TOWNSVILLE PORT EXPANSION PROJECT

Additional Information to the Environmental Impact Statement

APPENDIX A4

Air Quality Impact Assessment Supporting Information

TOWNSVILLE PORT EXPANSION PROJECT

AECOM BMT WBM

1.0 Introduction

The following summary outlines the aspects of the air quality assessment that were modified as a result of the design refinement and the findings of the revised dispersion modelling.

2.0 Ambient Air Quality Objectives

The *Environmental Protection (Air) Policy 2008* (EPP [Air]) sets ambient air quality objectives for priority air pollutants in Queensland. Table 1 presents air quality objectives for particulate matter and combustion gases included in this air dispersion modelling assessment, making reference to the environmental values the criteria were specifically developed to protect. It should be noted that the objectives for the particulate matter and combustion gases listed below are not applicable to air emissions experienced within a workplace that are emitted from that workplace, i.e. the objectives do not apply to the construction site itself.

These criteria are designed to provide a level to meet the health and well-being environmental value.

Table 1 Queensland EPP (Air) ambient air quality objectives

Indicator	Averaging Period	EPP (Air) Criteria	Environmental Value	Units
TSP	1 year	90	Health and well-being	$\mu g/m^3$
PM_{10}	24 hours	50*	Health and well-being	$\mu g/m^3$
$PM_{2.5}$	24 hours	25	Health and well-being	μg/m3
	Annual	8	Health and well-being	$\mu g/m^3$
NO_2	1 hour	250	Health and well-being	$\mu g/m^3$
	Annual	62	Health and well-being	$\mu g/m^3$
CO	8 hours	11,000	Health and well-being	$\mu g/m^3$
SO_2	1 hour	570	Health and well-being	$\mu g/m^3$
	24 hours	230	Health and well-being	$\mu g/m^3$
	Annual	57	Health and well-being	$\mu g/m^3$

Notes: * 5 days allowable exceedances per year. On this basis, the sixth highest predicted 24-hour concentration has been compared with the criterion.

To aid in the assessment of the dust emitted from the facility, additional criteria were sought to assist in the overall understanding of the potential for air quality impacts. The Queensland Department of Environment and Heritage Protection (DEHP) criteria for deposited dust and the NSW EPA criteria for annual average PM_{10} (DEC, 2005) were also used for assessment to assist in the understanding of dust fallout potential and long term particulate impacts from PM10. Criteria adopted were as follows:

- Deposited dust (dustfall) limit of 120 mg/m2.day averaged over 1 month.
- Annual average PM_{10} criterion of 30 $\mu g/m^3$.

3.0 Background Air Quality

The adopted background PM_{10}, Total Suspended Particulate (TSP), and dust deposition values were discussed in Section B.9.3.4.1 in the EIS. These values were still considered representative of exiting conditions at Townsville Port and have been adopted again for this Air Quality impact Assessment AQIA. The adopted values are presented in Table 2 and Table 3.

Nitrogen dioxide and sulfur dioxide are monitored in the Townsville area by DEHP at Pimlico, approximately 7 km to the south west of Townsville Port. Maximum concentrations measured during the period 2011 to 2013 were adopted as background air quality concentrations.

Table 2 Adopted background concentrations for dust

Particulate Matter Type	Averaging Period	Adopted Value (μg/m3)
PM_{10}	24 hours	24.7
	Annual	21.4
TSP	Annual	43.6
Dust Deposition	Annual	46.0 mg/m^2.day

Carbon monoxide is not monitored in the Townsville area. Carbon monoxide data were sourced from the DEHP operated monitoring station in Woolloongabba, Brisbane. The Woolloongabba station is located adjacent to a major freeway in a densely populated urban environment. CO concentrations at this location are likely to be higher than in the Townsville Port area due to higher population density and vehicle numbers. The Woolloongabba data were adopted as a conservative estimate of existing CO concentrations in Townsville.

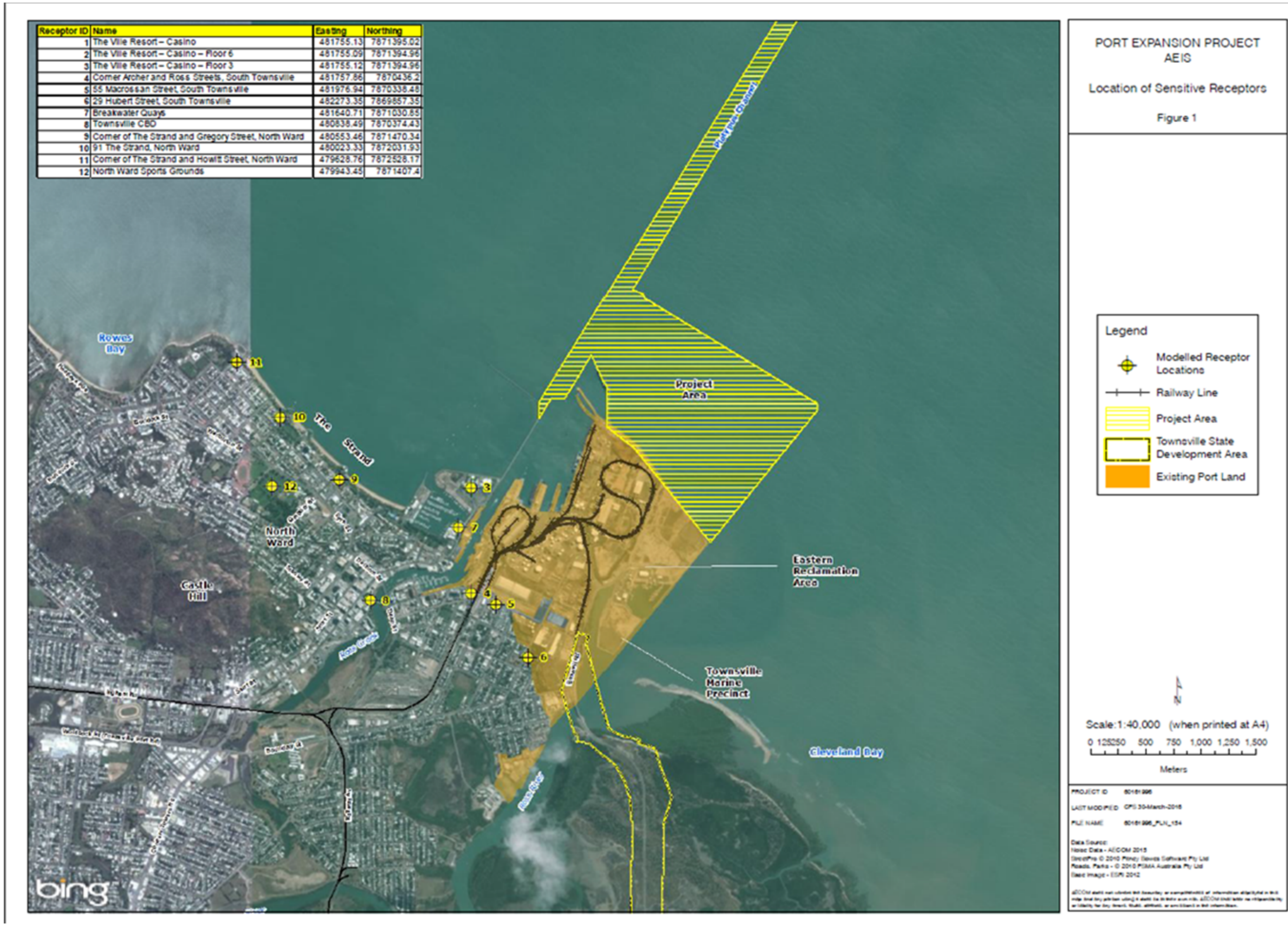
$PM_{2.5}$ data are not available in the Townsville area. These data were sourced from the DEHP Boat Creek monitoring station in Gladstone. $PM_{2.5}$ concentrations at Boat Creek are likely to be higher than in the Townsville area due to proximity of the monitoring station to heavy industry in the Gladstone area. The Boat Creek data were adopted as a conservative estimate of existing $PM_{2.5}$ concentrations in Townsville.

Table 3 Adopted background concentrations for combustion gases

Combustion Gases	Averaging Period	Station	Data period	Adopted Value (µg/m3)
NO_2	1 hour	Pimlico	2011 - 2013	86.3
	Annual	Pimlico	2011 - 2013	12.3
SO_2	1 hour	Pimlico	2011 - 2013	25.7
	24 hours	Pimlico	2011 - 2013	17.1
	Annual	Pimlico	2011 - 2013	2.9
CO	8 hour	Woolloongabba	2012 - 2013	2,250.0
$PM_{2.5}$	24 hours	Boat Creek	Feb 2013 – Jan 2014	19.9
	Annual	Boat Creek	Feb 2013 – Jan 2014	4.8

4.0 Receptors

Potential nearby sensitive receptors to the PEP are presented in Table 4 and Figure 1. Most receptors locations are identical to those included in the EIS, with the exception of Receptor 1, 2 and 3 which are flagpole receptors at The Ville Resort - Casino tower. The flagpole receptors at the Resort - Casino were included to account for the inclusion of shipping emissions, which are emitted from tall stacks and are have the potential to result in elevated concentrations above ground level.



Receptor ID	Name	Easting	Northing
1	The Ville Resort – Casino	481755.13	7871395.02
2	The Ville Resort – Casino – Floor 6	481755.09	7871394.96
3	The Ville Resort – Casino – Floor 3	481755.12	7871394.96
4	Corner Archer and Ross Streets, South Townsville	481757.86	7870436.2
5	55 Macrossan Street, South Townsville	481976.94	7870338.48
6	29 Hubert Street, South Townsville	482273.35	7869857.35
7	Breakwater Quays	481640.71	7871030.85
8	Townsville CBD	480838.49	7870374.43
9	Corner of The Strand and Gregory Street, North Ward	480553.46	7871470.34
10	91 The Strand, North Ward	480023.33	7872031.93
11	Corner of The Strand and Howitt Street, North Ward	479628.76	7872528.17
12	North Ward Sports Grounds	479943.45	7871407.4

Figure 1 Sensitive Receptors

Table 4 Sensitive receptors

Receptor ID	Modelled Receptor Location	Approximate Distance from PEP (km)	Receptor Type
1	The Ville Resort - Casino – Top Floor	1.4	Commercial
2	The Ville Resort - Casino – Floor 6	1.4	Commercial
3	The Ville Resort - Casino – Floor 3	1.4	Commercial
4	Corner Archer and Ross Streets, South Townsville	1.8	Residential
5	55 Macrossan Street, South Townsville	1.9	Residential
6	29 Hubert Street, South Townsville	2.0	Residential
7	Breakwater Quays	1.6	Residential
8	Townsville CBD	2.7	Residential
9	Corner of The Strand and Gregory Street, North Ward	2.6	Residential
10	91 The Strand, North Ward	3.1	Residential
11	Corner of The Strand and Howitt Street, North Ward	3.6	Residential
12	North Ward Sports Grounds	3.2	Public Space

5.0 Dispersion Modelling

5.1 Model

The CALPUFF air dispersion model (ASG, 2012) was used in the air quality impact assessment. CALPUFF is a non-steady-state, three-dimensional Gaussian puff model developed for the US Environmental Protection Agency for use in situations where basic Gaussian plume models are not effective, such as coastal areas with re-circulating sea breezes. Input parameters used in the CALPUFF dispersion modelling are summarised in Table 5. Further details of the modelling inputs are provided in the following sections.

Table 5 CALPUFF input parameters

Parameter	Input
CALPUFF version	6.42
Modelling domain	25 x 25 km
Modelling grid resolution	1 km
Number of sensitive receptors	13
Terrain data	Included in CALMET
Building wake data	Not included in model
Dispersion algorithm	Turbulence computed from micrometeorology using PDF method
Hours modelled	8,760 hours (365 days)
Meteorological data period	1 January 2013 to 31 December 2013

5.2 Meteorological data

Meteorological data for the period January to December 2013 used in the dispersion modelling were developed using a combination of prognostic data generated by The Air Pollution Model (TAPM) with inputs from measured data from the Coast Guard monitoring station. These data were generated in order to represent meteorological conditions at the Project area.

5.2.1 Validation of the meteorological data set

When using a single year of meteorological data as input into a dispersion model, it is necessary to demonstrate that the data are representative of the long term meteorological conditions at the site and of long term regional behaviour. The main features of the generated data set and a comparison with measured meteorological data are provided in this analysis. Note that the meteorological conditions for the single year of data used for the model will not match the long term data exactly due to yearly variation in meteorology. The purpose of this section is to demonstrate that the general long term trends are replicated by the 2013 data set.

The generated metrological data set was considered representative of long term meteorological conditions and expected regional behaviour and, subsequently, suitable for use in this assessment.

5.2.1.1 Wind

Wind rose diagrams for the site, from data generated by TAPM and CALMET meteorological models, are shown in Figure 2. For comparative purposes, the Bureau of Meteorology (BoM) wind roses from Townsville Airport are also shown.

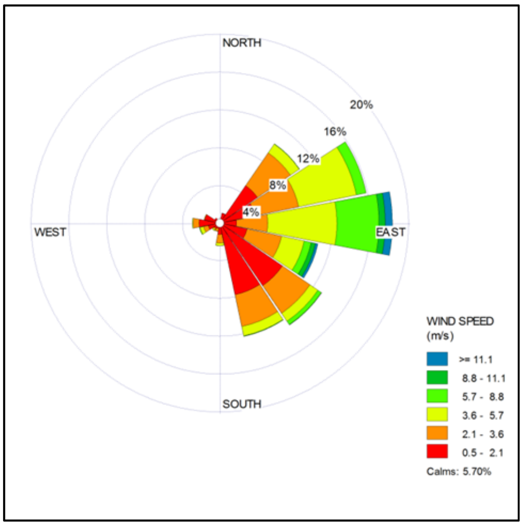
Note that the wind roses for the BoM station at Townsville Airport and the CALMET wind roses are presented on different scales. The BoM wind roses are provided in km/hr and cannot be changed whereby the CALMET wind roses are presented in m/s and have no option for presenting the data in km/hr. In addition, the number of sectors presented in the CALMET wind roses is 16, compared with 8 for the BoM wind roses. The difference in sectors results in a generally lower percentage for each sector in the CALMET wind roses. This accounts for the difference in the wind roses presented in Figure 3.

The wind roses show the frequency of occurrence of winds by direction and strength. The bar at the top of each wind rose diagram represents winds blowing from the north (i.e. northerly winds) and so on. The length of the bar represented frequency of occurrence of winds from that direction. The widths of the bars correspond to wind speed categories, the narrowest representing the lightest winds.

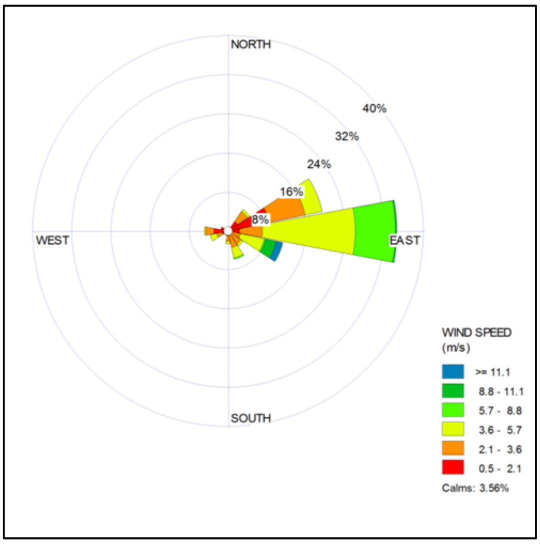
Morning winds at Townsville Port are dominated by easterly flows, rather than the south-easterly dominant BoM station at Townsville Airport. The difference is likely due to the location of the BoM station, which sits to the west of Castle Hill and is more influenced by morning south-easterly land breezes lighter easterly winds are blocked , and redirects easterlies blowing due east at the Airport. Afternoon winds are dominated by north easterly see breezes at both the Port and Airport. The winds at Townsville Port are generally the same during the dry season (Figure 3).

The estimated mean wind speed for the 2013 CALMET data was 12.9 km/hr (2.8 m/s) and 14.7 km/hr (4.1 m/s) at 9 am and 3 pm respectively. These average values are similar to the long term average 9 am wind speed but slightly lower than the long term 3 pm wind speed at BoM Townsville Airport, (11.2 m/s at 9 am and 20.8 m/s at 3 pm).

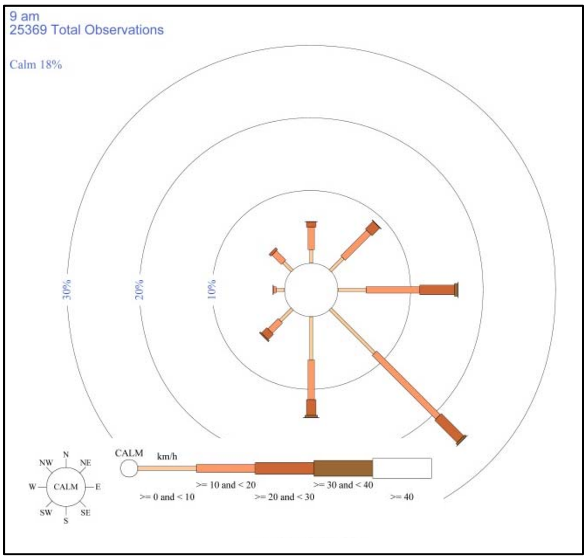
The frequency distribution of hourly averaged wind speed values is shown in Figure 4. Predicted wind speeds up to 9 m/s are relatively common, although slower wind speeds were predicted more frequently.



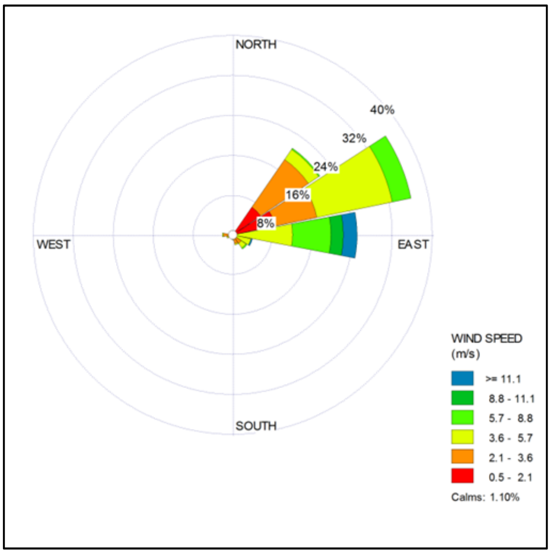
All hours – CALMET



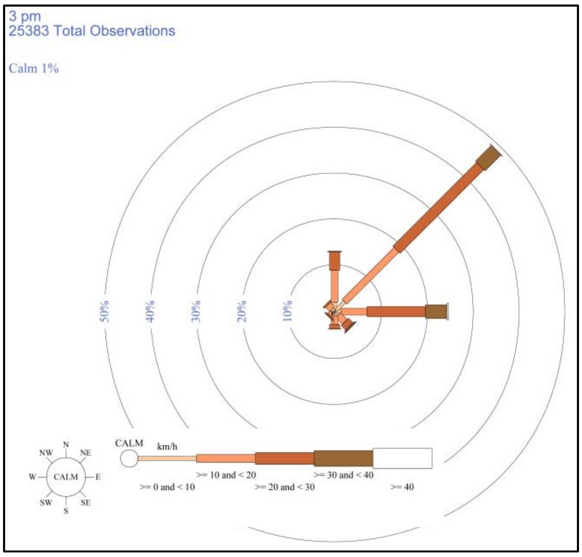
9 am - CALMET



9 am – BoM

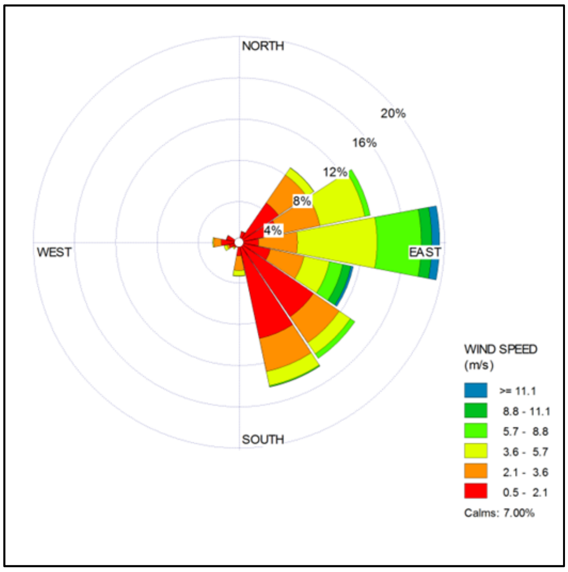


3 pm - CALMET

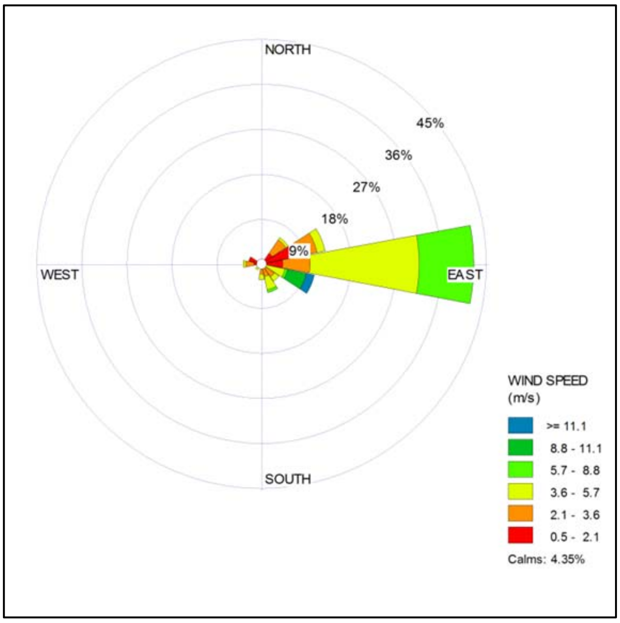


3 pm - BoM

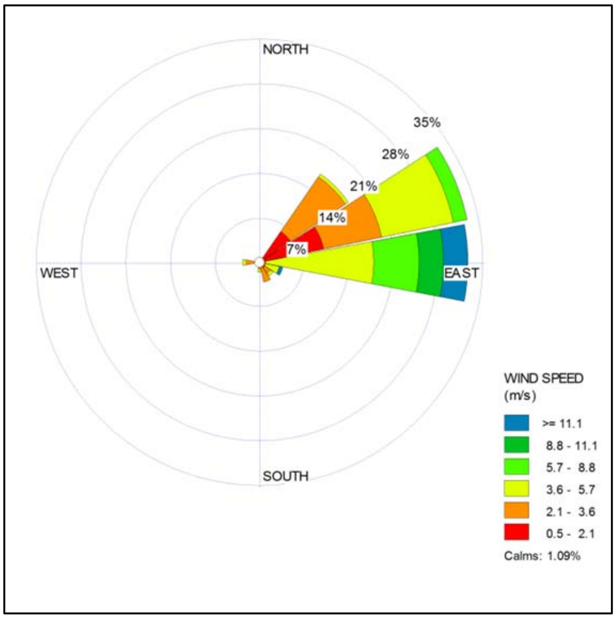
Figure 2 Wind roses for site data generated by TAPM – CALMET, 2013 vs BoM Townsville Airport, 1940 - 2010



May to October all hours - CALMET



May to October 9 am - CALMET



May to October 3 pm - CALMET

Figure 3 Dry season wind roses for site data generated by TAPM – CALMET, 2013

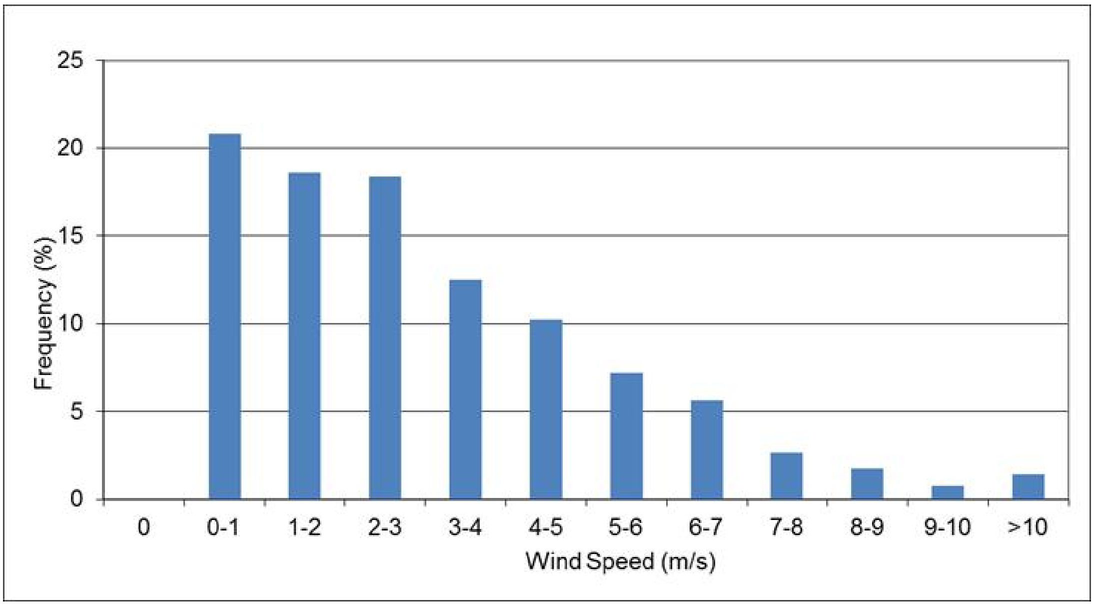


Figure 4 2013 Wind Speed Frequency Distribution – CALMET

As shown in Figure 5, average wind speeds are typically lower during the night hours, and increase during the morning and strongest by mid-afternoon. The predicted wind speeds generated from TAPM and CALMET were similar in the morning to those measured at BoM Townsville Airport but a slightly lower in the afternoon. Lower wind speeds typically results in worst-case dispersion and hence at locations close to the source for ground-based emissions lower wind speeds will result in worst-case impacts (due to the lower levels of turbulence and therefore lower mixing associated with lower wind speeds).

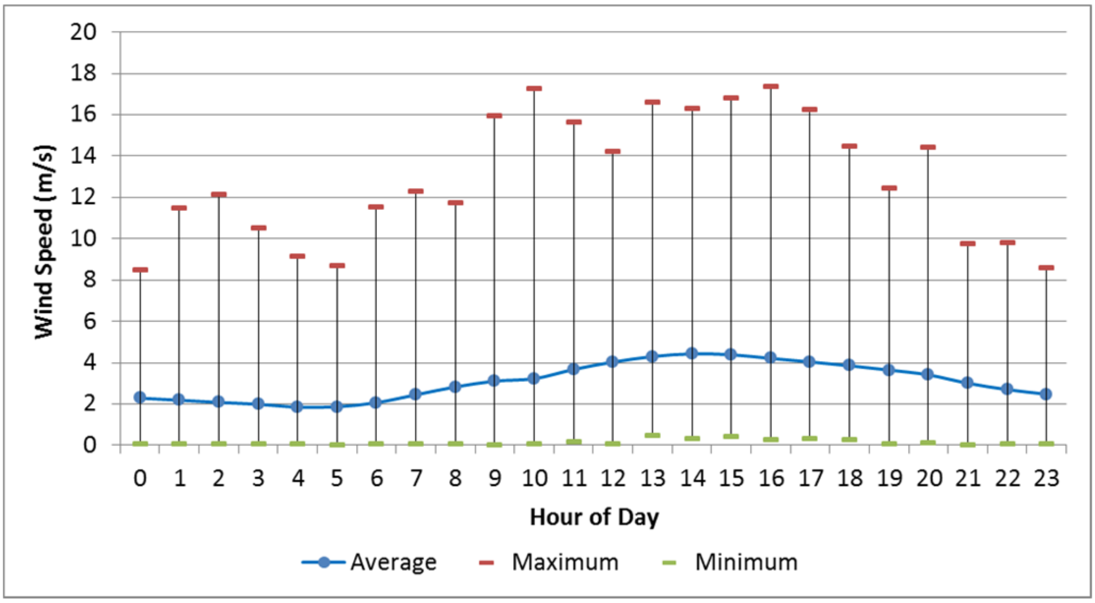


Figure 5 Wind Speed Analysis – CALMET Data

5.2.1.2 Mixing Height

Mixing height is the depth in the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of particulates and gases is generally considered to be limited by the mixing height, above which air tends to be stable with limited vertical movement.

CALMET was used to calculate mixing heights at the site. The diurnal variation of mixing height is presented in Figure 6. On average, mixing heights are lowest during the night and early morning hours (< 200 m), increasing after sunrise as the sun heats the air near the ground and drives vertical convection in the atmosphere. This pattern is consistent with the coastal location of the site.

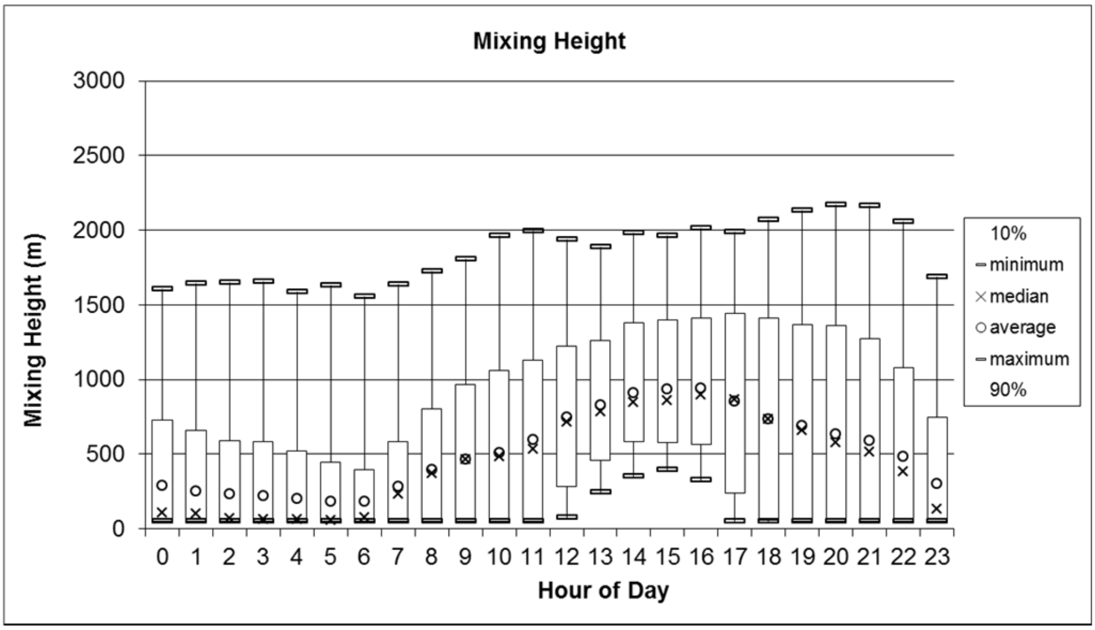


Figure 6 Hourly Mixing Height – CALMET Data, 2013

5.2.1.3 Stability Class

The Pasquill-Gifford stability classification scheme denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and enhanced dispersion. At the other extreme, Class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions, pollution is trapped beneath the inversion layer and can remain undiluted for considerable distances downwind from a source. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Wind classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small. As a general rule, unstable (or convective) conditions dominate during daytime and stable flows are dominant at night. The diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

The frequency distribution of estimated stability classes in the CALMET data file are presented in Figure 7. Nearly half of the data represent stable conditions (Classes E and F). This is consistent with the expected occurrence of stable conditions at site, given the coastal location and the relatively low occurrence of light winds.

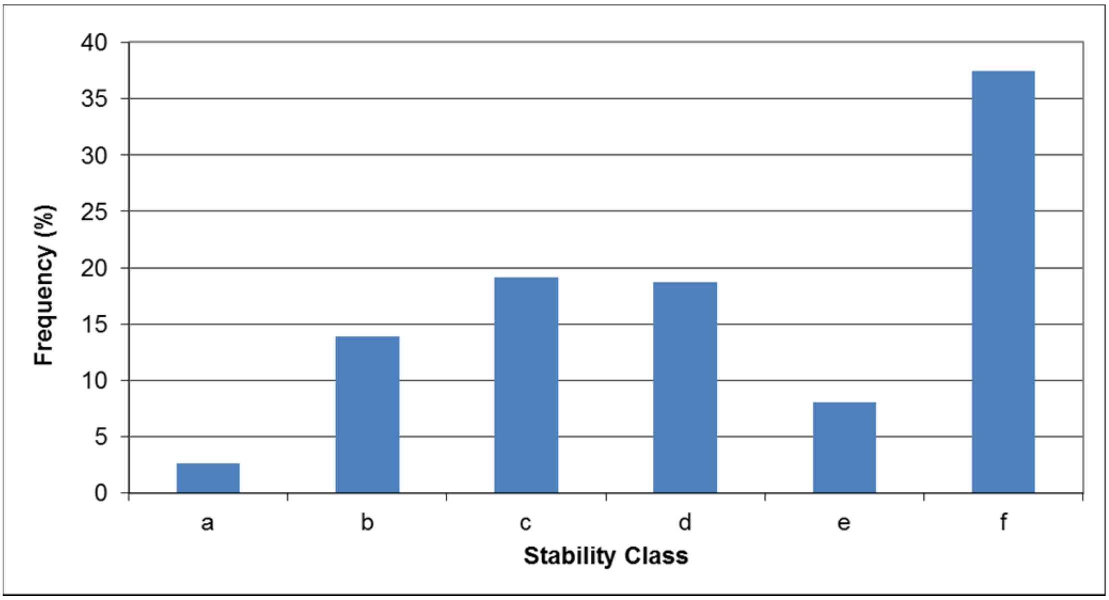


Figure 7 Pasquill-Gifford Stability Classes – CALMET Data, 2013

5.2.1.4 Temperature

The temperature distribution of the CALMET-generated data is presented in Figure 8. As expected, temperatures are coolest in the early morning and night. Maximum temperatures occur during early to mid-afternoon.

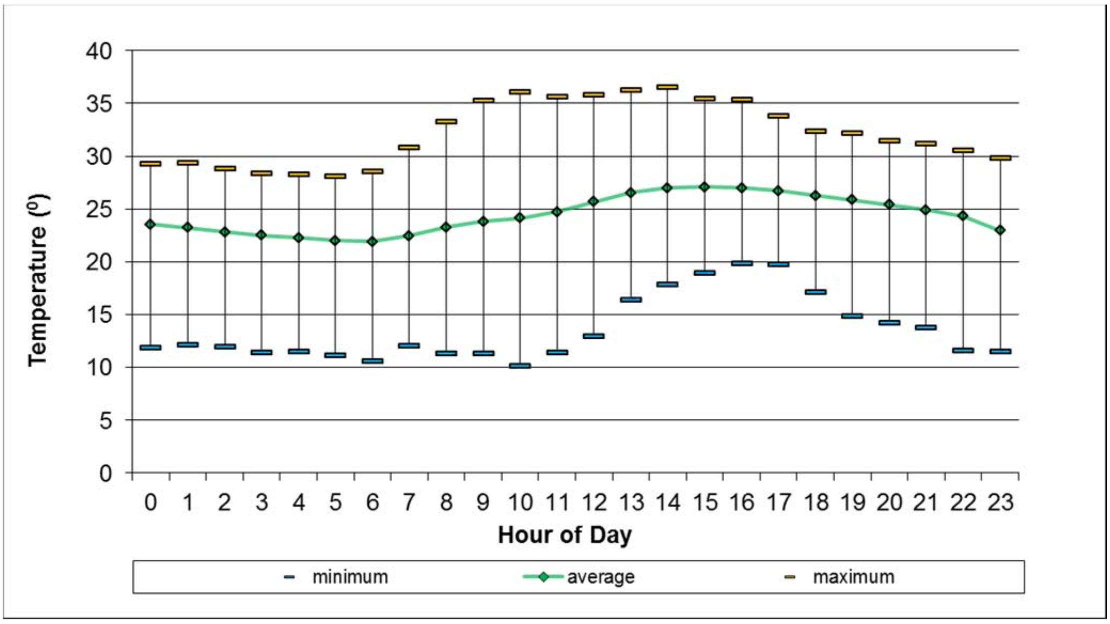


Figure 8 Temperature Distribution – CALMET Data, 2013

A comparison of the CALMET-generated monthly average maximum and minimum temperature data against long-term monthly average BoM data is presented in Figure 9. The monthly average BoM data site right on the average CALMET monthly averages, suggesting 2013 was a normal year when compared with long term averages.

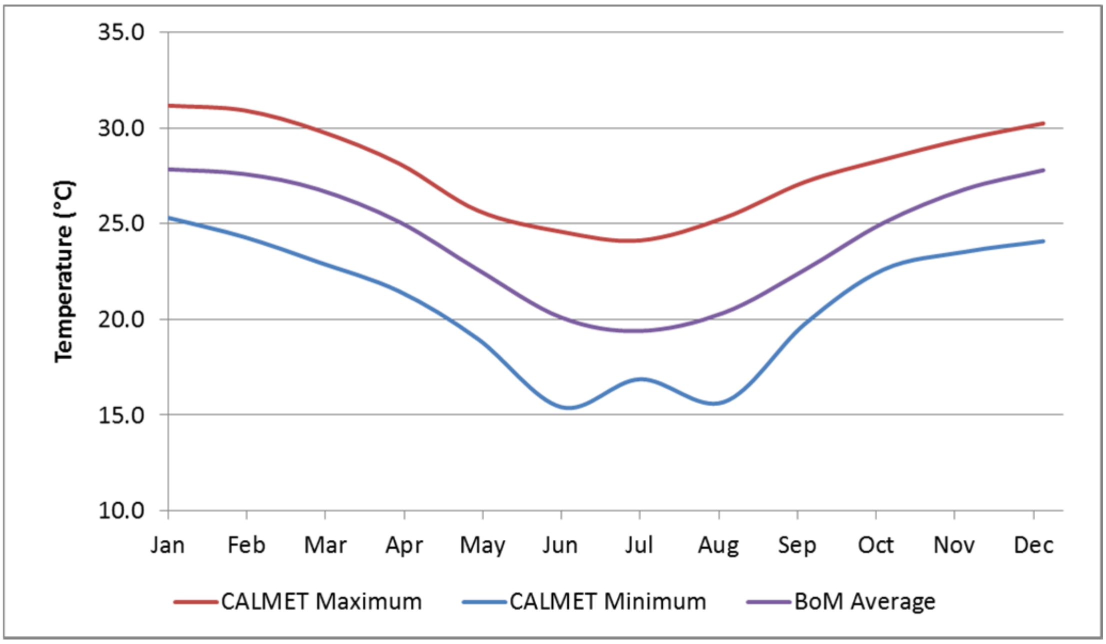


Figure 9 Temperature Data Comparison

5.3 Modelling Scenarios

The construction works for the refined PEP are expected to be undertaken in 3 stages (Stages 1 to 3). As part of this revised assessment, three scenarios, one for each of the revised PEP construction stages were selected to provide more detail on potential air quality impacts. The three modelling scenarios are described as follows.

- Stage 1 Scenario: Dust and shipping emissions for construction Stage 1, with haul roads unsealed. The haul roads are assumed to run from the boundary of the existing sealed section of road to approximately the centre of the Stage 1 reclamation area. The length of the unsealed haul road was modelled as 1 km (2 km round trip per vehicle). Wind erosion emissions were included for approximately 25 ha of the reclamation area.
- Stage 2 Scenario: Dust and shipping emissions for construction Stage 2, with internal haul roads from construction Stage 1 which have been sealed to a degree whereby negligible dust is emitted. This scenario assumed unsealed haul road distance of 1 km and that the initial entry road onto the PEP had been sealed. Wind erosion emissions were included only for newly reclaimed land in Stage 2 — reclaimed land from Stage 1 was assumed to be sealed (through surface sealing or vegetation).
- Stage 3 Scenario: Dust and shipping emission sources for construction Stage 3 with internal haul roads from construction Stage 1 and 2 which have been sealed to a degree whereby negligible dust is emitted. Wind erosion emissions were included only for newly reclaimed land in Stage 3. — reclaimed land from Stage 1 and 2 was assumed to be sealed (through surface sealing or vegetation).

The proposed development layout for construction Stages 1, 2 and 3 are presented in Figure 10 to Figure 12.

Shipping parameters for each scenario are presented in Table 6. Historical data provided by POTL indicated an approximately 65 % berth utilisation at the existing port. This utilisation rate was used to estimate the number of berths occupied in both the existing port and the PEP for each modelled scenario.

Construction activities and fleet data for each scenario are presented in Table 7.

Table 6 Summary of shipping emission included in each scenario

Scenario	Construction Stage	PEP Berths	PEP Berths Modelled	Existing Port Berths	Existing Port Berths Modelled	Dredge Emissions
Stage 1	1	Nil	Nil	9[1]	6	Yes
Stage 2	2	2	2	9	6	Yes
Stage 3	3	5	3	9	6	Yes

[1] Existing Berth 7 is currently being demolished (at the time of this report drafting) but was included in the modelling for consistency with EIS

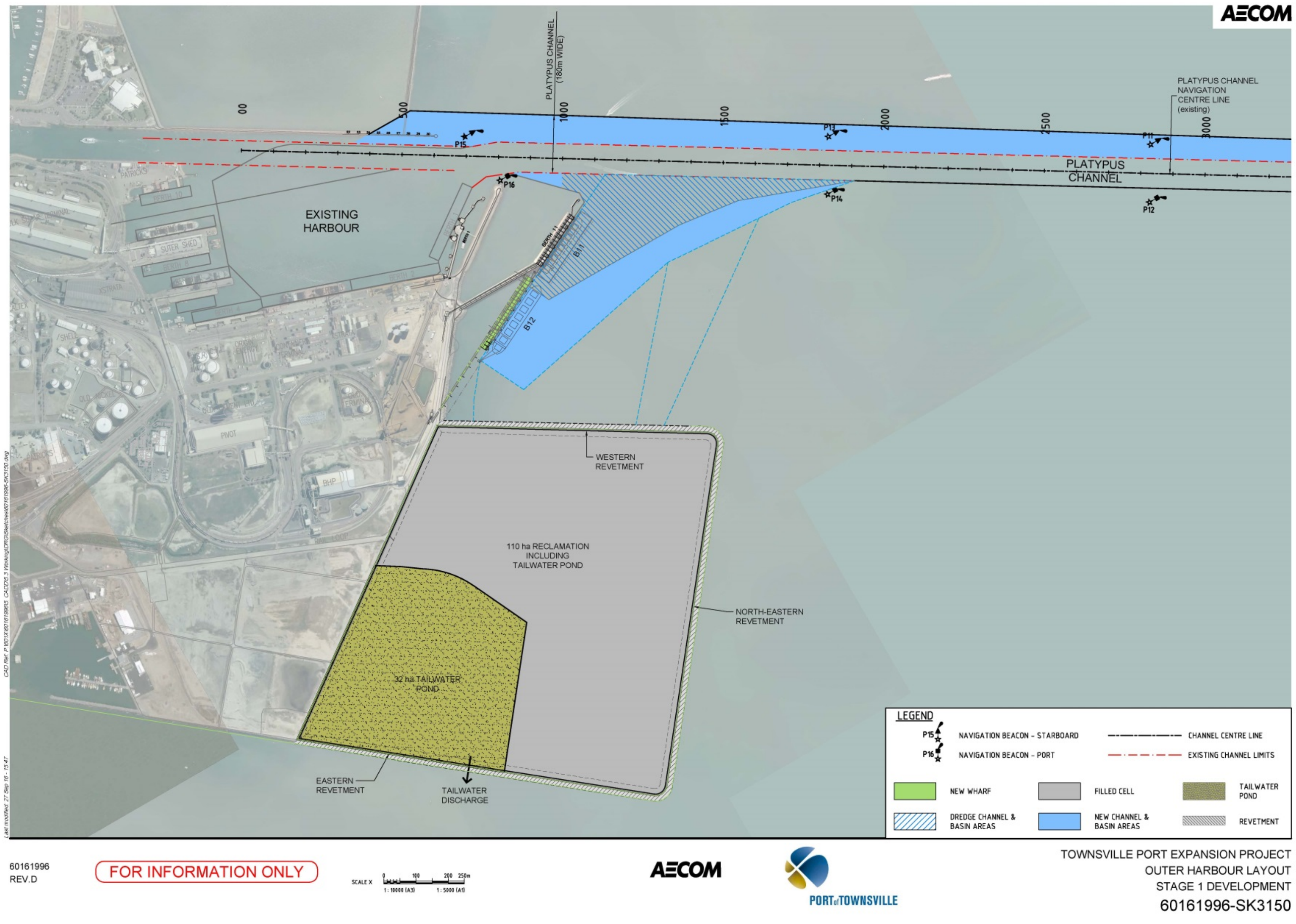


Figure 10 PEP Stage 1 Development

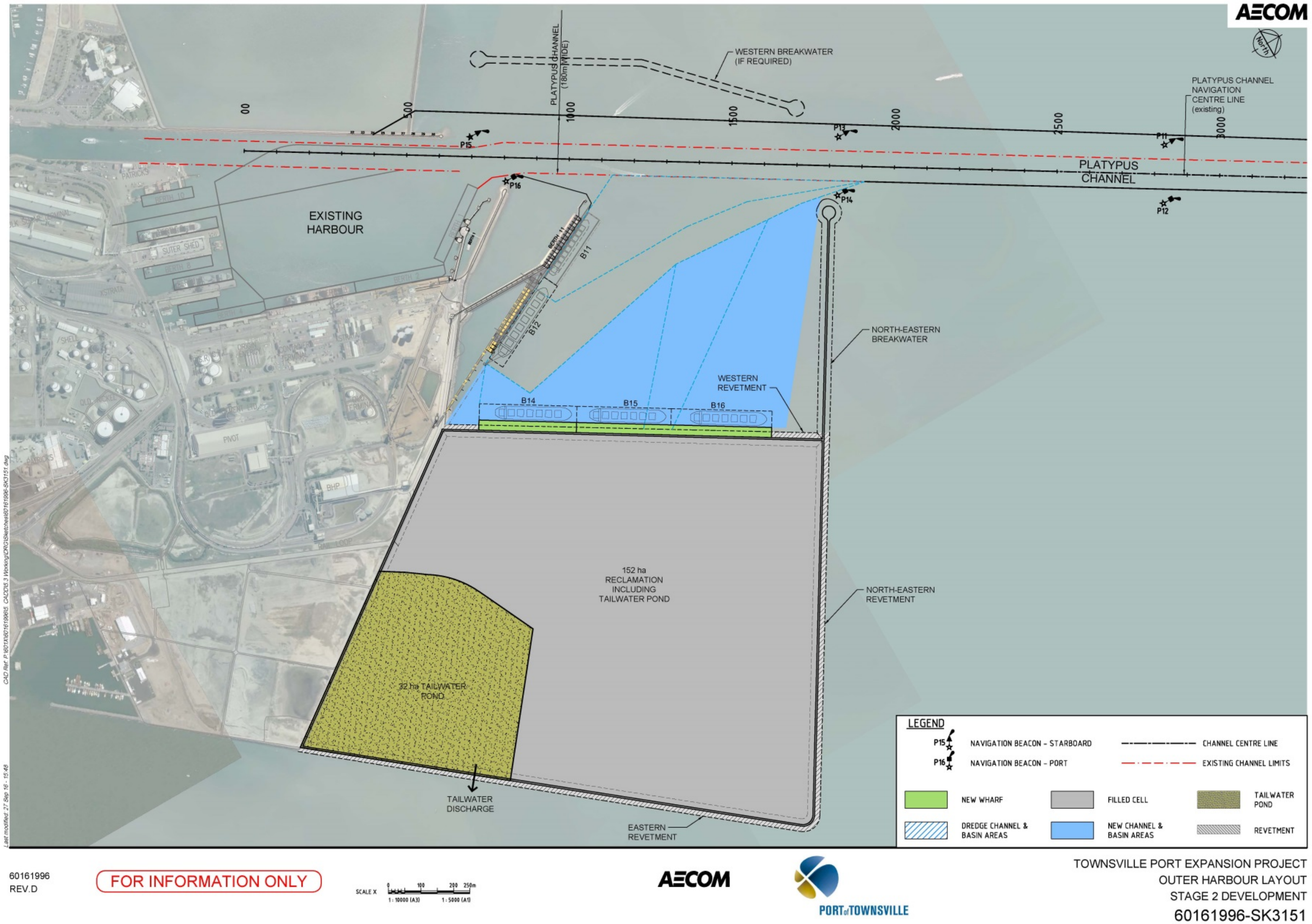


Figure 11 PEP Stage 2 Development

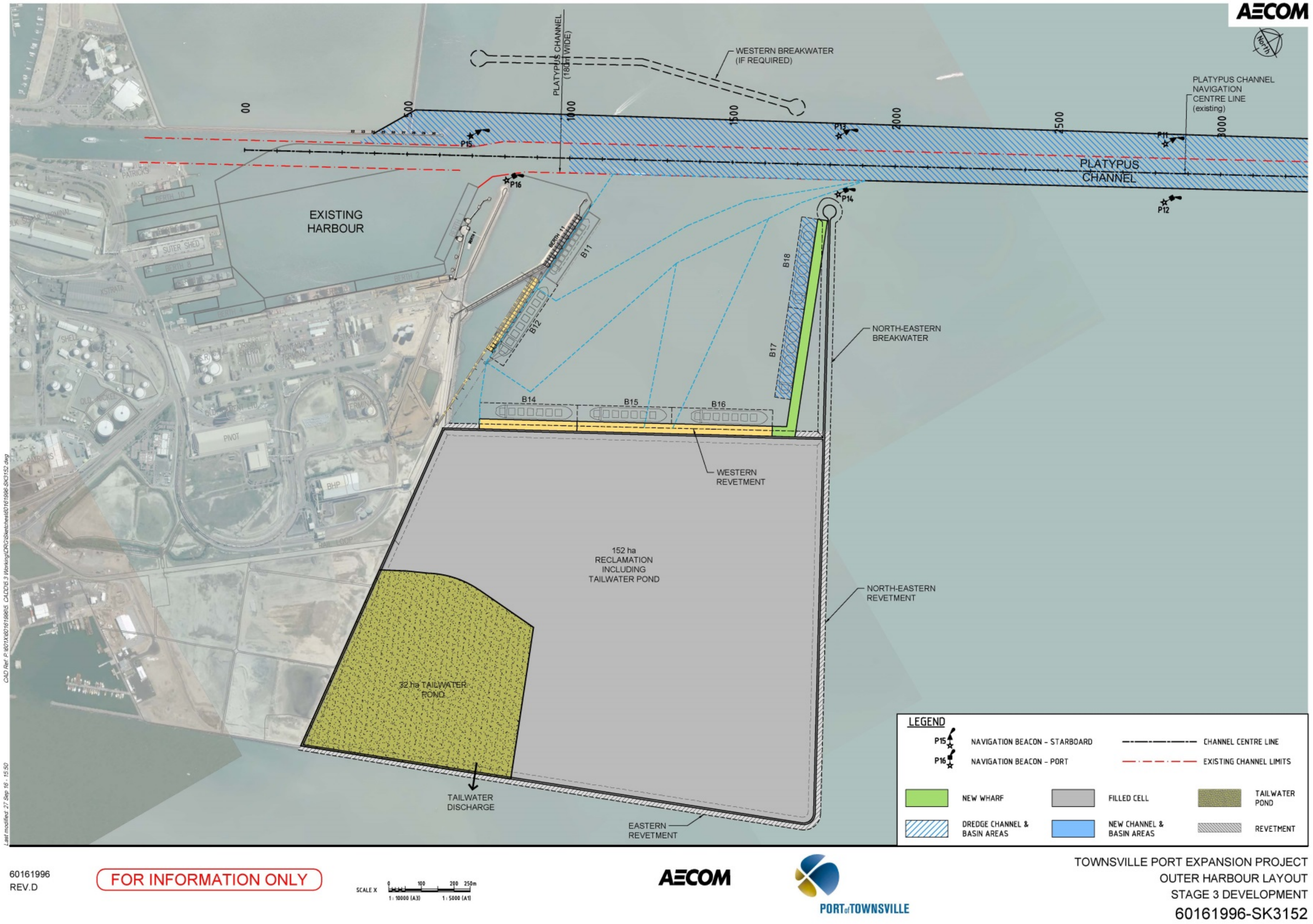


Figure 12 PEP Stage 3 Development

Table 7 Summary of construction emission sources

Works and Activities	Location	Equipment	Stage 1		Stage 2		Stage 3	
			Duration (weeks)	Number	Duration (weeks)	Number	Duration (weeks)	Number
Bund, Revetment Structures for Reclamation and Wharf Construction (24/7)								
Delivery of material for bunds, revetments, breakwaters and wharfs	Perimeter	Trucks	48	9 (trips/hour)	48	8 (trips/hour)	NA	NA
Handling and placing rockfill	Perimeter	Excavator	48	3	48	3	NA	NA
Trimming/level finish surface	Perimeter	Bulldozer	48	1	48	1	NA	NA
Construction management	Perimeter	Utility vehicles	48	2 (trips/hour)	48	2 (trips/hour)	NA	NA
Reclamation area (dredge discharge activity 24/7; capping layer activity 24/7)								
Reclamation operations involving moving of pipelines, shifting surcharge material, placement of capping layer	Reclamation area	Bulldozers/front-end loaders/ excavator	167	4	175	4	121	4
Delivery of material for capping layer and pavements	Reclamation area	On-road dump trucks	39	2 (trips/hour)	39	2 (trips/hour)	121	2 (trips/hour)
Construction management	Reclamation area	Utility vehicles	230	2 (trips/hour)	39	2 (trips/hour)	121	2 (trips/hour)

5.4 Emissions Estimation

5.4.1 Shipping Emissions

Shipping emissions were estimated based on a number of assumptions around ship size and engine power. Only ships at berth were considered for inclusion in the emissions inventory. All ships at berth were assumed to be running a single auxiliary engine 24 hours a day seven days a week. Dredging emissions were based on total on-board engine power rating.

Emissions factors for specific engine type and fuel type were sourced from Browning and Bailey (2006). A summary of emission factors is presented in Table 8. Ship engine power ratings were estimated.

Emission rates were calculated using the emission factors for each ship class based on 24 hours a day, 7 days a week operation, by means of the following equation [from Browning and Bailey (2006)]:

$$Emission\ Rate = P * LF * A * EF$$

Where:

- P = maximum continuous rating power (kilowatts [kW])
- LF = load factor (percent of vehicles total power)
- A = activity (hours [h])
- EF = emission factor (grams per kilowatt hour [g/kWh])

The numbers of ships in each size class that were included in each modelled scenario are presented in

Table 9. The number of ships included was based on an historical berth occupancy rate at the Port of 65 %.

Total calculated shipping emission rates (in grams per second) for each scenario are presented in Table 10. The emission rates represent the sum of emissions from all ships at berth and dredging activities.

Ship auxiliary engine exhaust stack parameters used in the modelling are presented in

Table 11. No data was available for ships berthed at the existing Townsville Port. These data were based on ship stack parameter data used in SKM (2007).

Table 8 Summary of shipping emission and correction factors

Ship Engine Type	Fuel Type	Emission Factor (g/kWh)	Engine Power (kW)	Load Factor	Factor Source
Ocean going vessel auxiliary engine	Marine Diesel Oil	NO_x = 13.9 SO_2 = 2.76 CO = 1.1 PM_{10} = 0.37 $PM_{2.5}$ =0.34	Support Vessels = 23 - 82 Hopper barge = 450 Small Ships = 500 Medium Ships = 1500 Large Ships = 6000	Hotelling 22% of the time	Browning and Bailey (2006)
Large backhoe dredge	Diesel	NO_x = 10 SO_2 = 0.63 CO = 1.5 PM_{10} = 0.4 $PM_{2.5}$ =0.39	1600	100 %	NPI (2008)
TSHD (trailing suction hopper dredger) pump (channel dredging)	Diesel	NO_x = 13 SO_2 = 0.63 CO = 2.5 PM_{10} = 0.3 $PM_{2.5}$ =0.29	1755	100 %	NPI (2008)

Table 9 Number of ships modelled by scenario

Scenario	Existing Port					PEP					
	No. Port Berths	No. Large Ships	No. Medium Ships	No. Small Ships	Total Ships	No. Port Berths	No. Large Ships	No. Medium Ships	No. Small Ships	Total PEP Ships Modelled	No. Port Berths
Stage 1	9	2	2	2	6	NA	NA	NA	NA	NA	9
Stage 2	9	2	2	2	6	2	2	0	0	2	9
Stage 3	9	2	2	2	6	3	2	1	0	3	9

Table 10 Summary of shipping emission rates

Scenario	Emission Rate (g/s)				
	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO
Stage 1	20.7	2.7	0.6	0.5	2.6
Stage 2	30.3	4.8	1.2	1.1	3.8
Stage 3	31.5	5.0	1.2	1.1	3.9

Table 11 Ship stack parameters

Ship Class	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (°K)
Small/ Medium/ Dredge	32.2	1.0	13.0	623
Large	39.8	1.0	32.8	623

5.4.2 Conversion of NOx to NO2

Nitrogen oxides (NOx) are produced in most combustion processes and are formed by the oxidation of nitrogen in the fuel and nitrogen in the air. During high-temperature processes a variety of nitrogen oxides are formed including nitric oxide (NO) and NO_2. At the point of emission NO will generally comprise the majority of the emissions, with 95% by volume with the remaining 5% taken up mostly by NO_2.

The oxidation of NO to NO_2 can be assessed by various methods. In this assessment a conservative assumption that 100% of NO_x emitted is converted to NO_2 was used.

5.4.3 Construction dust

A Project-specific emissions inventory of construction activities at the PEP for each emission of interest and each modelling scenario was developed based on published emission factors listed in the National Pollutant Inventory (NPI, 2012) and the US Environmental Protection Agency 'Emissions Factors and AP-42 – Compilation of Air Pollutant Emission Factors' (AP-42) (USEPA, 1998). In the absence of site-specific emissions data, the published emission factors have been adopted for this assessment.

Relevant mitigation control efficiencies listed in the NPI and AP-42 for were applied to construction activity emission rates. These measures were:

- road watering for unsealed roads
- watering of bulldozer activities on friable soil (where wet soils are being spread, watering is not required)
- areas which are not to be worked for long periods of time are to be sealed to prevent the generation of dust; for example, using one of a variety of methods such as hydromulching, chemical sealing etc.

A summary of the emission factors and relevant mitigation correction factors used are presented in Table 12.

Table 12 Summary of dust emission and correction factors

Activity	Emission Factor	Source	Units	Variables	Correction Factors
Wheel generated dust from unsealed haul roads –trucks	$EF_{TSP} = \frac{0.4536}{1.6093} \times 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$ $EF_{PM_{10}} = \frac{0.4536}{1.6093} \times 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	AP-42 (USEPA 2006) recommended in NPI (2012)	kg/VKT[1]	s = material silt content in % W = weight of vehicle in t	Level 2 Watering 75 %
Wheel generated dust from unsealed haul roads –light vehicles	Default of 0.94 for TSP Default of 0.33 for PM_{10}	NPI (2012)	kg/VKT[1]		Level 2 Watering 75 %
Bulldozers on fill material	Default of 17 for TSP Default of 4.1 for PM_{10}	NPI (2012)	kg/h/vehicle	-	Watering 50 %
Excavator on revetments/ reclamation fill material	Default of 0.018 for TSP Default of 0.008 for PM_{10}	AP-42 Chapter 11.9 Table 11.9-4 (USEPA 1988)	kg/t	-	-
Trucks dumping rocks/ fill material	Default of 0.012 for TSP Default of 0.0042 for PM_{10}	NPI (2012)	kg/t	-	-
Wind erosion from exposed areas	Default of 0.4 for TSP Default of 0.2 for PM_{10}	NPI (2012)	kg/ha/h	-	-

[1] VKT = vehicle kilometres travelled

Emission rates for construction activities for each modelling scenario are presented in Table 13 to Table 16. For Stages 1, 2 and 3, dust emission rates were estimated to be higher for construction of the reclamation area than for construction of the revetments. Because the reclamation area will be constructed after the construction of the revetments is finished, revetment construction emission sources were not considered for Stages 1, 2 or 3. Worst case construction emissions are expected to occur during the reclamation and as such the omission of the revetment construction is not expected to affect the result or conclusions of the assessment.

Table 13 Stage 1 construction activity emission rates

Stage 1	TSP (g/s)	% Contribution	PM_{10} (g/s)	% Contribution
Reclamation Area Construction Sources				
Truck Haul Emissions Loaded	1.33	14%	0.38	11%
Truck Haul Emissions Unloaded	0.81	8%	0.23	7%
Truck Dumping Emissions	0.31	3%	0.11	3%
Excavator Emissions	0.49	5%	0.24	7%
FEL Emissions	0.16	2%	0.08	2%
Bulldozer Emissions	3.50	37%	0.90	25%
Small Vehicle Emissions	0.10	1%	0.04	1%
Open Area Wind Erosion	2.93	30%	1.47	43%
Total Emissions	9.68	-	3.39	-
Contribution percentages have been rounded which has resulted in minor rounding errors when summed.				

Table 14 Stage 2 construction activity emission rates

Stage 2	TSP (g/s)	% Contribution	PM_{10} (g/s)	% Contribution
Reclamation Area Construction Sources				
Truck Haul Emissions Loaded	1.81	15%	0.52	11%
Truck Haul Emissions Unloaded	1.11	9%	0.32	7%
Truck Dumping Emissions	0.50	4%	0.18	4%
Excavator Emissions	0.79	6%	0.38	8%
FEL Emissions	0.26	2%	0.13	3%
Bulldozer Emissions	3.50	28%	0.90	19%
Small Vehicle Emissions	0.08	1%	0.03	1%
Open Area Wind Erosion	4.41	35%	2.20	48%
Total Emissions	12.51	-	4.61	-
Contribution percentages have been rounded which has resulted in minor rounding errors when summed.				

Table 15 Stage 3 construction activity emission rates

Stage 3	TSP (g/s)	% Contribution	PM_{10} (g/s)	% Contribution
Reclamation Area Construction Sources				
Truck Haul Emissions Loaded	0.81	10%	0.23	9%
Truck Haul Emissions Unloaded	0.50	6%	0.14	5%
Truck Dumping Emissions	0.46	6%	0.16	6%
Excavator Emissions	0.71	9%	0.34	13%
FEL Emissions	0.24	3%	0.11	4%
Bulldozer Emissions	3.50	45%	0.90	32%
Small Vehicle Emissions	0.05	1%	0.02	1%
Open Area Wind Erosion	1.53	20%	0.77	29%
Total Emissions	7.83	-	2.63	-
Contribution percentages have been rounded which has resulted in minor rounding errors when summed.				

6.0 Modelling Results Summary

The following section outlines the tabulated results for the sensitive receptors for the following emissions:

- Construction Emissions:
  - PM_{10}
  - TSP
  - Dust deposition rate.
- Shipping Emissions:
  - NO_2
  - SO_2
  - CO
  - $PM_{2.5}$.

6.1 Construction Dust (PEP in isolation from background)

The results for the dispersion modelling for the construction scenarios are presented in this section. Predicted 6th highest 24 hour average PM_{10} and annual average PM_{10} concentrations from PEP emissions in isolation at each modelled sensitive receptor are presented in Table 16. Predicted concentrations were well below the relevant criteria at all sensitive receptors.

Table 16 Predicted PM10 concentrations – PEP in isolation

Receptor ID	Predicted PEP Contribution PM_{10} ($\mu g/m^3$)					
	6th Highest 24 Hour Average			Annual Average		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	5.0	5.2	4.0	1.8	1.8	1.3
2 – Casino Floor 6	6.8	6.8	4.9	2.3	2.2	1.7
3 – Casino Floor 3	12.8	12.4	8.8	3.7	3.5	2.7
4 – Archer and Ross	14.7	13.5	10.5	3.0	3.1	2.3
5 – Macrossan	17.9	17.7	15.4	3.5	3.8	2.8
6 – Hubert	13.9	15.8	10.0	1.9	2.6	1.8
7 – Breakwater	12.2	13.1	11.0	3.2	3.1	2.6
8 – CBD	6.7	6.3	5.1	1.4	1.5	1.2
9 – Strand and Gregory	11.9	15.5	11.4	2.6	3.4	2.5
10 – Strand	12.1	14.4	11.4	2.8	3.5	2.7
11 – Strand and Howitt	9.9	15.8	12.3	3.0	3.8	2.9
12 – North Ward	7.9	8.8	6.9	1.7	1.9	1.4
Criteria	50			30		

Maximum predicted 24 hour average PM_{10} concentrations at each sensitive receptor are presented in Table 17. All predicted concentrations for PEP emissions in isolation were predicted to be below criteria at all sensitive receptors for all scenarios.

Table 17 Predicted maximum 24 hour average PM10 concentrations – Revised PEP in isolation

Receptor ID	Predicted PEP Contribution PM_{10} Maximum 24 Hour Average ($\mu g/m^3$)		
	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	7.3	6.3	4.9
2 – Casino Floor 6	10.2	8.1	5.9
3 – Casino Floor 3	18.0	14.0	11.4
4 – Archer and Ross	29.2	28.4	21.6
5 – Macrossan	37.2	33.0	26.0
6 – Hubert	26.9	24.3	16.8
7 – Breakwater	20.2	19.5	12.6
8 – CBD	16.6	15.2	10.6
9 – Strand and Gregory	20.2	28.4	17.4
10 – Strand	15.3	17.4	19.2
11 – Strand and Howitt	14.9	17.4	16.0
12 – North Ward	17.8	13.8	11.2

Predicted annual average TSP concentrations and dust deposition rates at sensitive receptors from PEP emission in isolation are presented in Table 18. Predicted TSP and dust deposition impacts were well below criteria at all sensitive receptors.

Table 18 Predicted TSP concentrations and dust deposition rates – PEP in isolation

Receptor ID	Predicted PEP Contribution Annual Average TSP ($\mu g/m^3$)			Predicted PEP Contribution Dust Deposition Rate ($g/m^2/month$)		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	5.7	5.5	4.0	0.00	0.00	0.00
2 – Casino Floor 6	9.1	7.2	5.3	0.00	0.00	0.00
3 – Casino Floor 3	7.2	11.1	8.3	0.00	0.00	0.00
4 – Archer and Ross	8.6	9.6	7.2	0.04	0.02	0.01
5 – Macrossan	4.6	12.2	8.7	0.04	0.03	0.01
6 – Hubert	7.6	8.4	6.2	0.02	0.01	0.00
7 – Breakwater	3.4	9.6	7.8	0.06	0.04	0.02
8 – CBD	6.2	4.7	3.8	0.02	0.01	0.01
9 – Strand and Gregory	6.6	10.0	7.8	0.03	0.03	0.02
10 – Strand	7.0	10.7	8.6	0.03	0.02	0.02
11 – Strand and Howitt	3.8	11.3	8.7	0.02	0.02	0.02
12 – North Ward	3.8	5.9	4.5	0.02	0.01	0.01
Criteria	90			4		

6.2 Shipping Emission Results (PEP in isolation from background)

The following Table 19 to Table 22 present the modelling results for the shipping emissions in isolation to the background. The predicted pollutant concentrations presented in these tables include emissions from ships berthed at both the existing port and the PEP. Predicted concentrations of combustion gases due to port operations in isolation were all below relevant air quality criteria at all sensitive receptors.

Table 19 Predicted NO2 concentrations at sensitive receptors - shipping emissions in isolation

Receptor ID	Predicted PEP NO_2 Contribution ($\mu g/m^3$)					
	Maximum 1 Hour Average			Annual Average		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	77.2	138.9	102.4	3.5	4.1	4.4
2 – Casino Floor 6	91.4	136.9	110.6	3.5	4.0	4.4
3 – Casino Floor 3	137.2	134.2	146.0	3.5	4.0	4.4
4 – Archer and Ross	66.4	80.1	80.6	1.6	2.2	2.1
5 – Macrossan	59.3	90.9	79.2	1.3	2.0	1.8
6 – Hubert	73.1	55.8	80.3	0.7	1.2	1.0
7 – Breakwater	60.0	97.8	78.5	2.7	3.5	3.4
8 – CBD	45.7	76.0	67.4	1.3	1.8	1.8
9 – Strand and Gregory	128.9	58.3	128.3	1.3	1.5	1.7
10 – Strand	72.6	51.2	64.9	0.9	1.2	1.2
11 – Strand and Howitt	75.9	44.4	105.2	0.8	1.0	1.0
12 – North Ward	41.0	53.6	44.6	1.1	1.3	1.4
Criteria	250			62		

Figures 13 – 15 illustrate NO_2 concentrations ($\mu g/m^3$)) at sensitive receptors for Stage 1, Stage 2 and Stage 3.

PORT EXPANSION PROJECT
AEIS

Stage 1
NO_2 Concentrations (µg/m3)

Figure 13

Legend

A	Modelled Receptor Locations
	Railway Line
	Existing Channel Limits
	Channel Centre Line
	Concentration Contours
	Existing Port Land
	Port Expansion Area

Scale: 1:35,000 (when printed at A4)

0 0.5 1

Kilometres

PROJECT ID 60161996

LAST MODIFIED XL 27-Sep-2016

FILE NAME G60161996_008_AirContours_20160927_A3

Data Source:
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Parks - © 2010 PSMA Australia Pty Ltd
Imagery - QBing 2016.
Receptors - AECOM 2016

PORT EXPANSION PROJECT AEIS

Stage 2

NO_2 Concentrations (µg/m3)

Figure 14

Legend

- A Modelled Receptor Locations
- Railway Line
- Existing Channel Limits
- Channel Centre Line
- Concentration Contours
- Existing Port Land
- Port Expansion Area

Scale:1:35,000 (when printed at A4)

0 0.5 1

Kilometres

PROJECT ID 60161996

LAST MODIFIED XL 27-Sep-2016

FILE NAME G60161996_009_AirContours_20160927_A3

Data Source:
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Parks - © 2010 PSMA Australia Pty Ltd
Imagery - QBing 2016.
Receptors - AECOM 2016

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Stage 3
NO_2 Concentrations (µg/m3)

Figure 15

Legend

A	Modelled Receptor Locations
	Railway Line
	Existing Channel Limits
	Channel Centre Line
	Concentration Contours
	Existing Port Land
	Port Expansion Area

Scale:1:35,000 (when printed at A4)

0 0.5 1

Kilometres

PROJECT ID 60161996

LAST MODIFIED XL 27-Sep-2016

FILE NAME G60161996_010_AirContours_20160927_A3

Data Source:
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Parks - © 2010 PSMA Australia Pty Ltd
Imagery - QBing 2016.
Receptors - AECOM 2016

Table 20 Predicted SO2 concentrations at sensitive receptors - shipping emissions in isolation

Receptor ID	Predicted PEP SO_2 Contribution (µg/m³)								
	Maximum 1 Hour Average			Maximum 24 Hour Average			Annual Average		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	15.3	20.3	20.2	2.3	2.6	2.6	0.6	0.7	0.7
2 – Casino Floor 6	15.1	20.1	19.9	2.3	2.6	2.6	0.6	0.7	0.7
3 – Casino Floor 3	14.9	19.8	19.6	2.3	2.6	2.5	0.6	0.7	0.7
4 – Archer and Ross	11.4	14.7	14.7	1.6	2.2	2.2	0.3	0.4	0.4
5 – Macrossan	11.2	15.2	15.2	1.6	2.1	2.1	0.2	0.3	0.3
6 – Hubert	11.6	11.6	11.7	1.4	1.8	1.8	0.1	0.2	0.2
7 – Breakwater	11.3	15.3	15.2	2.5	3.2	3.2	0.5	0.6	0.6
8 – CBD	9.3	13.6	13.6	1.4	2.0	2.0	0.2	0.3	0.3
9 – Strand and Gregory	4.8	9.6	9.6	1.5	1.6	1.6	0.2	0.3	0.3
10 – Strand	4.4	10.1	10.1	0.7	1.6	1.6	0.1	0.2	0.2
11 – Strand and Howitt	4.0	8.7	8.7	1.1	2.1	2.1	0.1	0.2	0.2
12 – North Ward	4.3	5.4	5.2	1.4	1.8	1.8	0.1	0.2	0.2
Criteria	570			230			57		

Table 21 Predicted CO concentrations at sensitive receptors - shipping emissions in isolation

Receptor ID	Predicted PEP CO Contribution Maximum 8 Hour Average (µg/m³)		
	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	10.0	6.1	9.3
2 – Casino Floor 6	11.0	5.1	10.9
3 – Casino Floor 3	12.3	4.6	13.3
4 – Archer and Ross	2.1	3.1	2.3
5 – Macrossan	2.5	4.5	2.7
6 – Hubert	2.5	5.0	2.8
7 – Breakwater	2.8	4.8	2.9
8 – CBD	1.5	5.0	1.8
9 – Strand and Gregory	4.8	2.9	4.9
10 – Strand	1.9	2.9	1.9
11 – Strand and Howitt	2.4	2.0	2.8
12 – North Ward	5.2	6.5	4.9
Criteria	11,000		

Table 22 Predicted PM2.5 concentrations at sensitive receptors - shipping emissions in isolation

Receptor ID	Predicted PEP $PM_{2.5}$ Contribution ($\mu g/m^3$)					
	Maximum 24 Hour Average			Annual Average		
	S Stage cenario 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	0.5	0.8	0.5	0.09	0.12	0.11
2 – Casino Floor 6	0.6	0.7	0.5	0.09	0.12	0.11
3 – Casino Floor 3	0.7	0.6	0.7	0.09	0.12	0.11
4 – Archer and Ross	0.2	0.5	0.3	0.04	0.07	0.05
5 – Macrossan	0.2	0.5	0.3	0.03	0.07	0.04
6 – Hubert	0.2	0.5	0.3	0.02	0.05	0.03
7 – Breakwater	0.3	0.7	0.4	0.07	0.11	0.08
8 – CBD	0.2	0.6	0.2	0.03	0.06	0.04
9 – Strand and Gregory	0.3	0.4	0.4	0.03	0.04	0.04
10 – Strand	0.1	0.4	0.2	0.02	0.03	0.03
11 – Strand and Howitt	0.1	0.3	0.3	0.02	0.03	0.02
12 – North Ward	0.3	0.7	0.3	0.03	0.04	0.03
Criteria	25			8		

7.0 Cumulative Emissions

Cumulative dust emissions have been discussed in Section 11.3.4 of the AEIS. The following section outlines the cumulative results for the shipping emissions only.

Predicted cumulative concentrations of NO_2, SO_2 and CO at nearby sensitive receptors are presented in Table 23, Table 24 and Table 25. Predicted cumulative concentrations of these emissions were predicted to be below criteria at all sensitive receptors.

Table 23 Predicted cumulative NO2 concentrations at sensitive receptors

Receptor ID	Predicted Cumulative NO_2 ($\mu g/m^3$)					
	Maximum 1 Hour Average			Annual Average		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	163.5	225.2	188.7	15.8	16.4	16.7
2 – Casino Floor 6	177.7	223.2	196.9	15.8	16.3	16.7
3 – Casino Floor 3	223.5	220.5	232.3	15.8	16.3	16.7
4 – Archer and Ross	152.7	166.4	166.9	13.9	14.5	14.4
5 – Macrossan	145.6	177.2	165.5	13.6	14.3	14.1
6 – Hubert	159.4	142.1	166.6	13.0	13.5	13.3
7 – Breakwater	146.3	184.1	164.8	15.0	15.8	15.7
8 – CBD	132.0	162.3	153.7	13.6	14.1	14.1
9 – Strand and Gregory	215.2	144.6	214.6	13.6	13.8	14.0
10 – Strand	158.9	137.5	151.2	13.2	13.5	13.5
11 – Strand and Howitt	162.2	130.7	191.5	13.1	13.3	13.3
12 – North Ward	127.3	139.9	130.9	13.4	13.6	13.7
Criteria	250			62		

Table 24 Predicted cumulative SO2 concentrations at sensitive receptors

Receptor ID	Predicted Cumulative SO_2 (µg/m³)								
	Maximum 1 Hour Average			Maximum 24 Hour Average			Annual Average		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	39.7	42.4	44.1	20.3	20.3	20.4	3.9	3.9	3.9
2 – Casino Floor 6	41.7	43.8	45.4	19.8	19.7	19.8	3.7	3.6	3.7
3 – Casino Floor 3	41.4	43.5	45.1	19.9	19.8	19.9	3.7	3.6	3.6
4 – Archer and Ross	41.3	43.4	45.0	20.0	19.9	20.0	3.7	3.6	3.6
5 – Macrossan	40.1	41.0	41.0	19.3	19.4	19.4	3.3	3.3	3.3
6 – Hubert	41.2	42.5	42.8	19.2	19.3	19.3	3.2	3.2	3.3
7 – Breakwater	37.5	37.3	37.3	18.8	18.8	18.8	3.1	3.1	3.1
8 – CBD	40.9	41.4	42.0	20.4	20.5	20.6	3.5	3.5	3.5
9 – Strand and Gregory	40.4	40.3	40.5	19.4	19.2	19.4	3.2	3.2	3.2
10 – Strand	31.6	31.2	31.3	18.8	18.9	18.9	3.2	3.2	3.2
11 – Strand and Howitt	35.2	33.5	33.5	18.6	18.5	18.5	3.1	3.1	3.1
12 – North Ward	33.3	33.3	33.3	18.3	18.3	18.3	3.1	3.1	3.1
Criteria	570			230			57		

Table 25 Predicted Cumulative Maximum 8 Hour Average CO Concentrations at Sensitive receptors

Receptor ID	Predicted Cumulative CO Maximum 8 Hour Average (µg/m³)		
	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	2,260	2,256	2,259
2 – Casino Floor 6	2,261	2,255	2,261
3 – Casino Floor 3	2,262	2,255	2,263
4 – Archer and Ross	2,252	2,253	2,252
5 – Macrossan	2,252	2,255	2,253
6 – Hubert	2,252	2,255	2,253
7 – Breakwater	2,253	2,255	2,253
8 – CBD	2,252	2,255	2,252
9 – Strand and Gregory	2,255	2,253	2,255
10 – Strand	2,252	2,253	2,252
11 – Strand and Howitt	2,252	2,252	2,253
12 – North Ward	2,255	2,256	2,255
Criteria	11,000		

Predicted cumulative $PM_{2.5}$ concentrations at nearby sensitive receptors are presented in Table 26. Predicted short term 24 hour average concentrations and long term annual average concentrations were predicted to be below criteria at all sensitive receptors.

Table 26 Predicted cumulative PM2.5 concentrations at sensitive receptors

Receptor ID	Predicted Cumulative $PM_{2.5}$ ($\mu g/m^3$)					
	Maximum 24 Hour Average			Annual Average		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1 – Casino Top Floor	20.4	20.7	20.4	4.9	4.9	4.9
2 – Casino Floor 6	20.5	20.6	20.4	4.9	4.9	4.9
3 – Casino Floor 3	20.6	20.5	20.6	4.9	4.9	4.9
4 – Archer and Ross	20.1	20.4	20.2	4.8	4.9	4.9
5 – Macrossan	20.1	20.4	20.2	4.8	4.9	4.8
6 – Hubert	20.1	20.4	20.2	4.8	4.9	4.8
7 – Breakwater	20.2	20.6	20.3	4.9	4.9	4.9
8 – CBD	20.1	20.5	20.1	4.8	4.9	4.8
9 – Strand and Gregory	20.2	20.3	20.3	4.8	4.8	4.8
10 – Strand	20.0	20.3	20.1	4.8	4.8	4.8
11 – Strand and Howitt	20.0	20.2	20.2	4.8	4.8	4.8
12 – North Ward	20.2	20.6	20.2	4.8	4.8	4.8
Criteria	25			8		

8.0 Conclusion

The potential air quality impacts associated with the construction of the proposed Port Expansion Project (PEP) were reassessed, with the inclusion of shipping emissions at both the existing port and the PEP. The magnitude of dust emissions from PEP construction activities was reduced (compared with the EIS) due to major construction activities not occurring concurrently. Concentrations of particulates and combustion gases at indicative sensitive receptor locations were estimated using the CALPUFF model.

Concentrations of PM_{10} and TSP were predicted to be below the EPP (Air) criteria (established for health and well-being) for all averaging periods, at all indicative sensitive receptors. Dust deposition rates were predicted to be below the NSW criterion for dustfall at all indicative sensitive receptors.

Concentrations of NO_2, SO_2, CO, and $PM_{2.5}$ from shipping emissions were predicted to be below the EPP (Air) criteria (established for health and well-being) for both short term and long term averaging periods, at all indicative sensitive receptors. The overall risk to health and well-being from shipping emissions was considered low.

In order to minimise adverse impacts, a range of mitigation measures should be implemented during the construction period. An air quality monitoring and management plan, which outlines mitigation measures and site practices to minimise the generation of dust from the site, particularly during periods where the meteorological conditions are likely to transport the dust off-site, should be prepared and implemented for both the construction and operational periods of the development. All activities on the site should be undertaken with the objective of preventing visible emissions of dust beyond the site boundary. In the event of visible dust emissions occurring at any time, all practicable dust mitigation measures, including cessation of dust-generating works, should be identified and implemented.