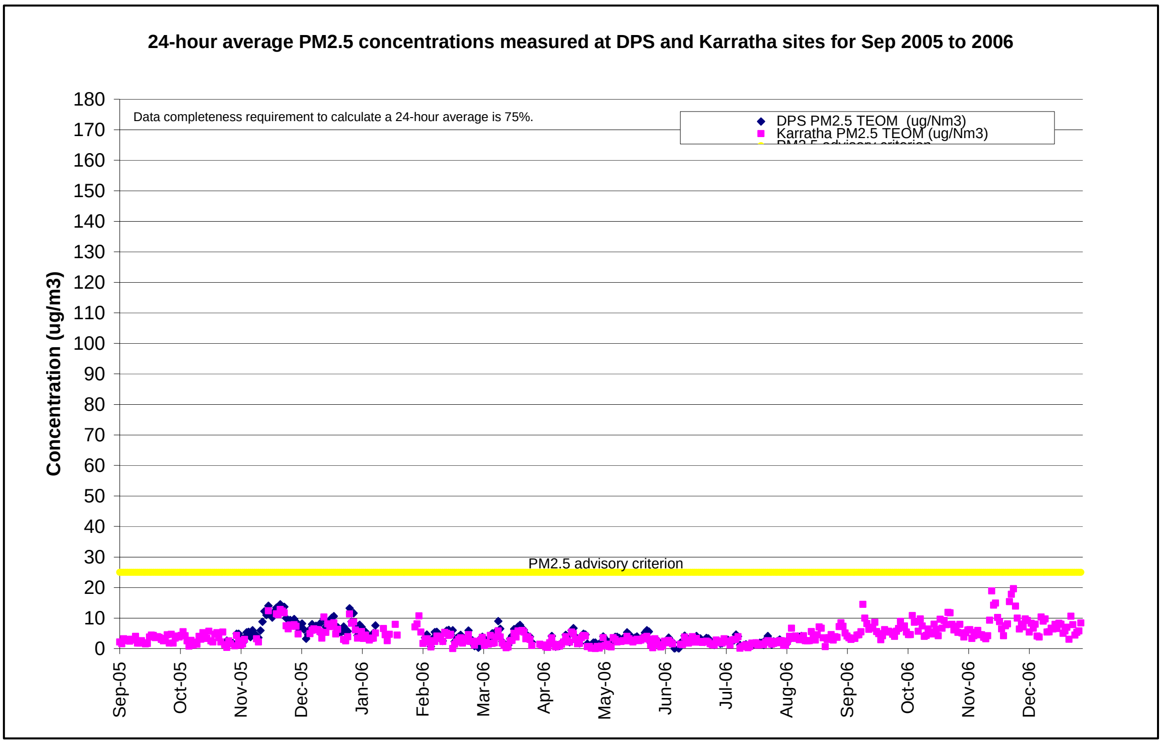


Figure 9 24-hour average PM2.5 concentrations measured at DPS and Karratha sites for September 2005-06

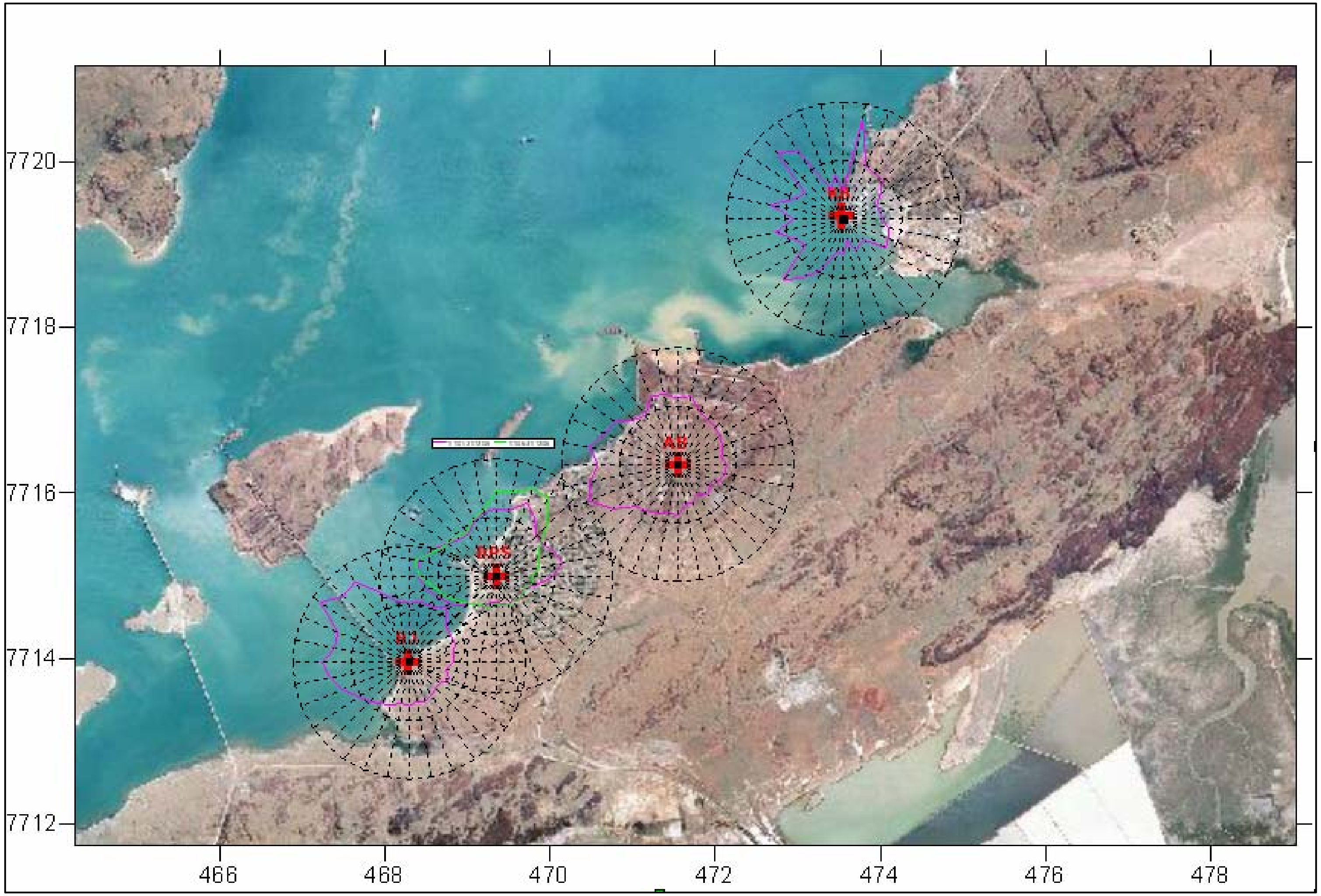


Figure 10 Polar plot of average PM10 concentrations with wind direction at BJ, DPS, AB and KB sites

Notes: Pink traces show all data (except 2006 for DPS); Green trace for DPS is for 2006 data; The radial scales are at 25 $\mu g/m^3$ and 50 $\mu g/m^3$; Wind direction data is from the respective sites of the dust measurements - this may not be representative of winds further away.

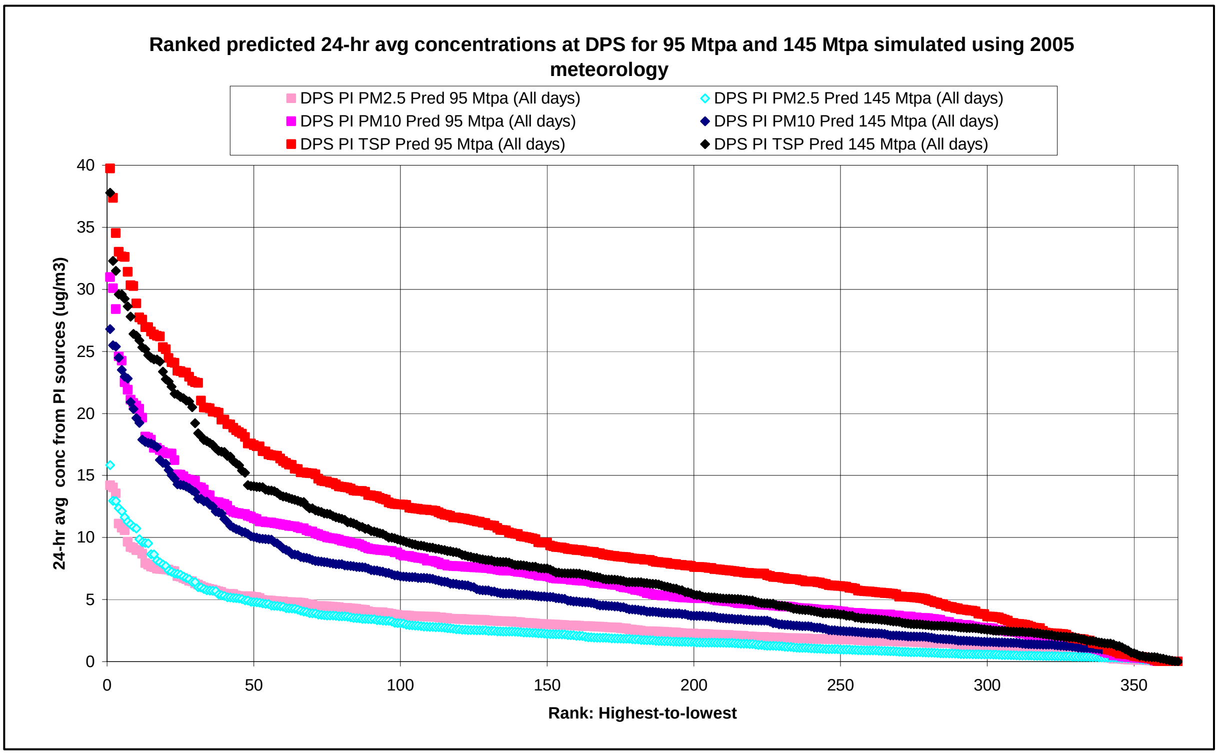


Figure 11 Ranked predicted 24-hr avg concentrations at DPS for 95 Mtpa and 145 Mtpa simulated using 2005 meteorology

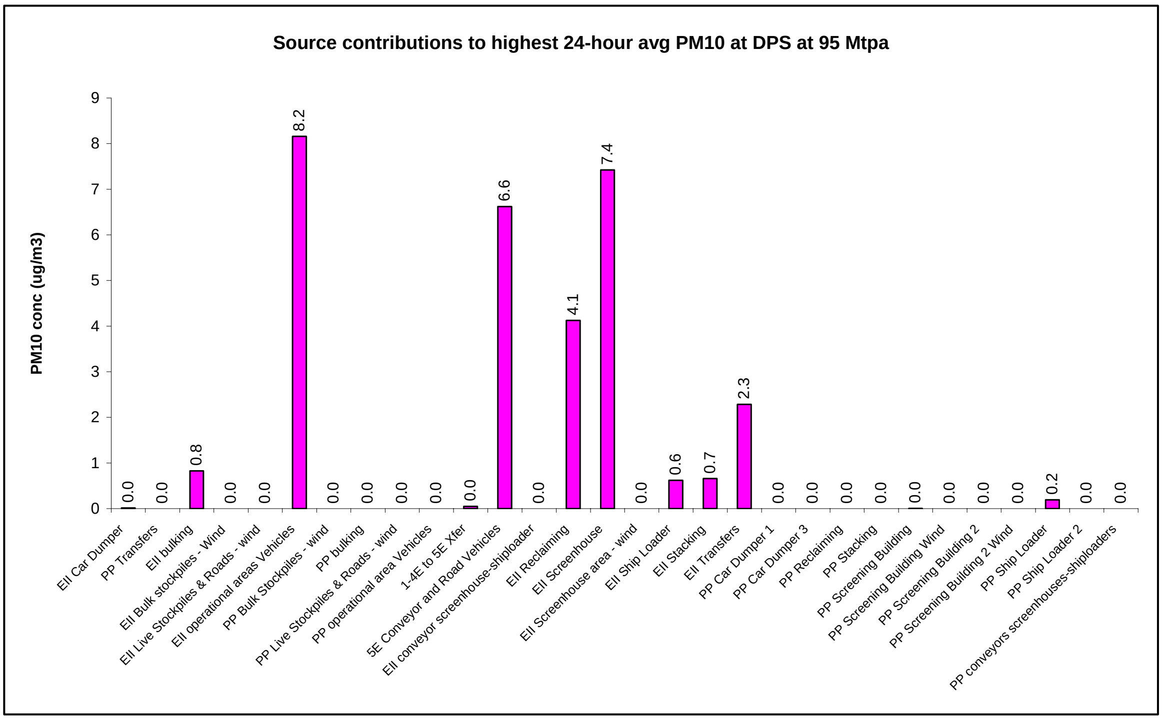


Figure 12 Source contributions to highest 24-hour average PM10 concentration at DPS for 95 Mtpa

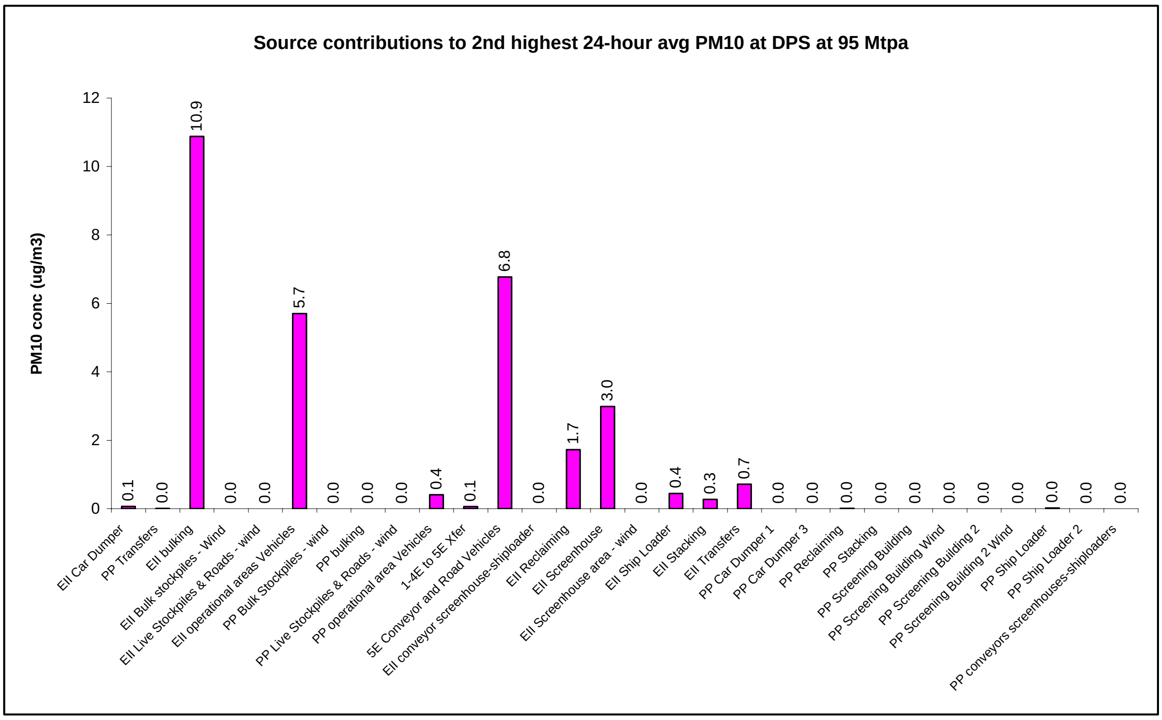


Figure 13 Source contributions to 2nd highest 24-hour average PM10 concentration at DPS for 95 Mtpa

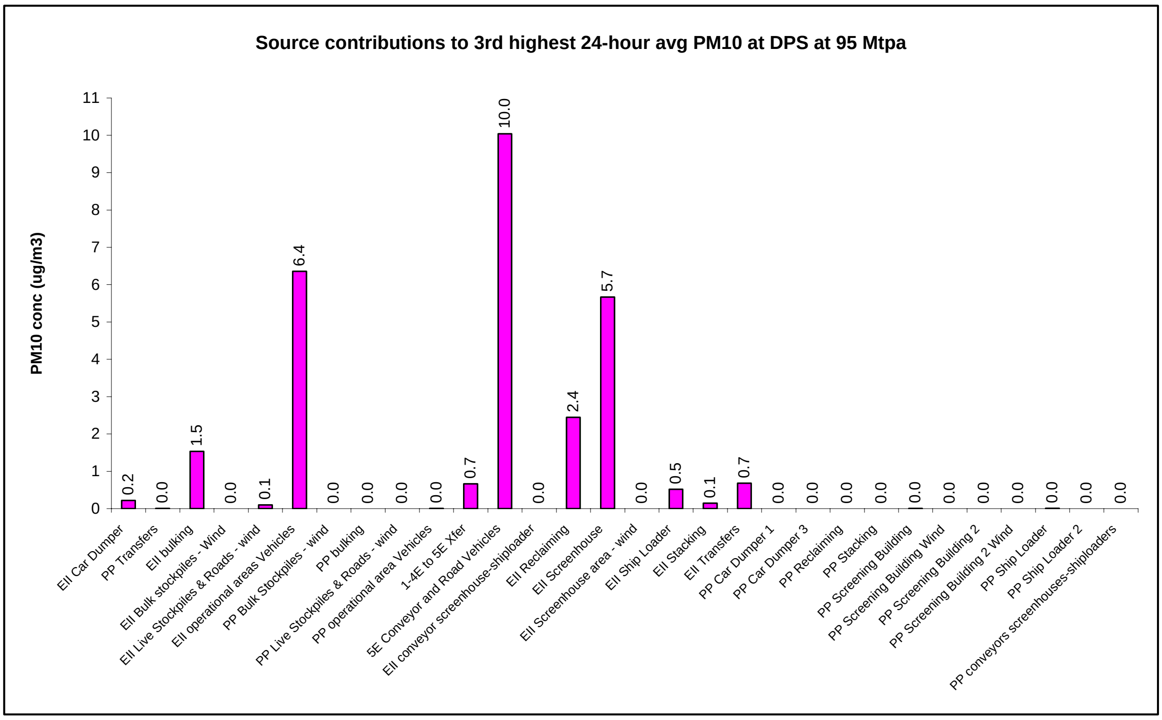


Figure 14 Source contributions to 3rd highest 24-hour average PM10 concentration at DPS for 95 Mtpa

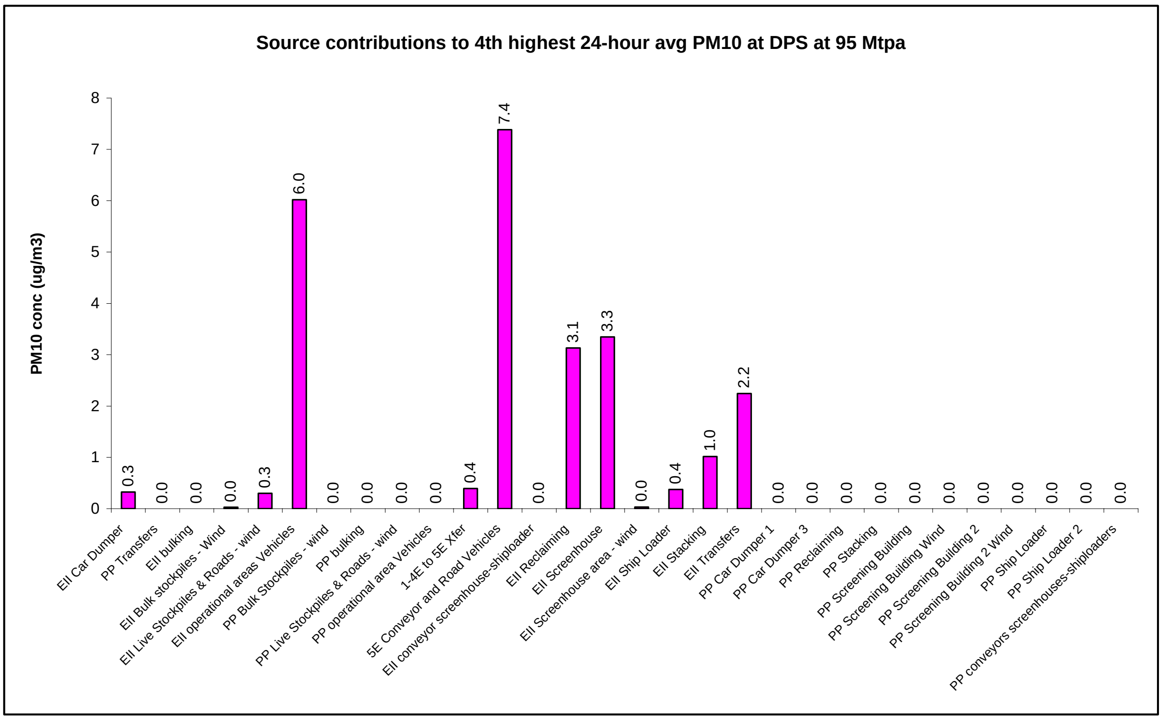


Figure 15 Source contributions to 4th highest 24-hour average PM10 concentration at DPS for 95 Mtpa

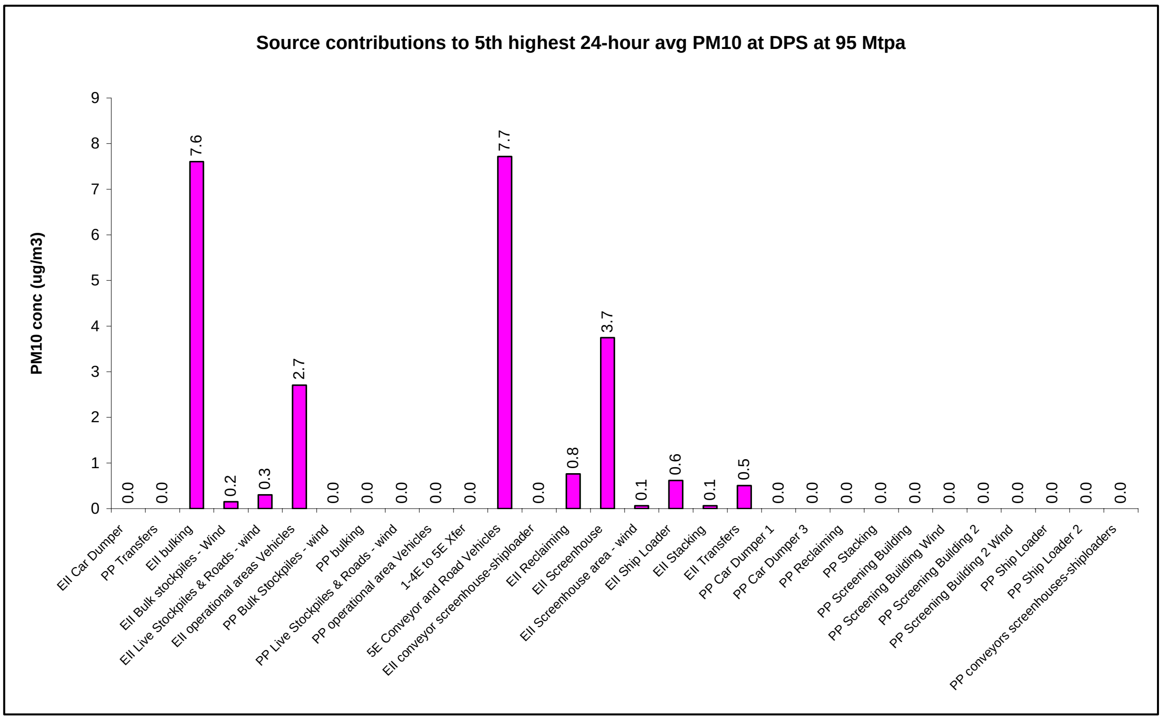


Figure 16 Source contributions to 5th highest 24-hour average PM10 concentration at DPS for 95 Mtpa

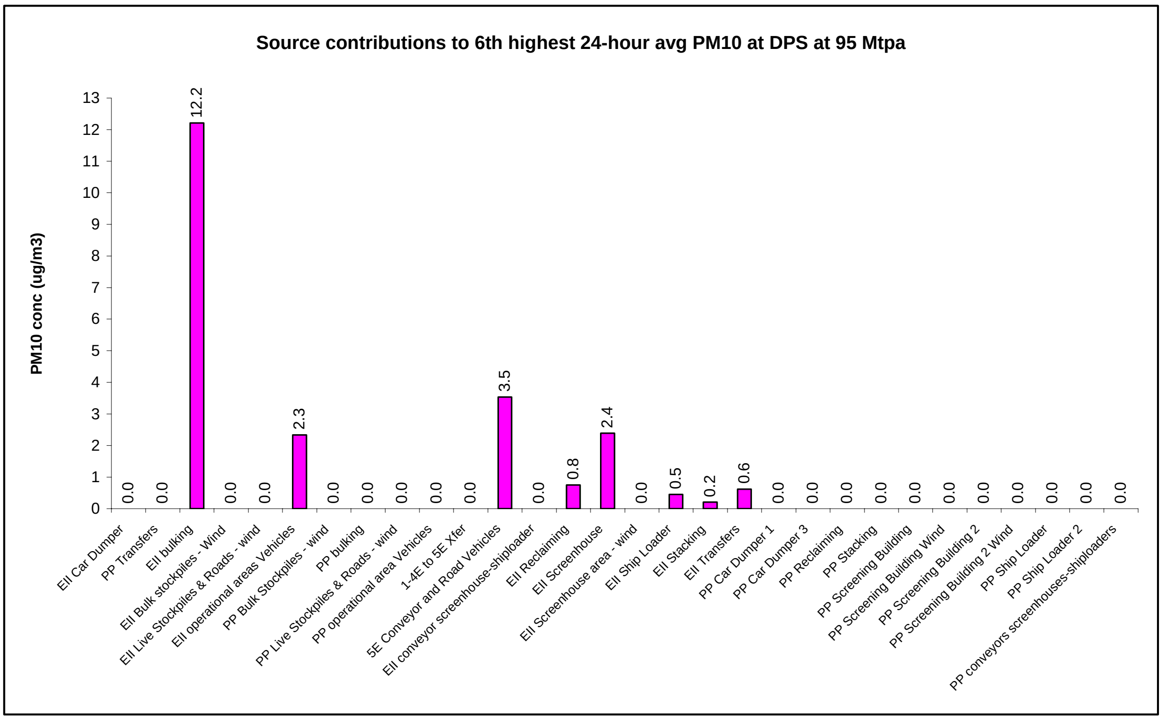


Figure 17 Source contributions to 6th highest 24-hour average PM10 concentration at DPS for 95 Mtpa

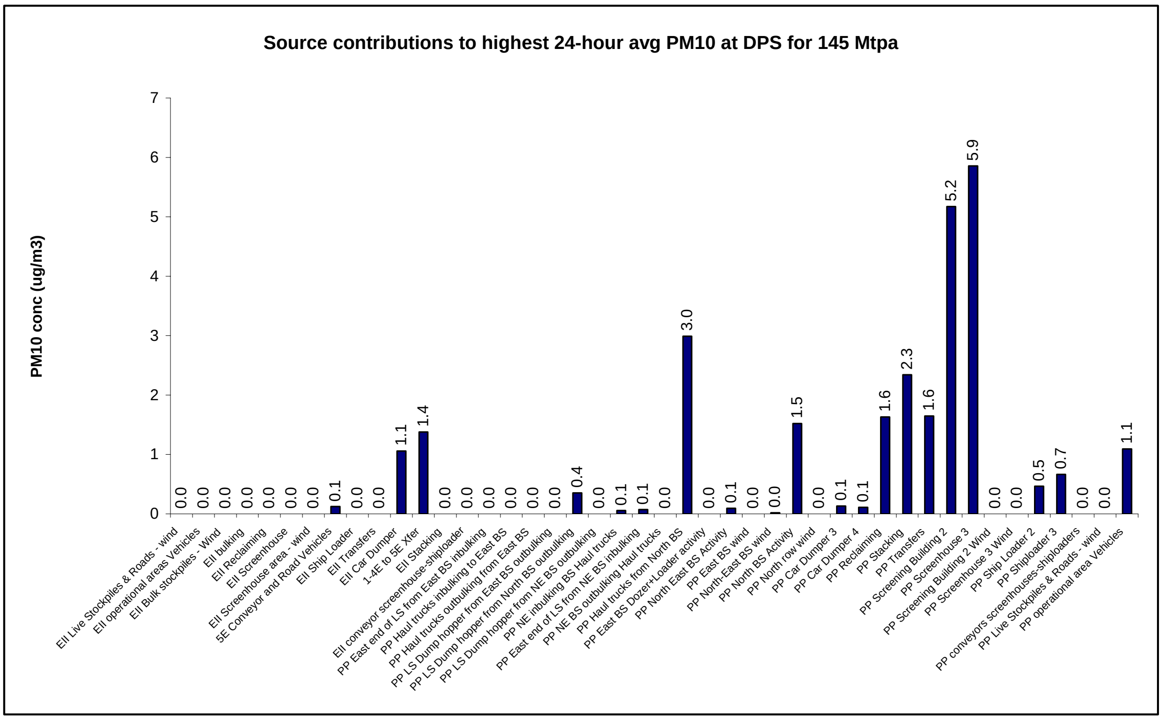


Figure 18 Source contributions to highest 24-hour average PM10 concentration at DPS for 145 Mtpa

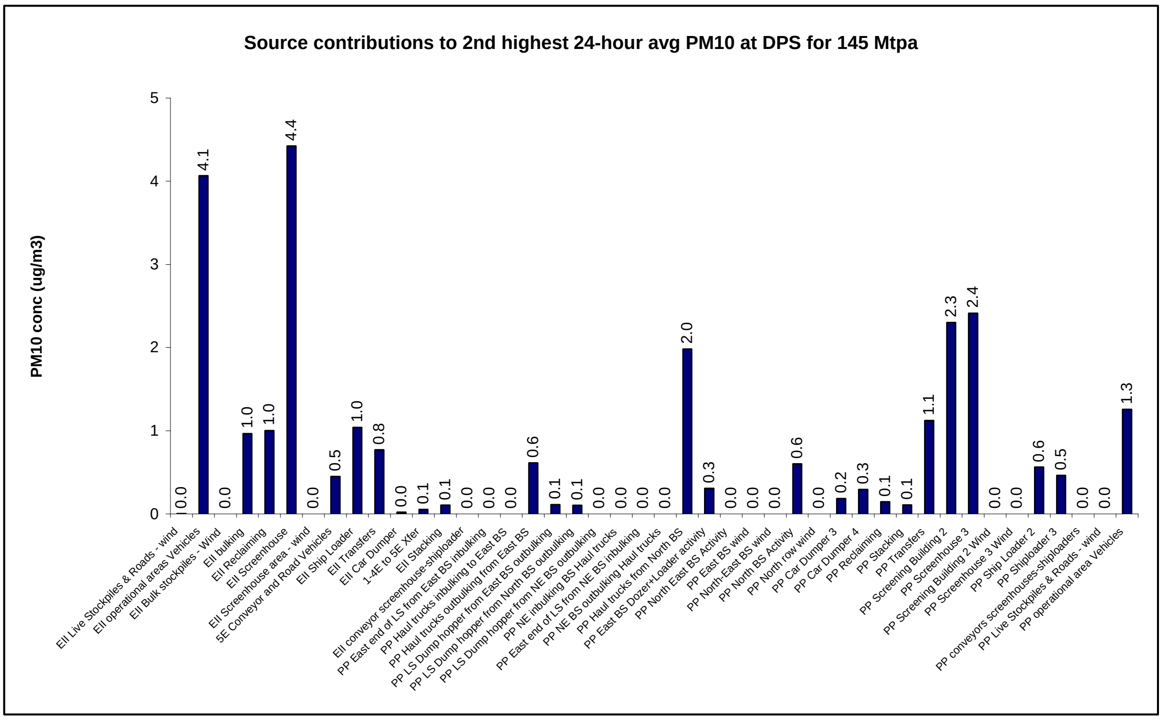


Figure 19 Source contributions to 2nd highest 24-hour average PM10 concentration at DPS for 145 Mtpa

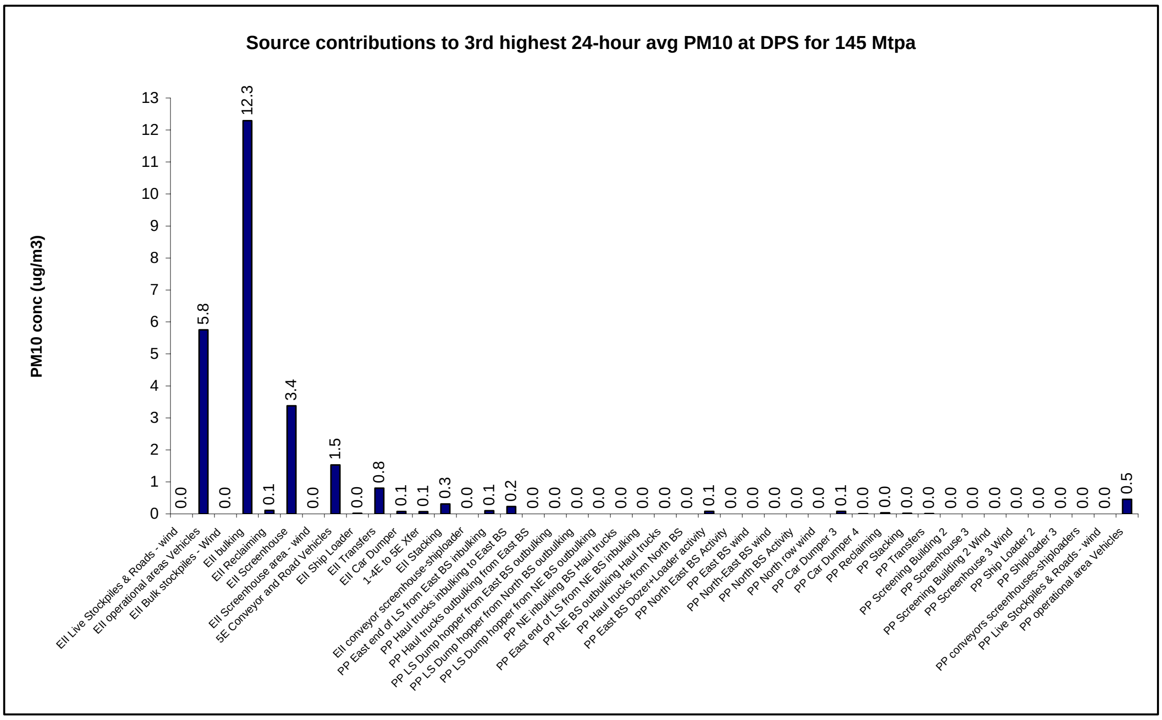


Figure 20 Source contributions to 3rd highest 24-hour average PM10 concentration at DPS for 145 Mtpa

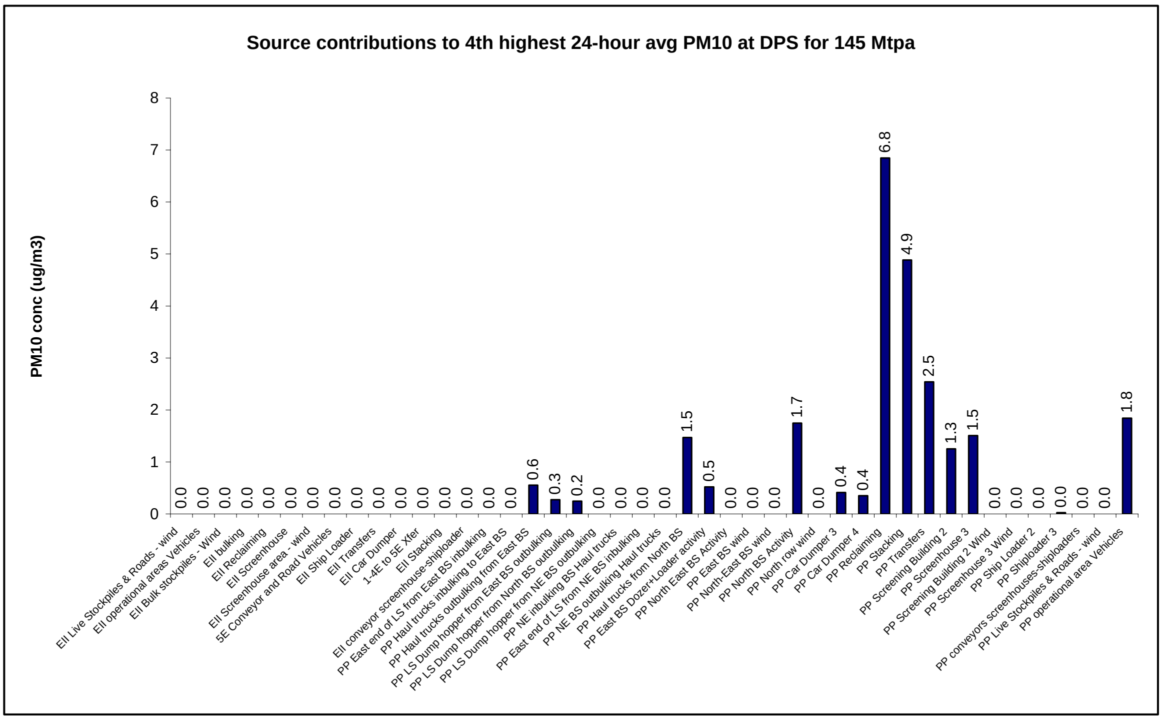


Figure 21 Source contributions to 4th highest 24-hour average PM10 concentration at DPS for 145 Mtpa

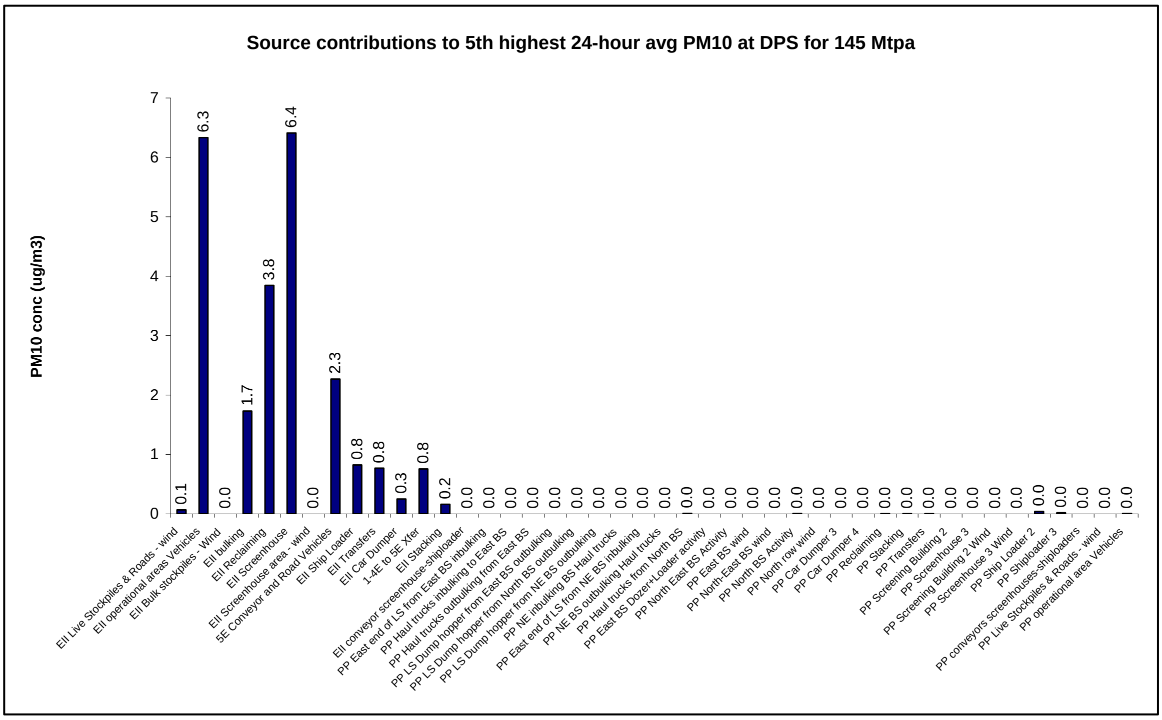


Figure 22 Source contributions to 5th highest 24-hour average PM10 concentration at DPS for 145 Mtpa

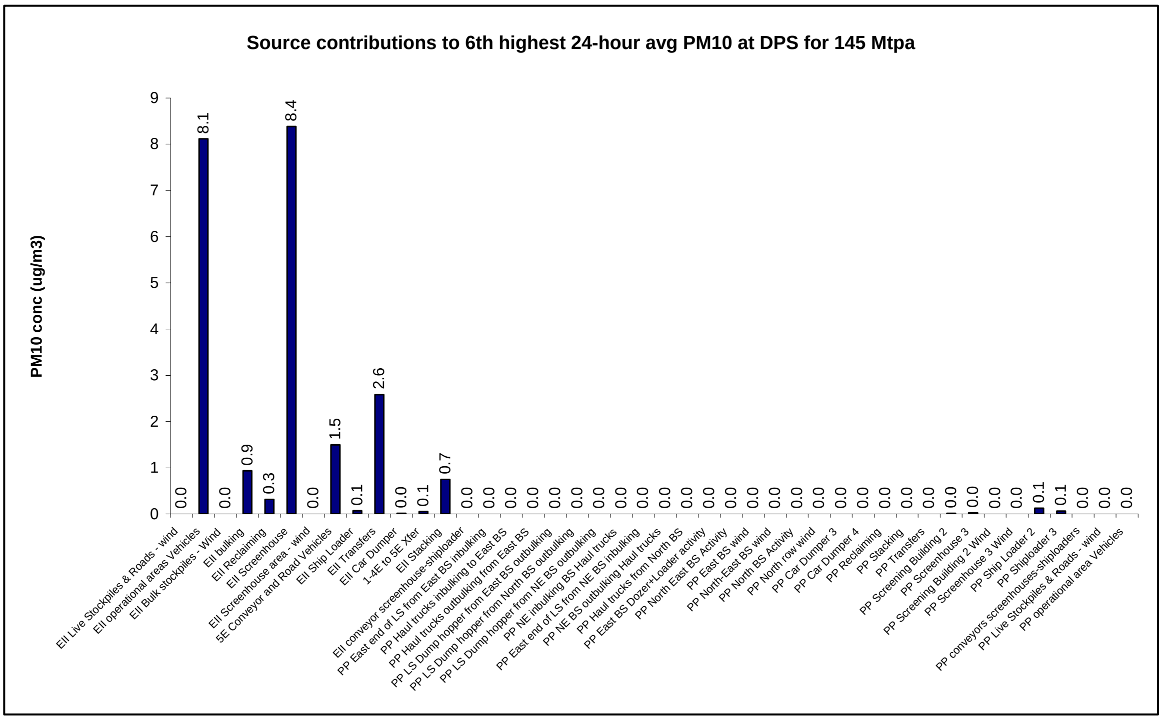


Figure 23 Source contributions to 6th highest 24-hour average PM10 concentration at DPS for 145 Mtpa

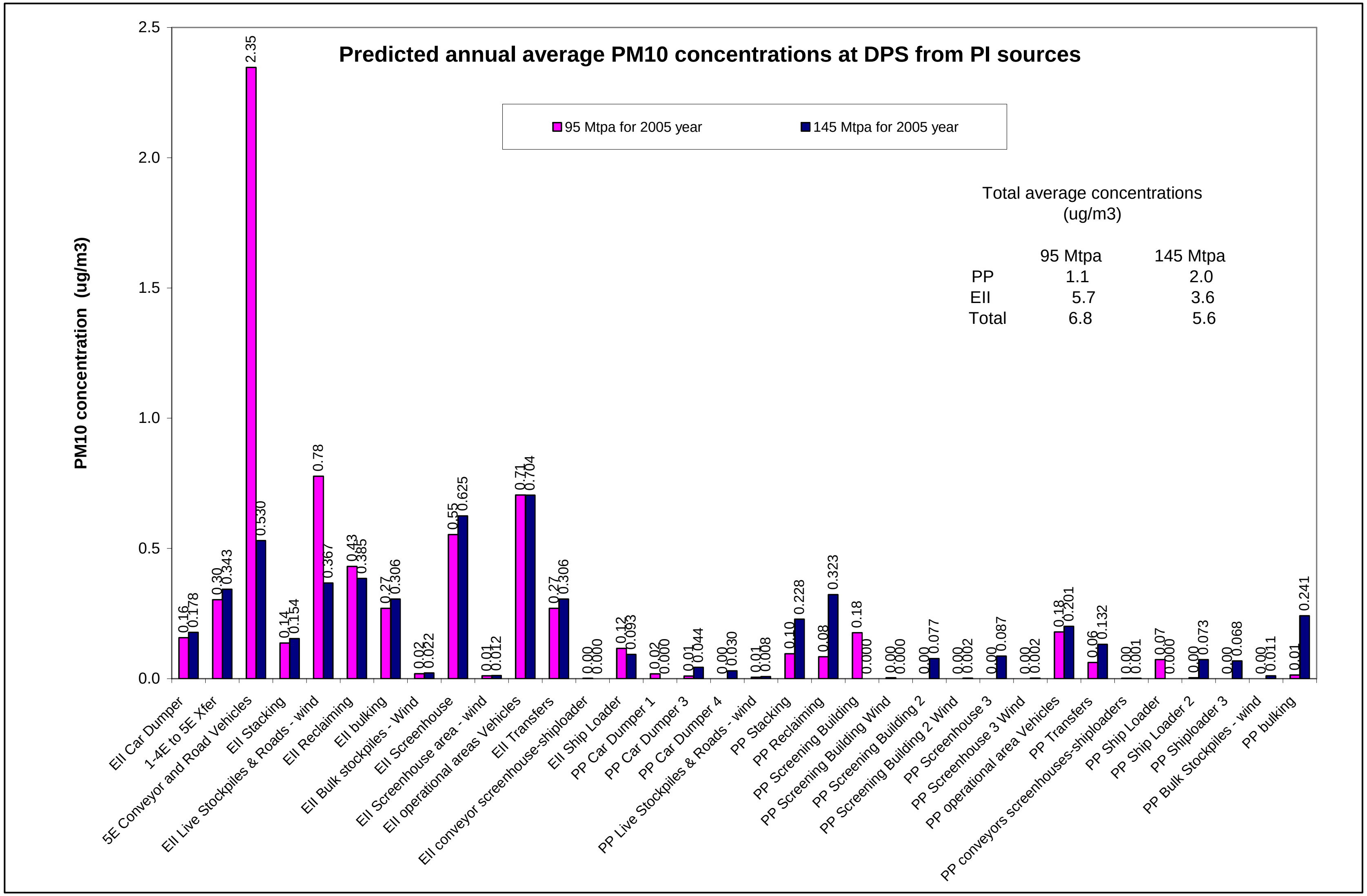


Figure 24 Predicted annual average PM10 concentrations at DPS from PI sources

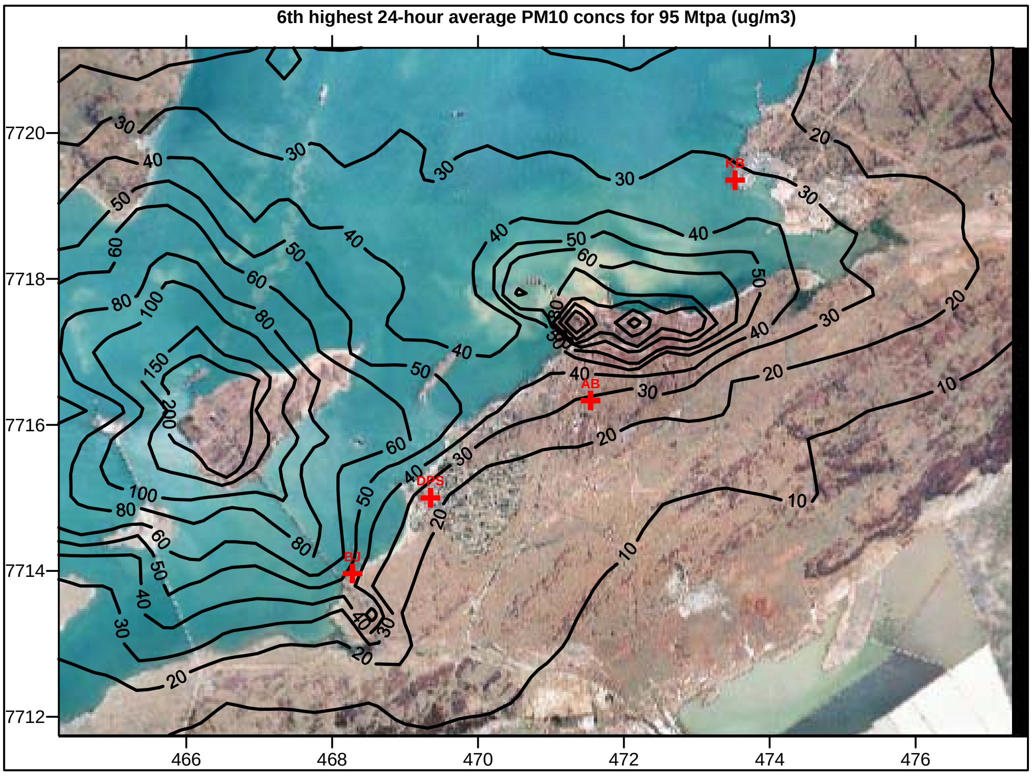


Figure 25 Predicted 6th highest 24-hour average PM10 concentrations for 95 Mtpa from PI sources

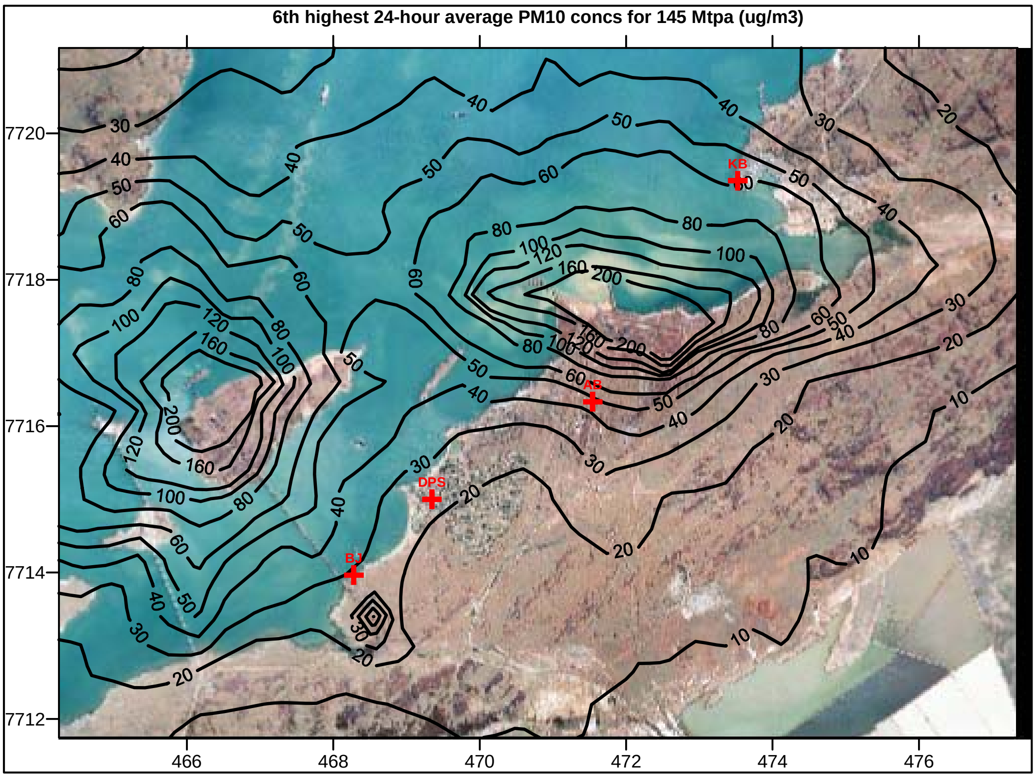


Figure 26 Predicted 6th highest 24-hour average PM10 concentrations for 145 Mtpa from PI sources

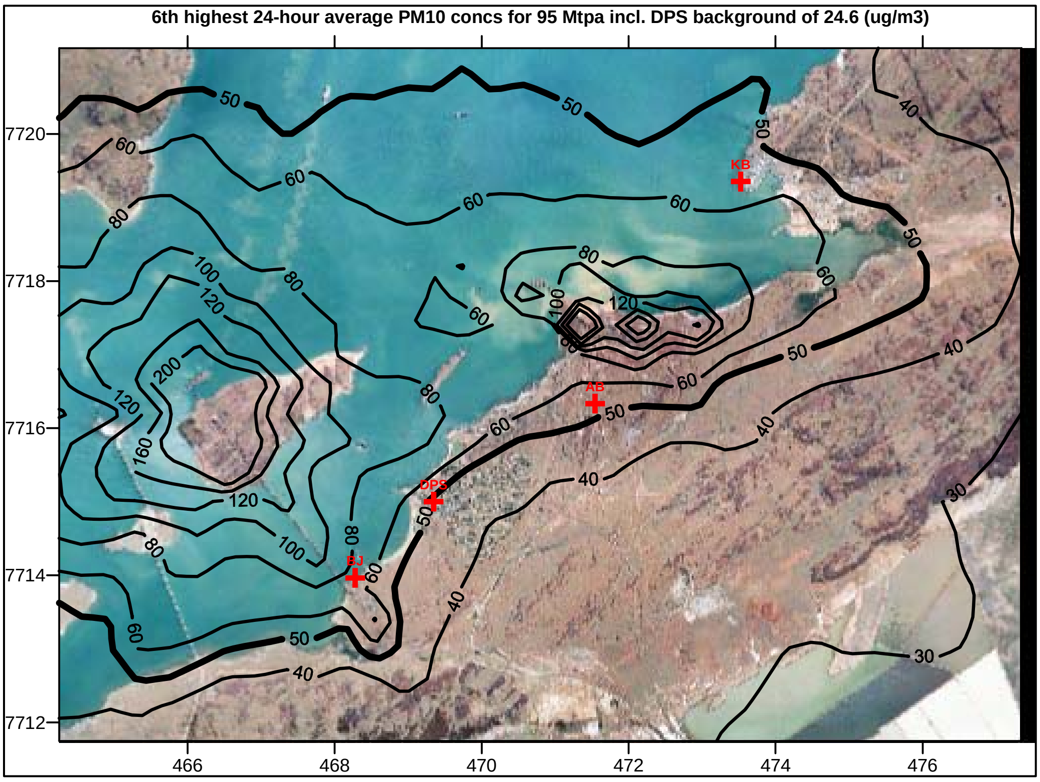


Figure 27 Predicted 6th highest 24-hour average PM10 concentrations for 95 Mtpa including background

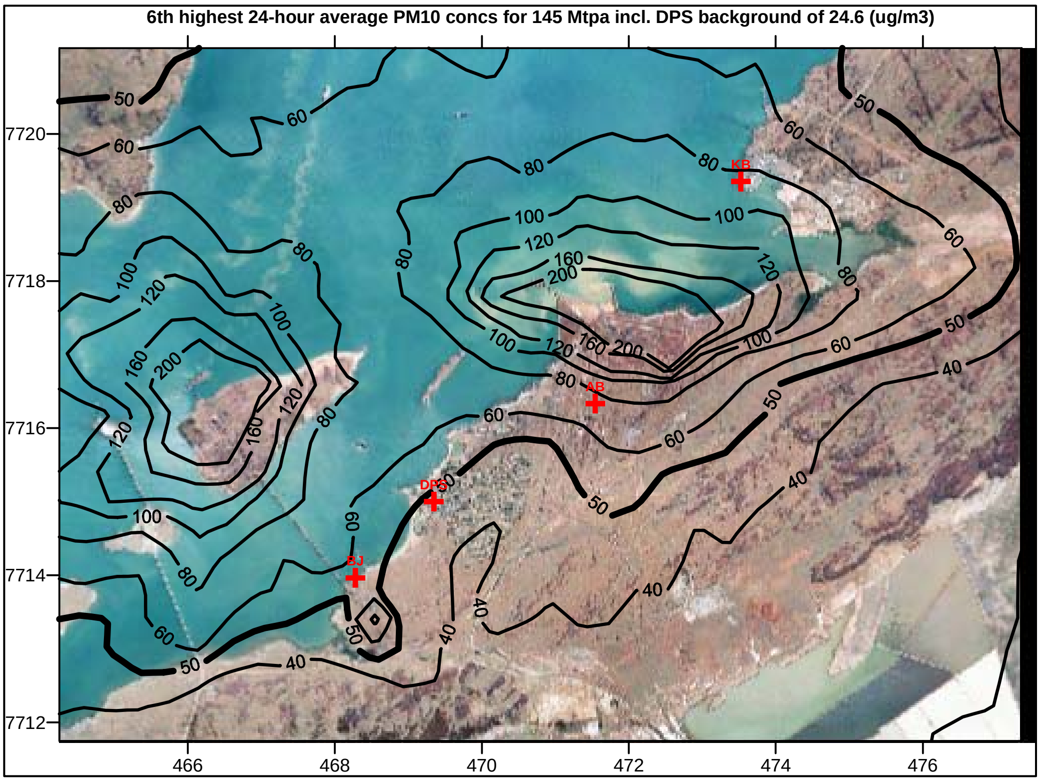


Figure 28 Predicted 6th highest 24-hour average PM10 concentrations for 145 Mtpa including background

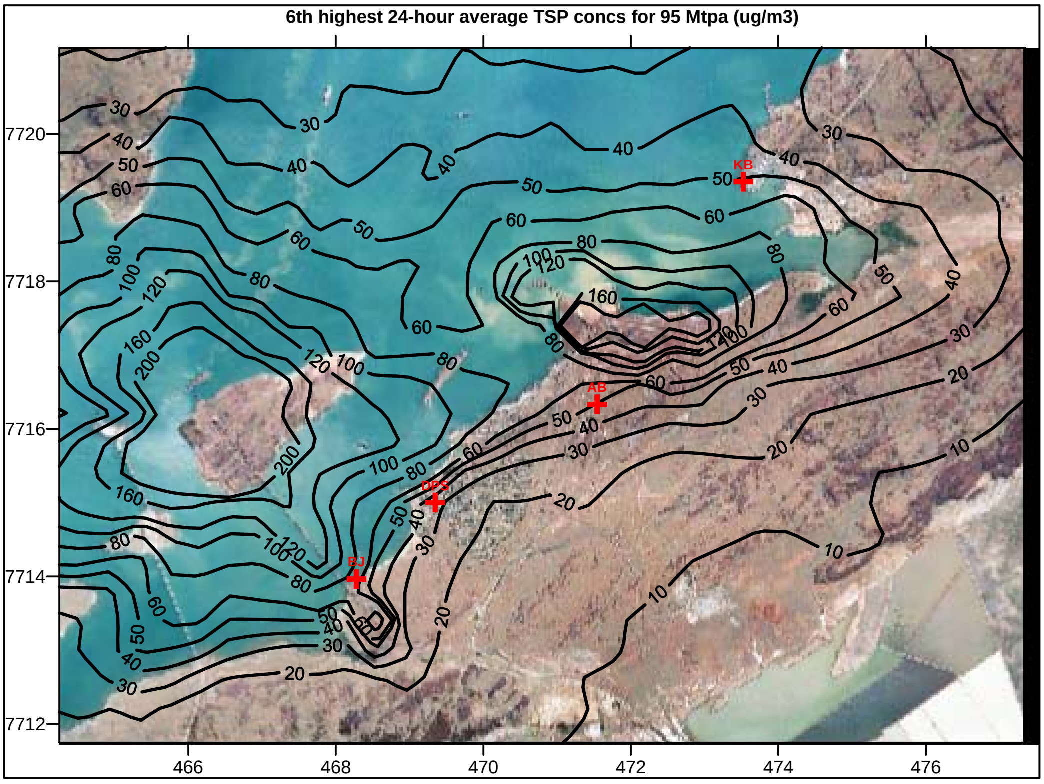


Figure 29 Predicted 6th highest 24-hour average TSP concentrations for 95 Mtpa from PI sources

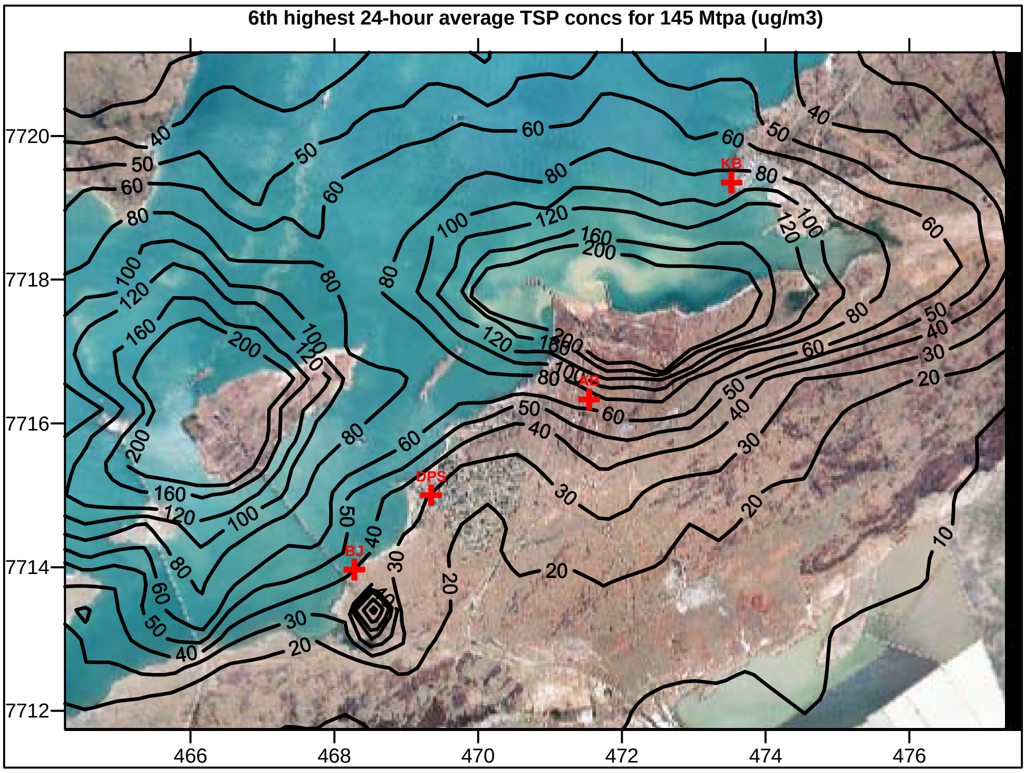


Figure 30 Predicted 6th highest 24-hour average TSP concentrations for 145 Mtpa from PI sources

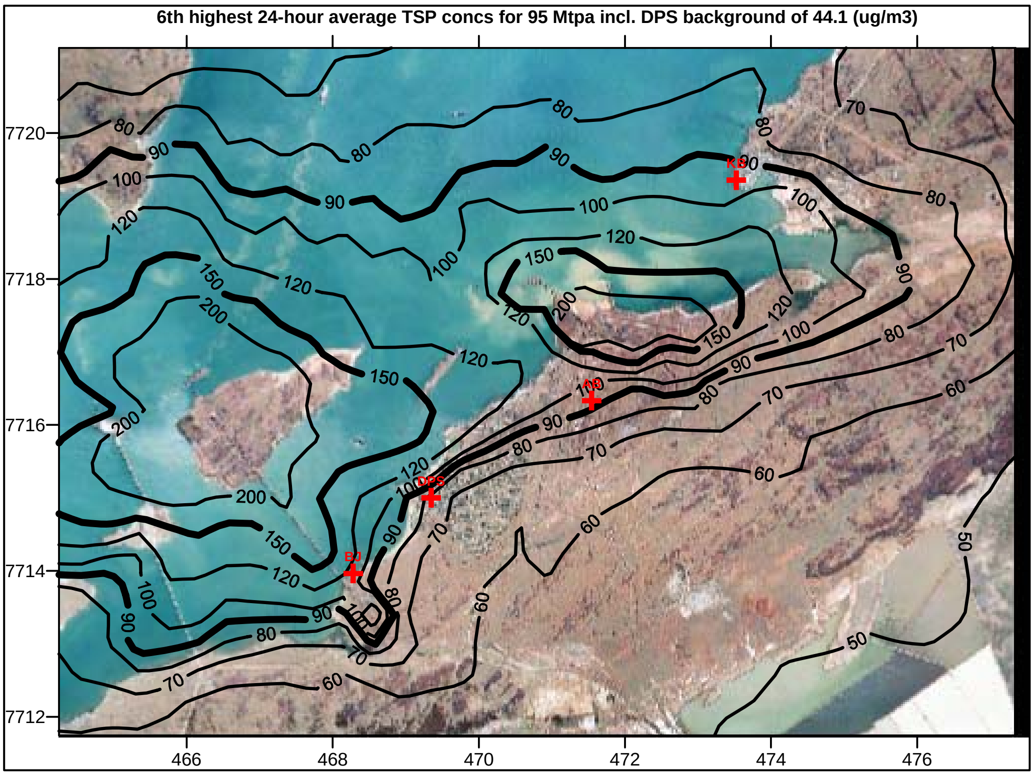


Figure 31 Predicted 6th highest 24-hour average TSP concentrations for 95 Mtpa including background

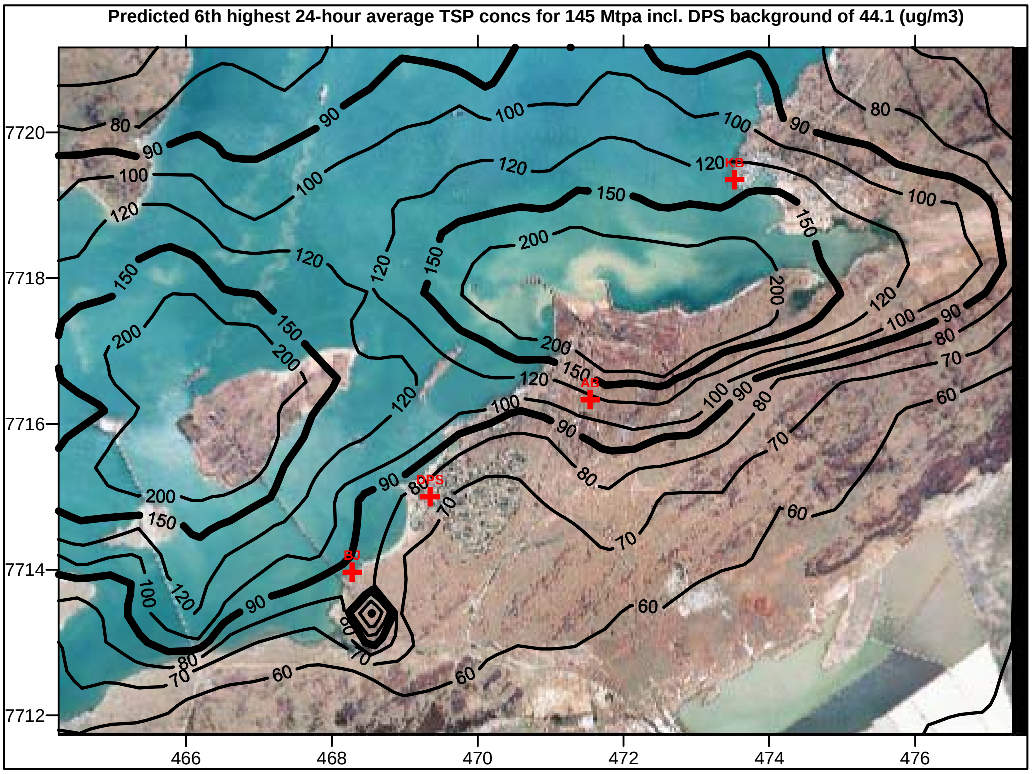


Figure 32 Predicted 6th highest 24-hour average TSP concentrations for 145 Mtpa including background

Note that these over-estimate concentrations in the King Bay region due to the assumption of DPS “background”.

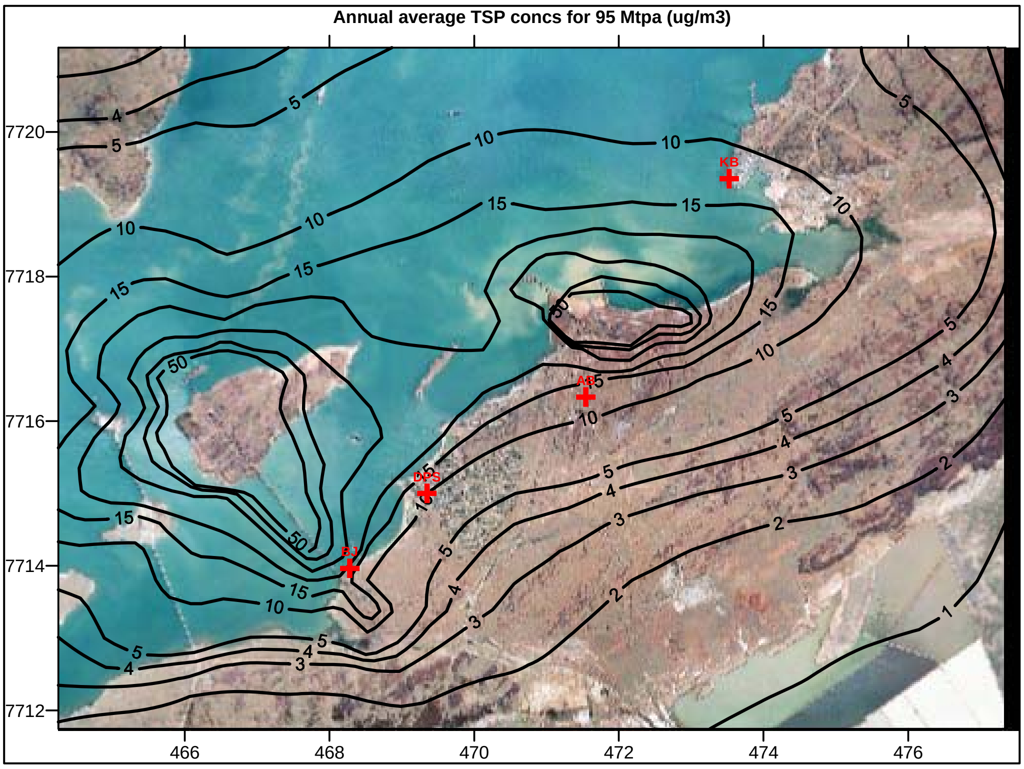


Figure 33 Predicted annual average TSP concentrations for 95 Mtpa from PI sources

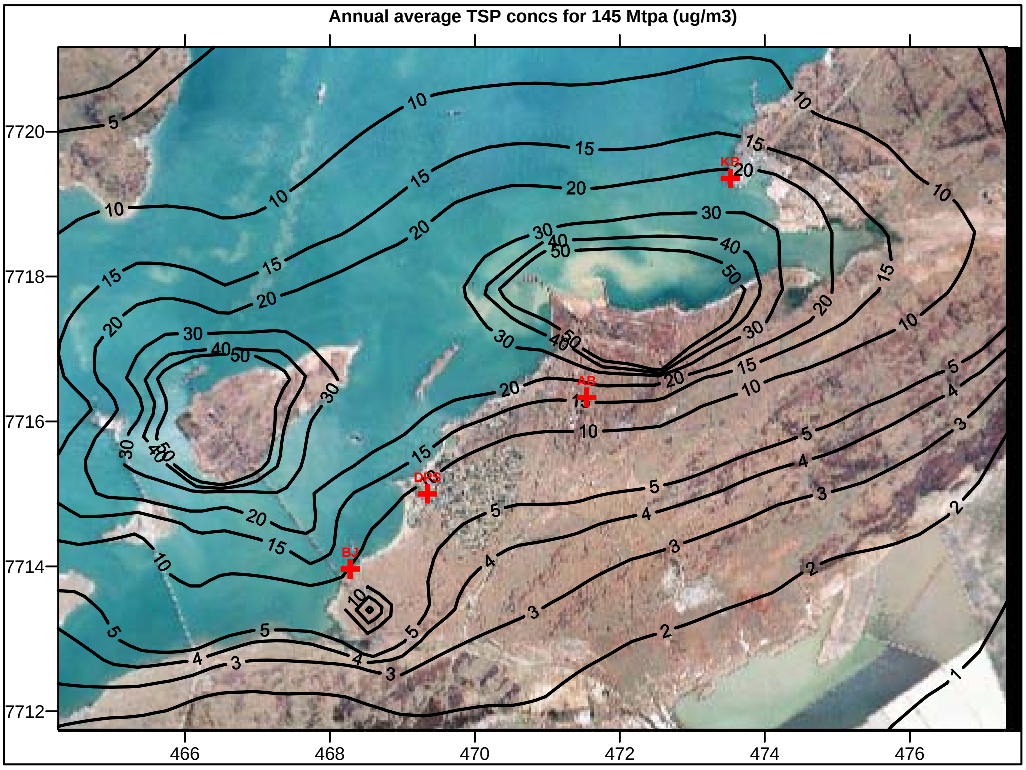


Figure 34 Predicted annual average TSP concentrations for 145 Mtpa from PI sources

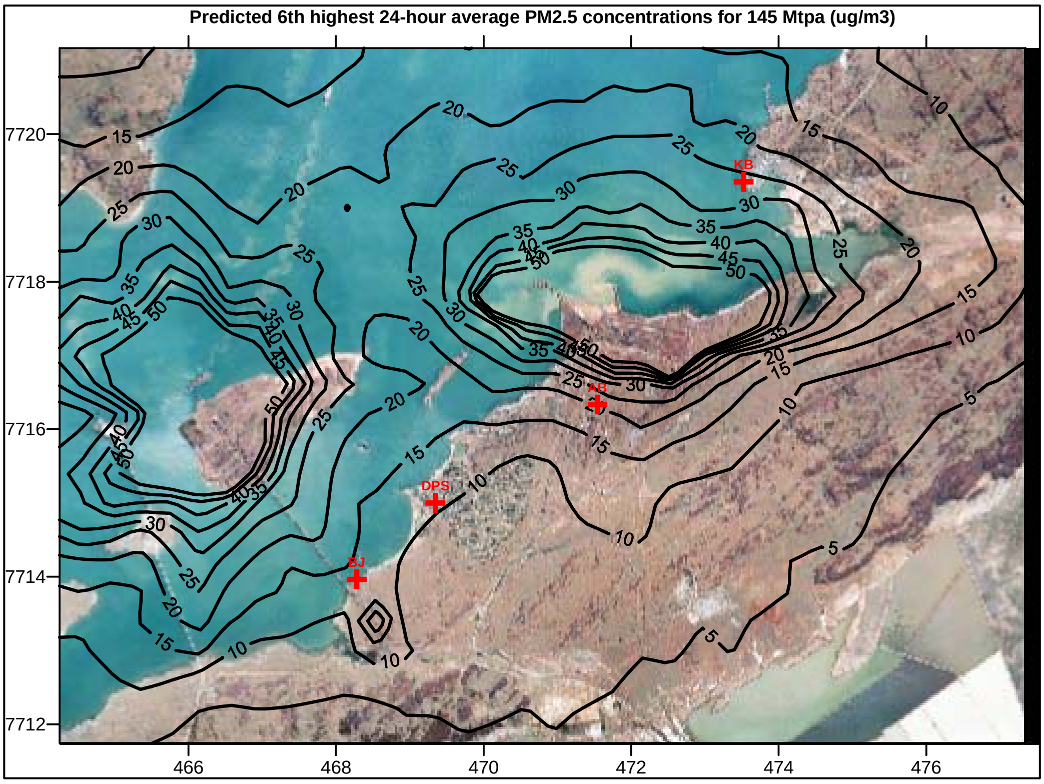


Figure 35 Predicted 6th highest 24-hour average PM2.5 concentrations for 95 Mtpa from PI sources

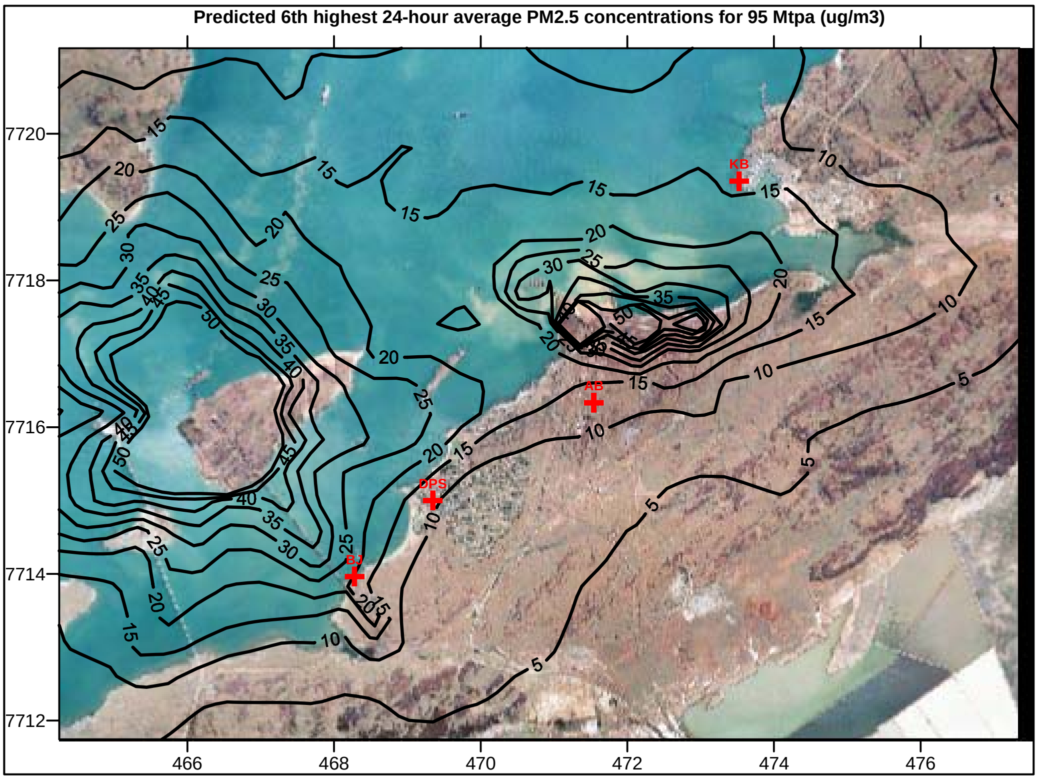


Figure 36 Predicted 6th highest 24-hour average PM2.5 concentrations for 145 Mtpa from PI sources

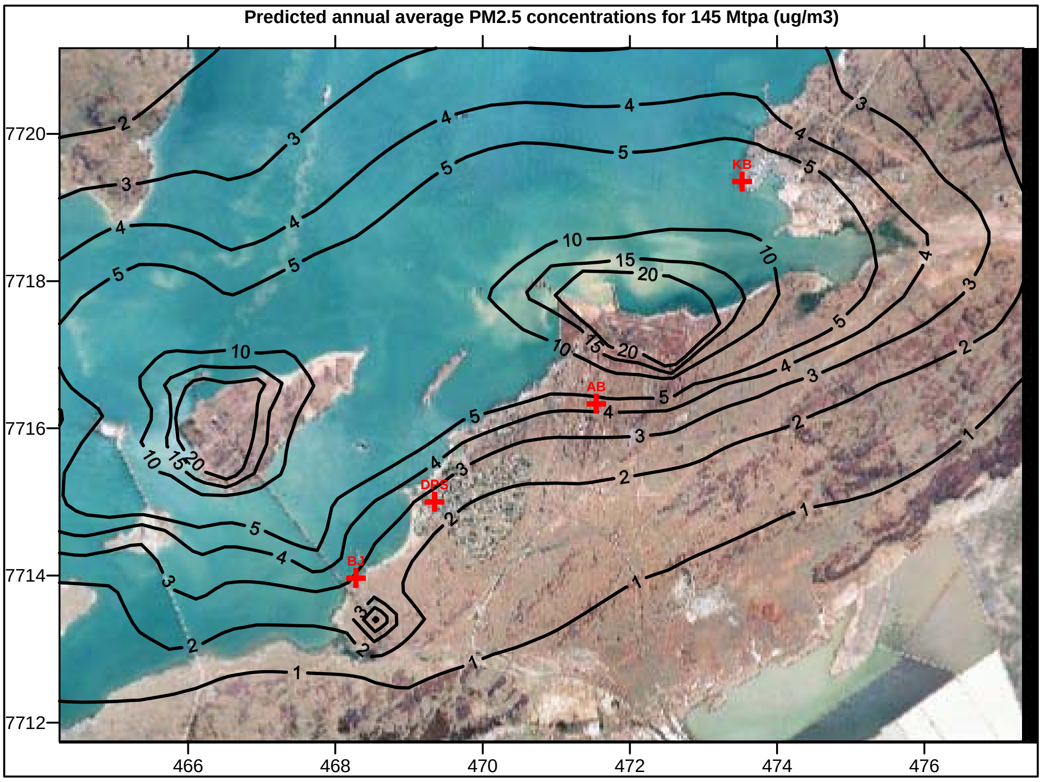


Figure 37 Predicted annual average PM2.5 concentrations for 95 Mtpa from PI sources

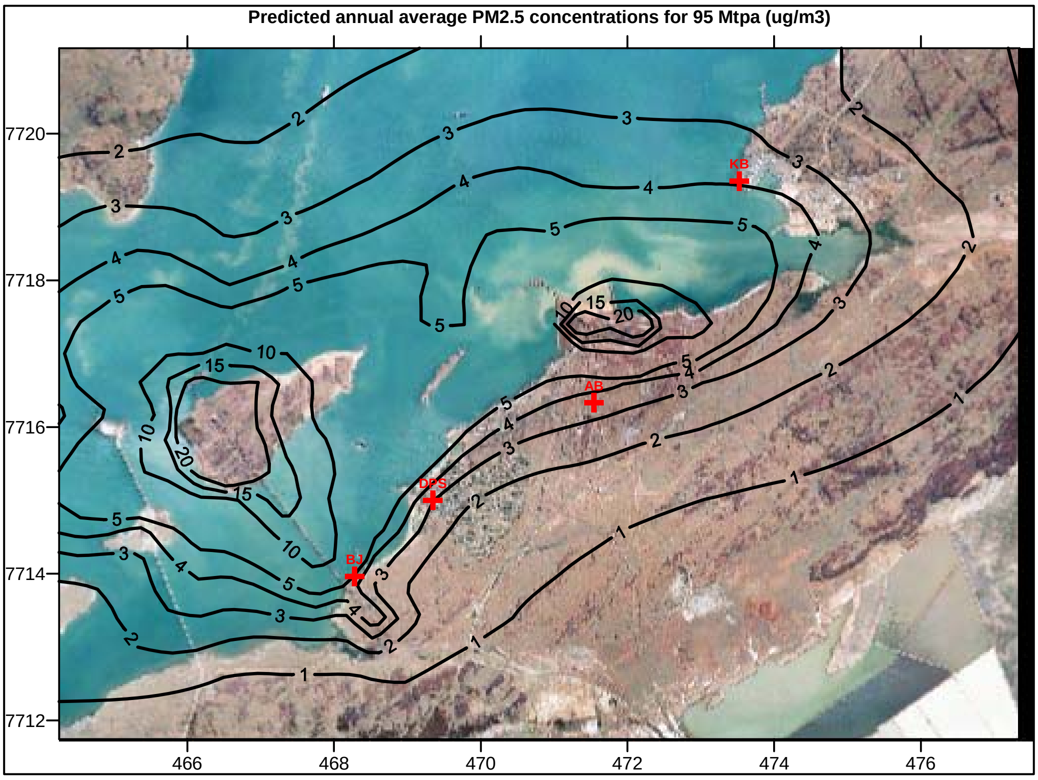


Figure 38 Predicted annual average PM2.5 concentrations for 145 Mtpa from PI sources

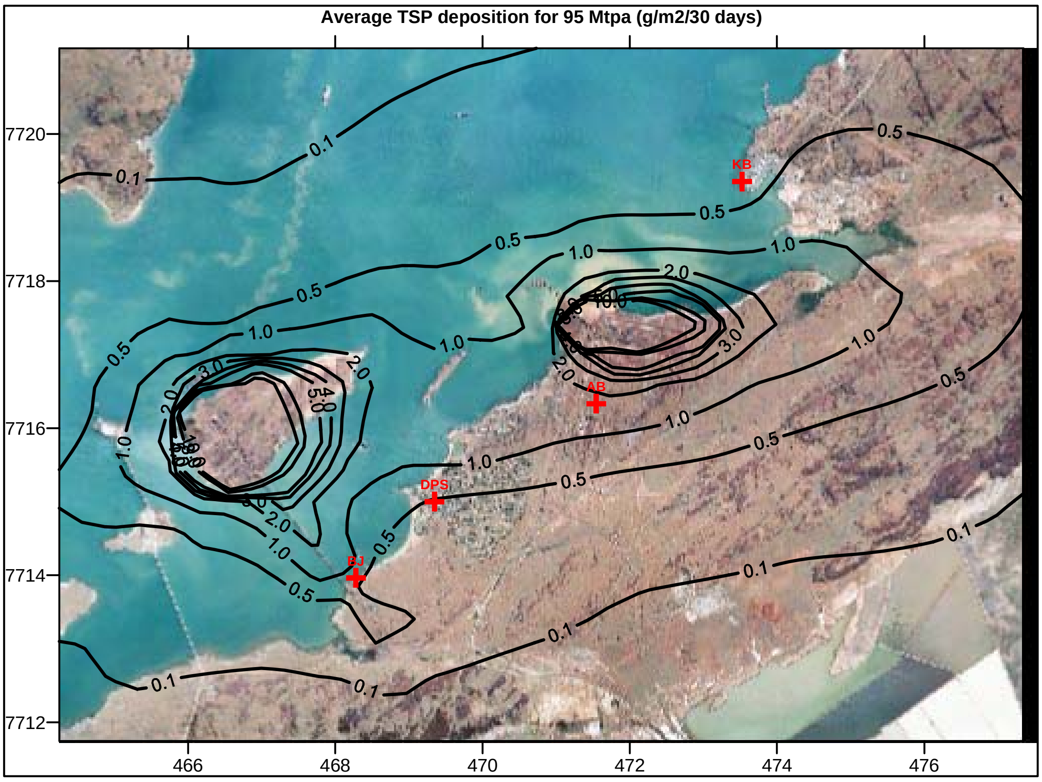


Figure 39 Predicted average dust dry deposition for 95 Mtpa from PI sources

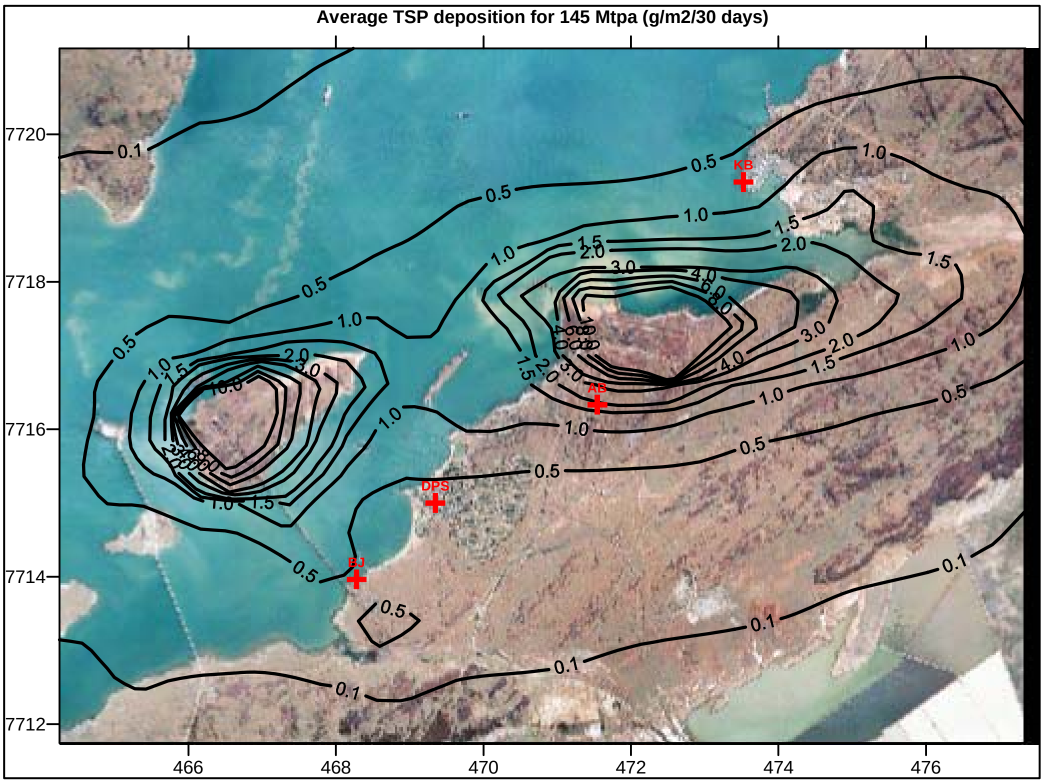


Figure 40 Predicted average dust dry deposition for 145 Mtpa from PI sources

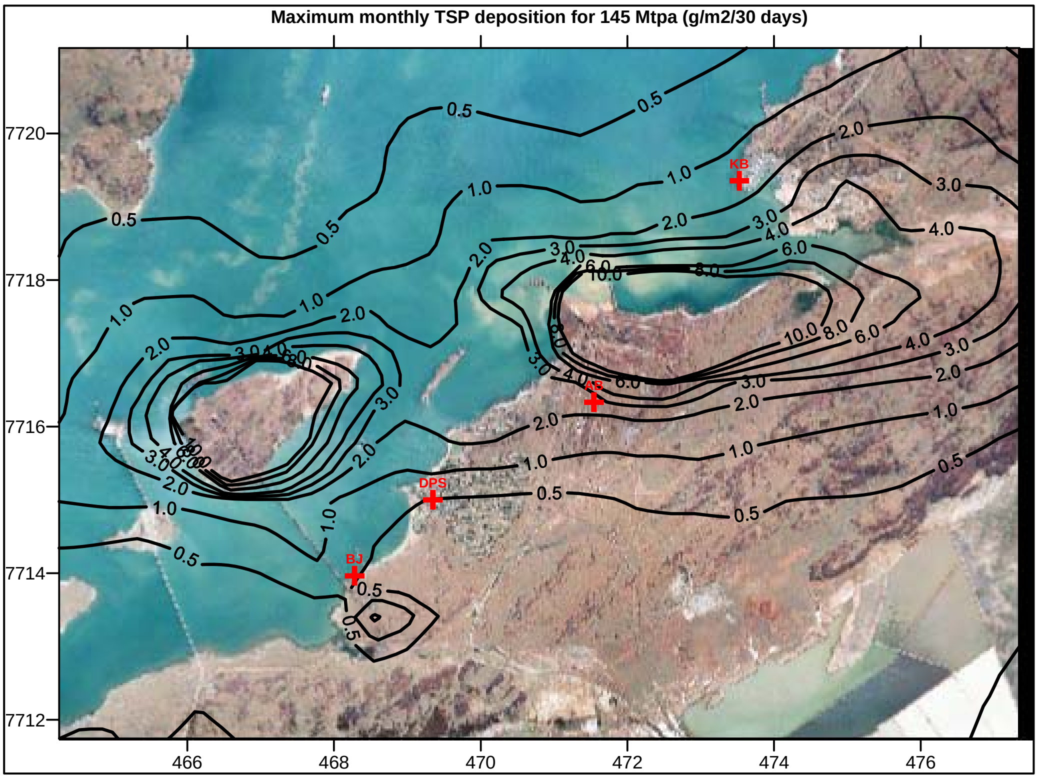


Figure 41 Predicted maximum monthly dust dry deposition for 95 Mtpa from PI sources

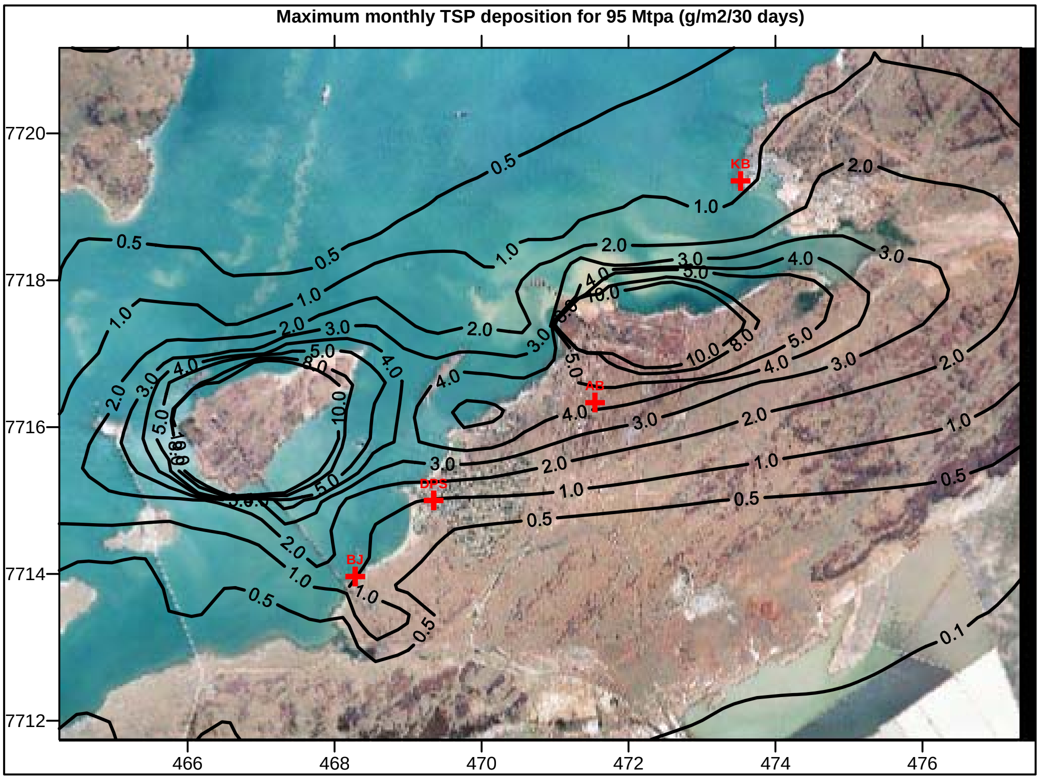


Figure 42 Predicted maximum monthly dust dry deposition for 145 Mtpa from PI sources

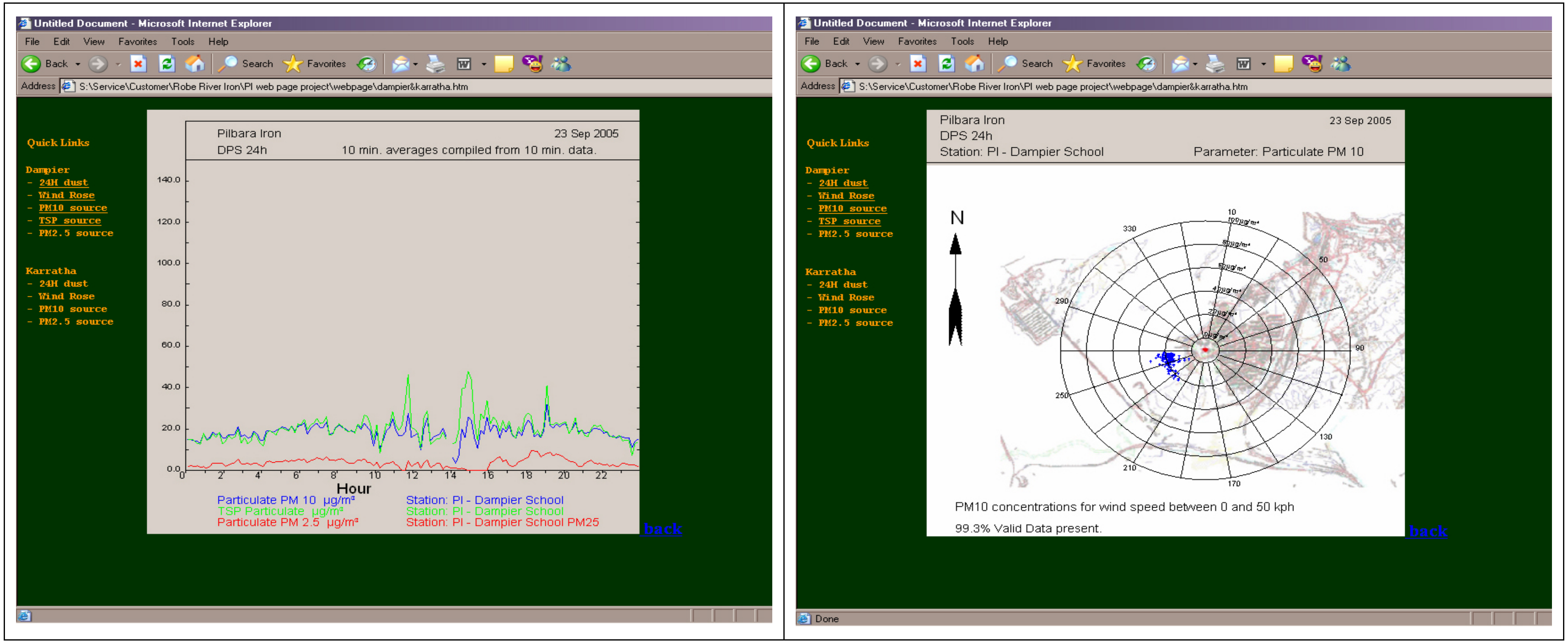


Figure 43 Examples of PI dust monitoring information web pages

Appendix 1 Analysis of high dust levels and meteorology for 1/6/2004 to 31/12/2006

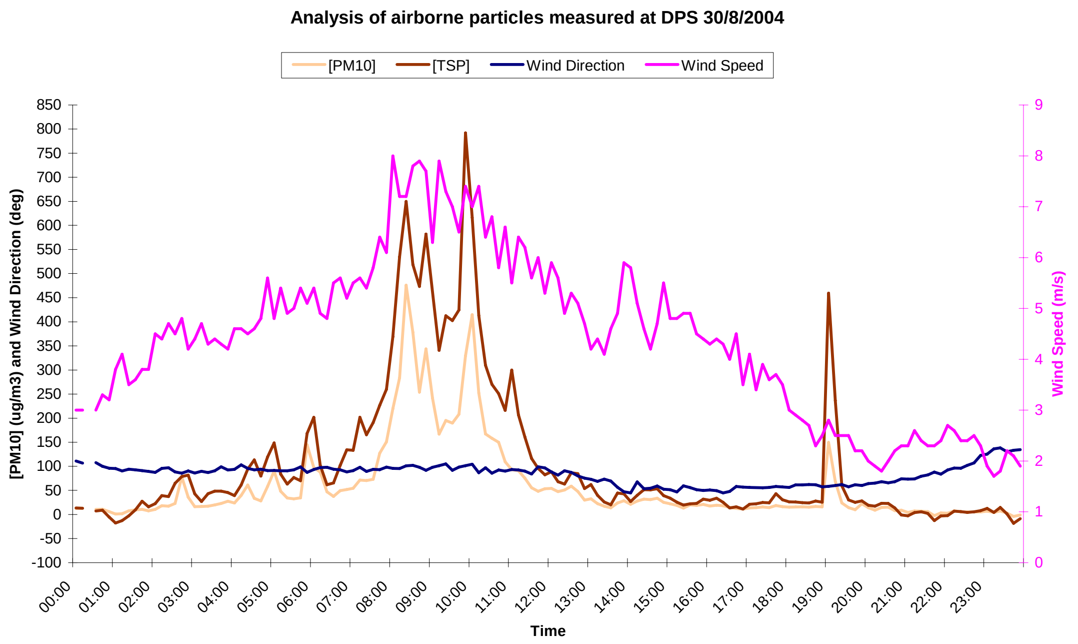
The bearings from the DPS site to the PI operational areas are shown in Table 2.

Table 15 Bearings to PI operation areas

PI operation	PP	EII
Bearing from DPS (deg)	18 - 59	201 – 305
Bearing from Dampier township extents[a]	0 – 72	248[b] - 314

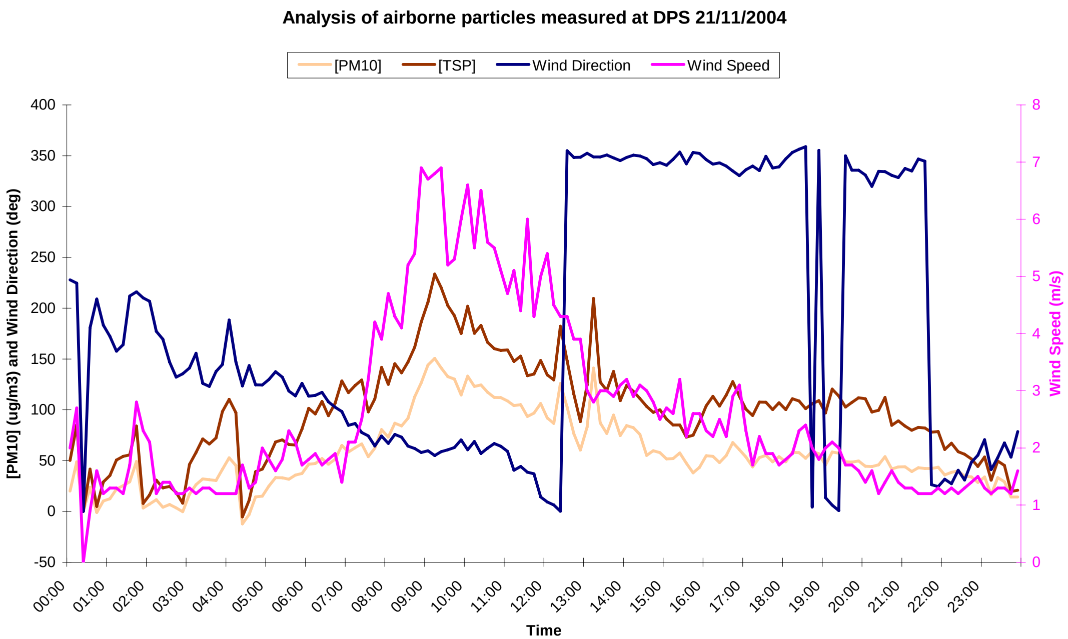
[a] Dust Risk Matrix as at 19/9/2006.
[b] From EII only – doesn't include 5E conveyor and EII car dumper.

Time series plots of the 10-minute data are shown in the following Figures for each event accompanied by a brief description.



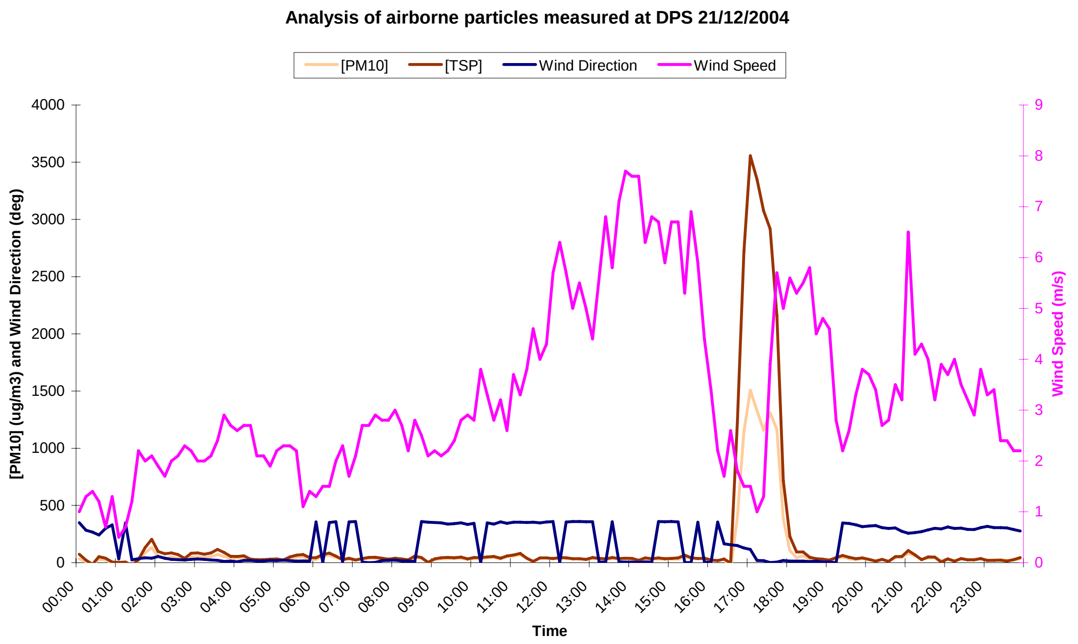
30/8/2004

The elevated PM10 and TSP concentrations are strongly correlated with increasing wind speed. The wind direction however is steady at around ESE, therefore PI sources are not implicated as significant contributor to this event.



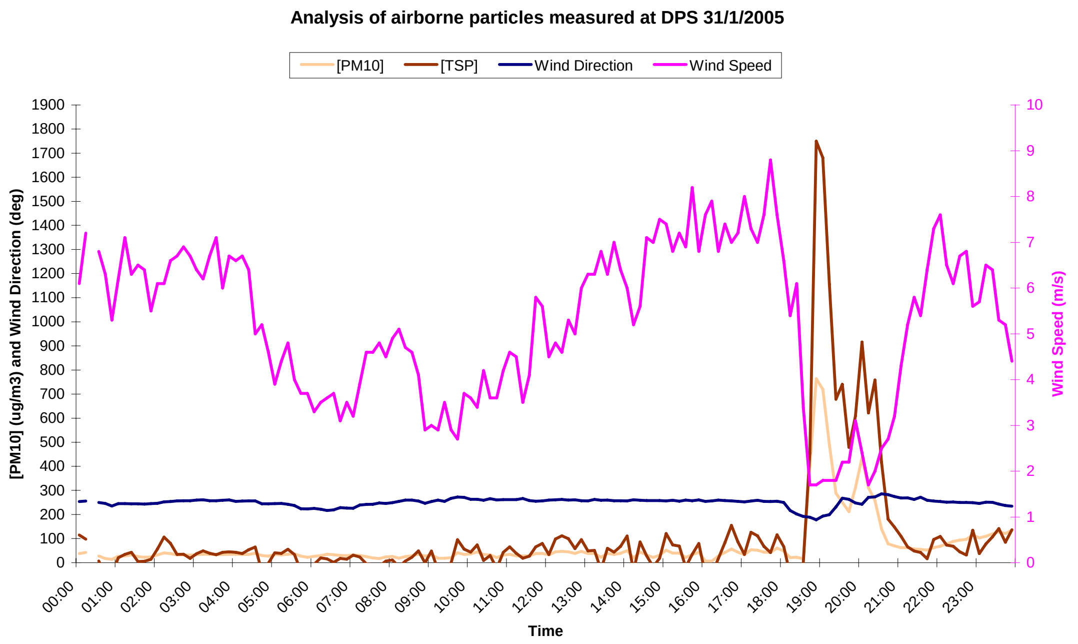
21/11/2004

Again, the elevated PM10 and TSP concentrations are strongly correlated with increasing wind speed. The wind direction during the elevated concentrations NE and swinging anti-clockwise towards north. This is through the bearing to the car park (unsealed at the time) and the PP operational area. Some contribution from PP cannot therefore be ruled out. It is probably a line call whether this is "significant" with the automated calculation suggesting that PI sources contributed to 42% of dust over this event.



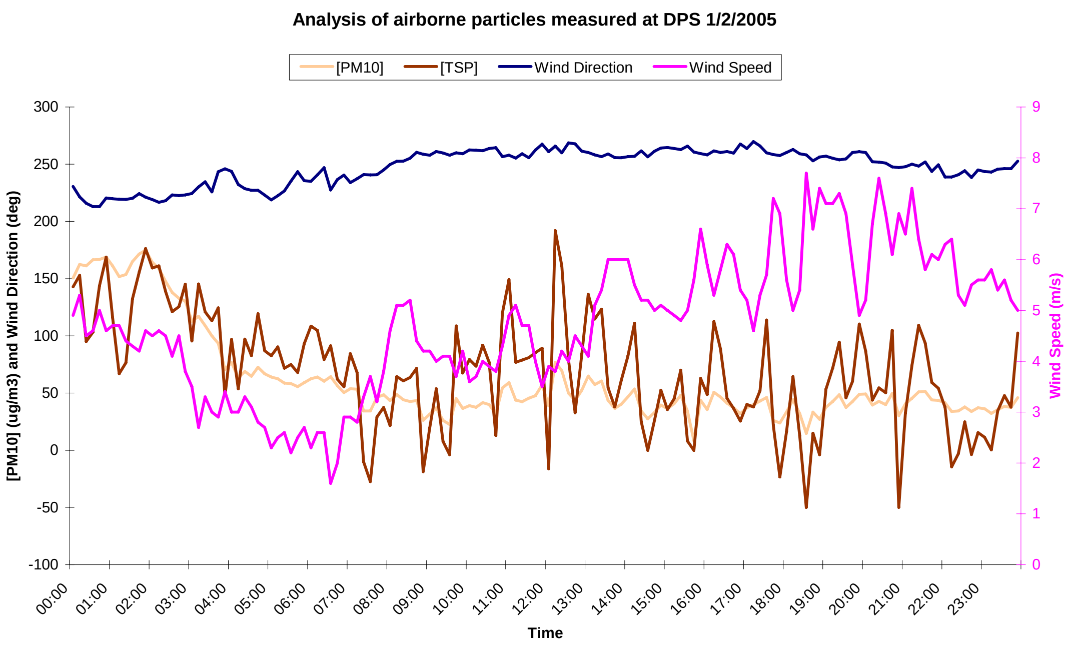
21/12/2004

This event was driven by extremely high dust levels around 1700 to 1800 hours. The preceding six hours were characterised by very high wind speeds from around north (the choppy looking wind direction plot is simply the result of the wind oscillating slightly either side of north). The period of extreme dust was photographed by PI personnel as shown below. The dust cloud reportedly drifted in from over the ocean. While contributions from PI sources cannot be excluded, this is a classical example of a naturally occurring severe dust episode in the Pilbara.



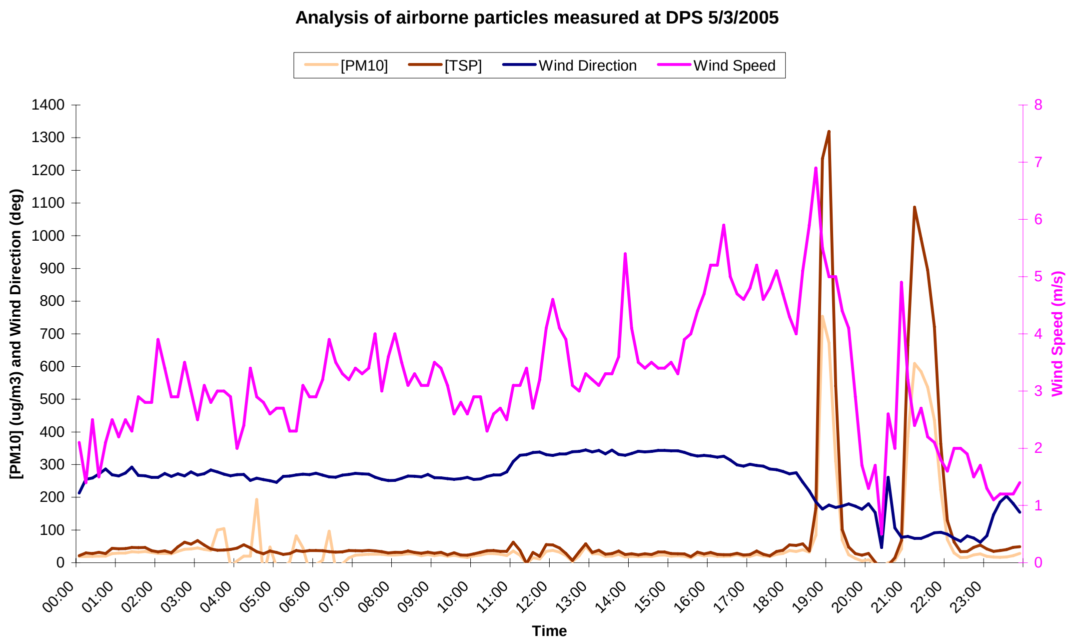
31/1/2005

This event was driven by high dust levels around 1800 to 2000 hours. The preceding six hours were characterised by very high wind speeds from the west with a slight turn towards south coincided with the elevated concentrations. In the absence of other information indicated a dust cloud similar to that of 21/12/2004, the EII operational area is strongly implicated s the key contributing source. It is noted that some 15,000 tonnes of fines ore were bulked at EII on this day. This seems to be the type of event that could be prevented through a predictive dust management strategy.



1/2/2005

The wind direction throughout the event was steady from around west. The wind speed during the most elevated dust measurements (0000 to 0200 hours) was moderate to strong. The dust levels remained at a constant high – but not extreme level for the remainder of the day. (The erratic TSP trace is a symptom of a highly loaded filter). An increase in the wind speed in the latter half of the day did not cause more elevated dust. . It is noted that some 10,000 tonnes of fines ore were bulked at EII on this day. Again, EII is strongly implicated as the key contributing source. This type of event could probably be prevented through a predictive dust management strategy or a reactive approach, since the high final average dust level was an accumulated slowly through the day.

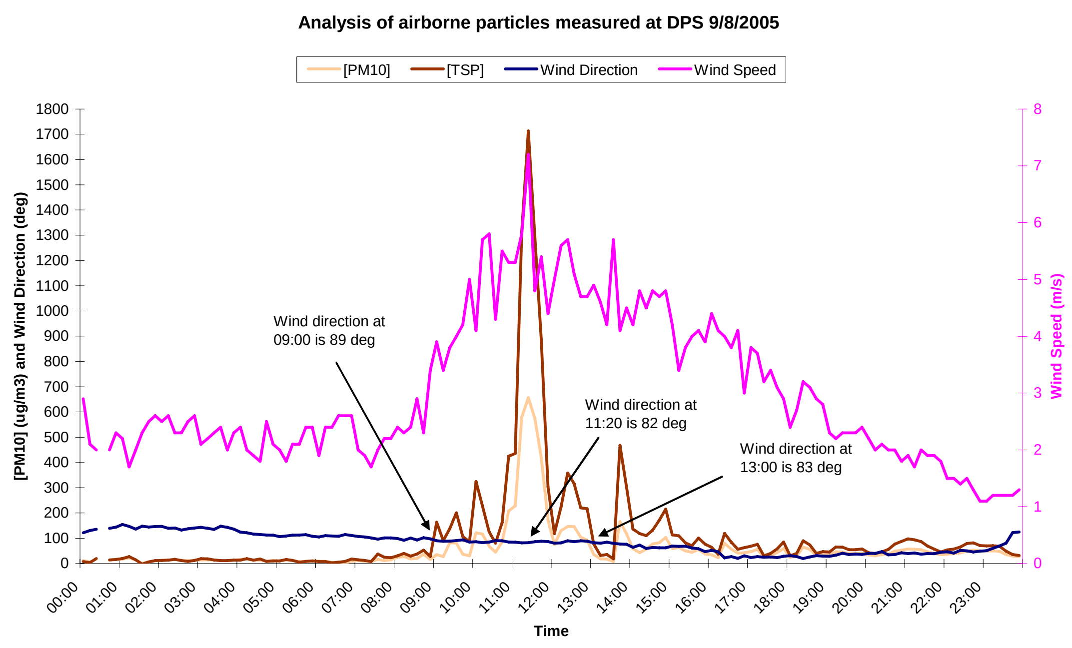


5/3/2005

Up to about 1800 hours, the winds were moderate to strong (gradually increasing) from about the west.

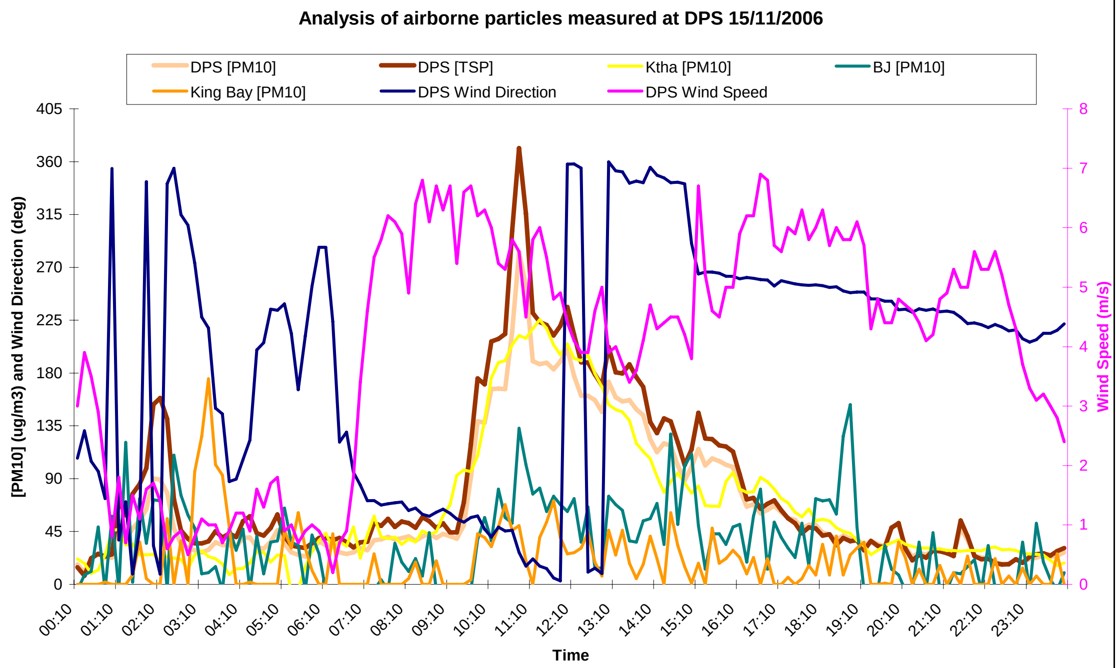
It is noted that some 8,000 tonnes of fines ore were bulked at EII on this day.

The peaks in the dust measurements follow (slightly lagged) the peaks in the wind speeds – the first coinciding with a shift from west to south – the second with a shift from south to east. Similar peaks are evident in the AB data, indicating a large dust cloud. It is possible that this is recirculated dust that originated from EII earlier. This is an interesting event. The first peak would require a predictive dust management strategy to prevent, while the second peak, if indeed the result of recirculation, would be very difficult to prevent.



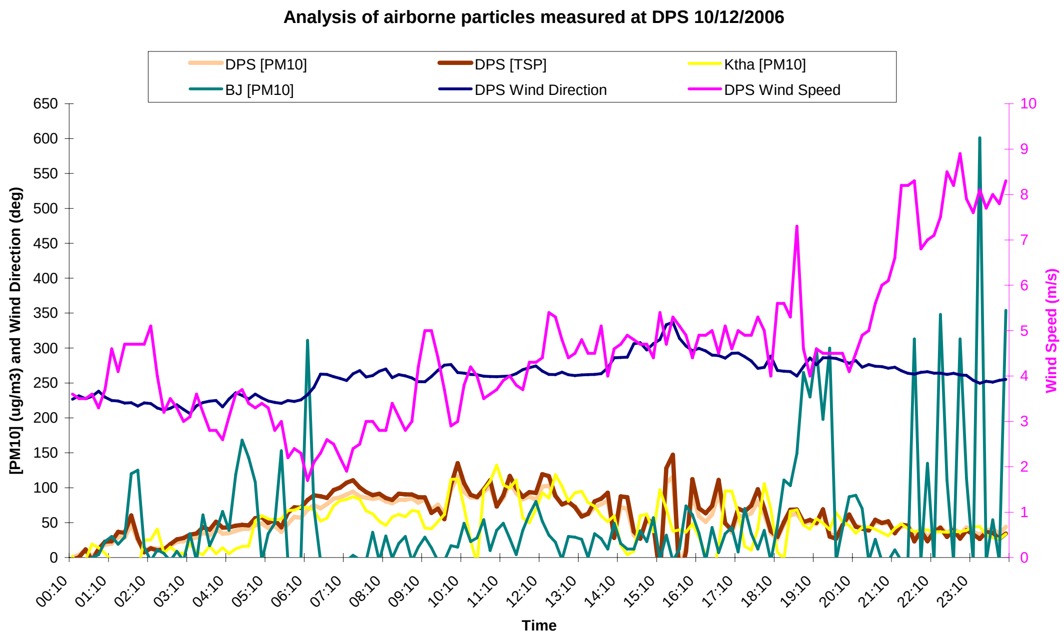
9/8/2005

The dust levels are clearly correlated with wind speeds. The wind direction throughout the during of the dust event was very steady at between 80 to 90°. The other Dampier dust monitors did not show the similar levels of increased dust during the period of the event shown here. This indicates the source causing the levels at the DPS monitor was localised. An unpaved car-park at the School located east of the monitor was sealed sometime during 2005 but possibly after this event. Notwithstanding, PI sources were unlikely to have contributed significantly to this exceedence.



15/11/2006

The elevated PM10 and TSP concentration peak is from about 0920 to 1630. Wind speeds from about 07:00 were high. Wind direction during the dust peak is from 50° swinging anti-clockwise to 340°. PP operations are implicated as the source of the dust since the King Bap monitor (upwind) does not show elevated dust and the BJ monitor downwind also shows a slight increase in dust although much less pronounced. However, the Karratha PM10 follows an almost identical trace to the DPS measurements, which indicates either a regional dust source north of the Dampier/Karratha region, or another local dust source at Karratha north of the monitor. It seems more likely that PP was a significant contributor to the DPS exceedence although this is by no means clear.



10/12/2006

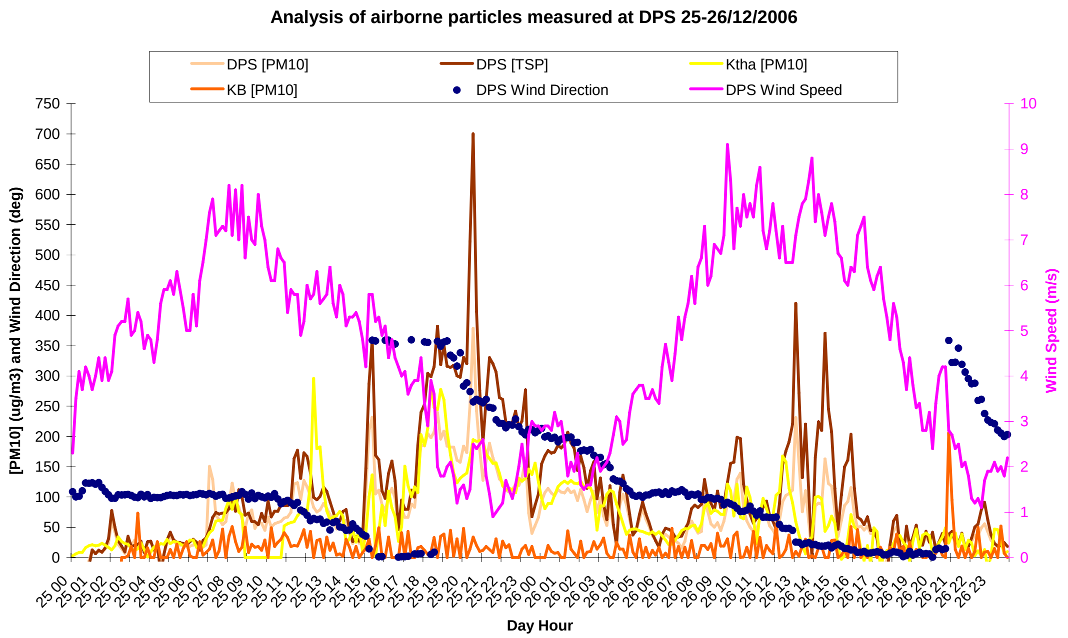
The elevated PM10 and TSP concentration peak is from about 0400 to 1900. Wind speeds were initially fairly light, generally increasing throughout the day. Wind direction during the dust peak is reasonable steady from 200° to 330°.

The EII operations are implicated as the source of the dust. The BJ trace also shows elevated dust levels particularly after wind gust periods.

As for 15/11/2006, the Karratha PM10 however, follows an remarkably similar trace to the DPS PM10.

It is not considered likely that the EII dust can affect the Karratha monitor, however there is considerable exposed ground to the west of the Karratha monitor.

At this time, it is considered that the DPS dust and Karratha dust measurements are coincidental – both due to different sources to the west, and therefore that EII is a key contributor to the exceedence at the DPS.



Wind speeds are very high during the middle of the day on both the 25th and 26th. The King Bay PM10 shows little variation in measurements throughout.

25/12/2006

The PM10 and TSP concentration initially become elevated on 25/12/2006 is from about 1500. The wind direction during the dust peak is about 50° swinging anti-clockwise. PP is clearly implicated.

The PM10 and TSP again start to peak at about 1800 with wind from the due north. The source of the dust at this stage is unclear. As the wind continues its anti-clockwise rotation through 290° downwind of EII, around 2000 the PM10 and TSP reach their maximum peak.

Dust levels slowly subside to a minimum around 26/12/2007 0500 when the wind the wind speed has subsided and direction has continued it's rotation to 100°.

26/12/2006

The elevated PM10 and TSP concentration peak is from about 0900 to 1630. The wind direction during the dust peak is from 90° swinging anti-clockwise to 10°. PP appears to be a significant contributor to the event.

The Karratha PM10 again follows a similar pattern from about 900 to 1330 however is lower than the DPS PM10 from then until the end of the event.

The PI operations are therefore considered to be significant contributors to the exceedences on both days although on top of a fairly high background.