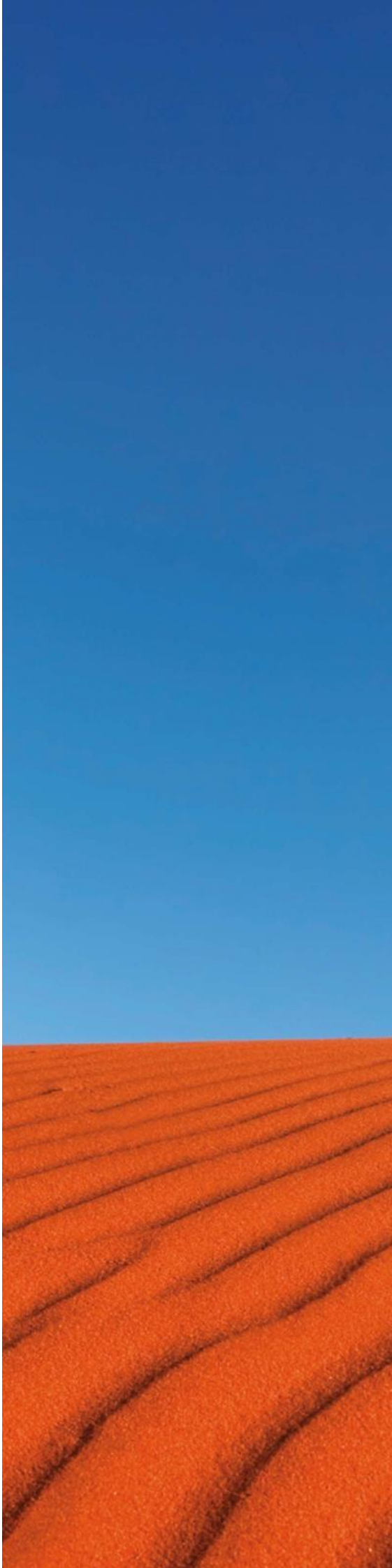
PORT HEDLAND
INDUSTRIES COUNCIL

ANNUAL REPORT

AMBIENT AIR QUALITY MONITORING REPORT TO THE PORT HEDLAND DUST MANAGEMENT TASKFORCE (2014-2015)

Port Hedland Industries Council

October 2015



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Data handling procedure used in this study is only appropriate for this report. This PHIC data handling procedure has been reviewed and is considered to be adequate by the Department of Environment and Regulation (Appendix A).

EXECUTIVE SUMMARY

The Port Hedland Industries Council (PHIC) was established by industry in 2009 to develop an integrated approach to air quality (and noise) monitoring in Port Hedland, Western Australia. This has included the establishment of a network of eight ambient air quality monitoring stations across the area.

PHIC has the ambient monitoring network in place to measure airborne particulates within the Port Hedland air shed. The real-time data is also made accessible to the community via a monitoring website.

The focus of the monitoring network is on the measurement of particles, and all eight stations monitor particles, with six sites being further analysed for the presence of metals in the particle sample. Oxides of nitrogen and sulfur dioxide are being monitored at three stations to determine the relative change in the ambient concentration of these parameters over time.

This report presents the analysis of the 2014-2015 (FY15) air quality monitoring in Port Hedland and assesses the data against the criteria specified in the Ambient Air Quality National Environment Protection Measure (NEPM) and by the Port Hedland Dust Management Taskforce (PHDMT).

The NEPM defines national air quality standards for pollutants most commonly found in urban air, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particles (as PM_{10}). The NEPM criteria are defined to be protective of human health and well-being. The PHDMT has specified an interim guideline of 70 µg/m^3 for PM_{10} (24 hour average) with 10 exceedances per year, as determined at the Taplin Street monitoring station. This interim guideline has been specified in order to maintain the co-existence of industry and community as well as to manage potential risk to human health. This criterion is part of a continuous improvement framework within which industries in Port Hedland can work to reduce emissions over time (DSD, 2010).

MONITORING NETWORK PERFORMANCE

The performance of the monitoring network during the year proved to be reliable, with annual data recovery of at least 75% being achieved for most monitored parameters at all monitoring stations.

MONITORED LEVELS OF OXIDES OF NITROGEN

During the year, nitrogen dioxide levels at the three monitoring stations (Taplin Street, Acacia Way and BoM monitoring stations) are shown to be lower than the 1-hour and annual NEPM NO_2 standard. These standards were also met for the 2012-2013 and 2013-2014 financial years.

MONITORED LEVELS OF SULFUR DIOXIDE

Similar to the 2012-2013 and 2013-2014 financial year, monitored sulfur dioxide levels during the year are shown to be significantly lower than the specified NEPM standards (i.e. 1-hour, 24-hour and annual criteria) at the current monitoring stations (Taplin Street, Acacia Way and Bureau of Meteorology (BoM) stations.

MONITORED LEVELS OF PARTICLES (AS PM_{10})

PHIC monitored particles (PM_{10}) at all eight monitoring stations throughout the year. Due to its strategic position the Taskforce has set Taplin Street monitor to be used for the compliance analysis. (DSD, 2010). Monitoring at the BoM station demonstrates the relative background level of particles in the region. A visual comparison of the daily averages for the BoM and Taplin Street stations are shown in Figure ES-1. Recorded dust events at Taplin Street are also shown.

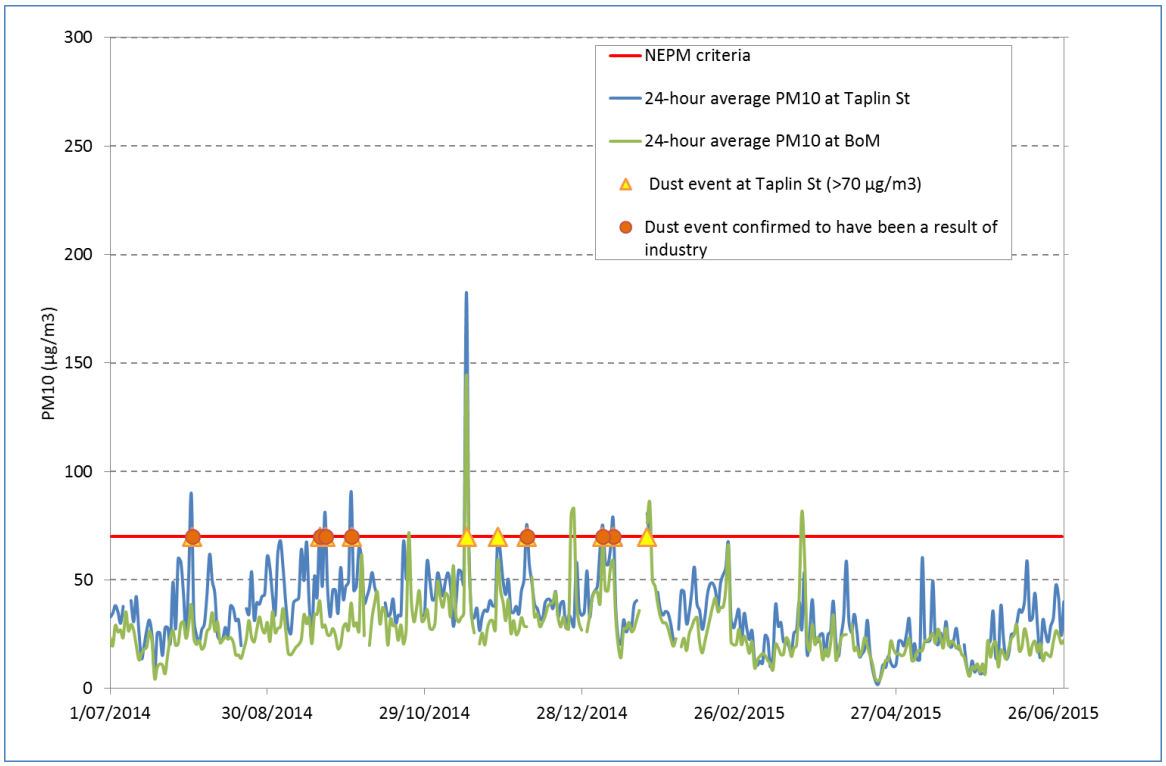


Figure ES-1: Particle levels measured at Taplin Street and Bureau of Meteorology

There were 10 days in FY15 when particle levels recorded at the Taplin Street monitoring station were above the Taskforce criterion, in contrast to 17 days in FY13 and 6 days in FY14.The number of occasions where the 24-hour average PM_{10} concentration exceeded 70 µg/m^3 decreased by 41% in relation to FY13 and increased by 67% in comparison to FY14. Analysis of the data shows that three of the events were attributable to the elevated background dust levels (shaded in blue in Table E-1). The non-background events were likely to be caused by various factors including emissions from nearby industrial activities, wind erosion and the presence of inversion conditions, which is similar to what was observed in FY13 and FY14.

Table E-1: PM_{10} concentration recorded at Taplin Street and BoM sites during dust events (µg/m^3)

Date	Taplin St	BoM	Difference	Inferred cause
1/08/2014	90	39	51	Non background
19/09/2014	72	40	32	Non background
21/09/2014	81	29	52	Non background
1/10/2014	91	39	51	Non background
14/11/2014	182	144	38	Background
26/11/2014	71	59	12	Background
7/12/2014	76	28	47	Non background
5/01/2015	75	67	9	Non Background
9/01/2015	78	59	19	Non-background
22/01/2015	81	76	5	Background

Compared to last year (FY14), most stations recorded an increased number of cases of PM_{10} higher than 70 µg/m^3 except Wedgefield which decreased in the number of events. In terms of exceedances in 24-hour average PM_{10} greater than 50 µg/m^3, all stations recorded a greater number of cases compared to the previous year. The three year summary for each station is shown in Figure ES-1 and Figure ES-2.

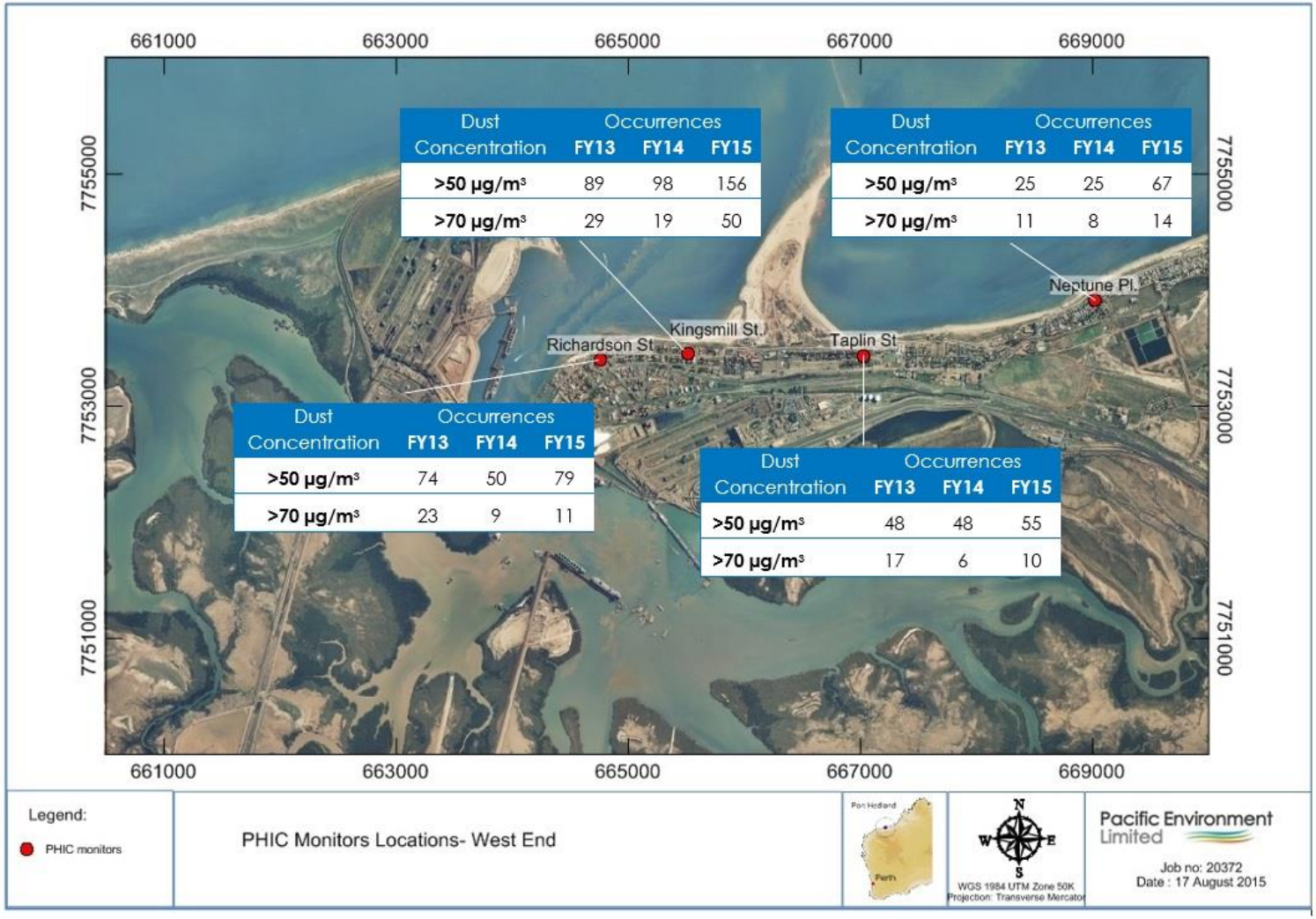
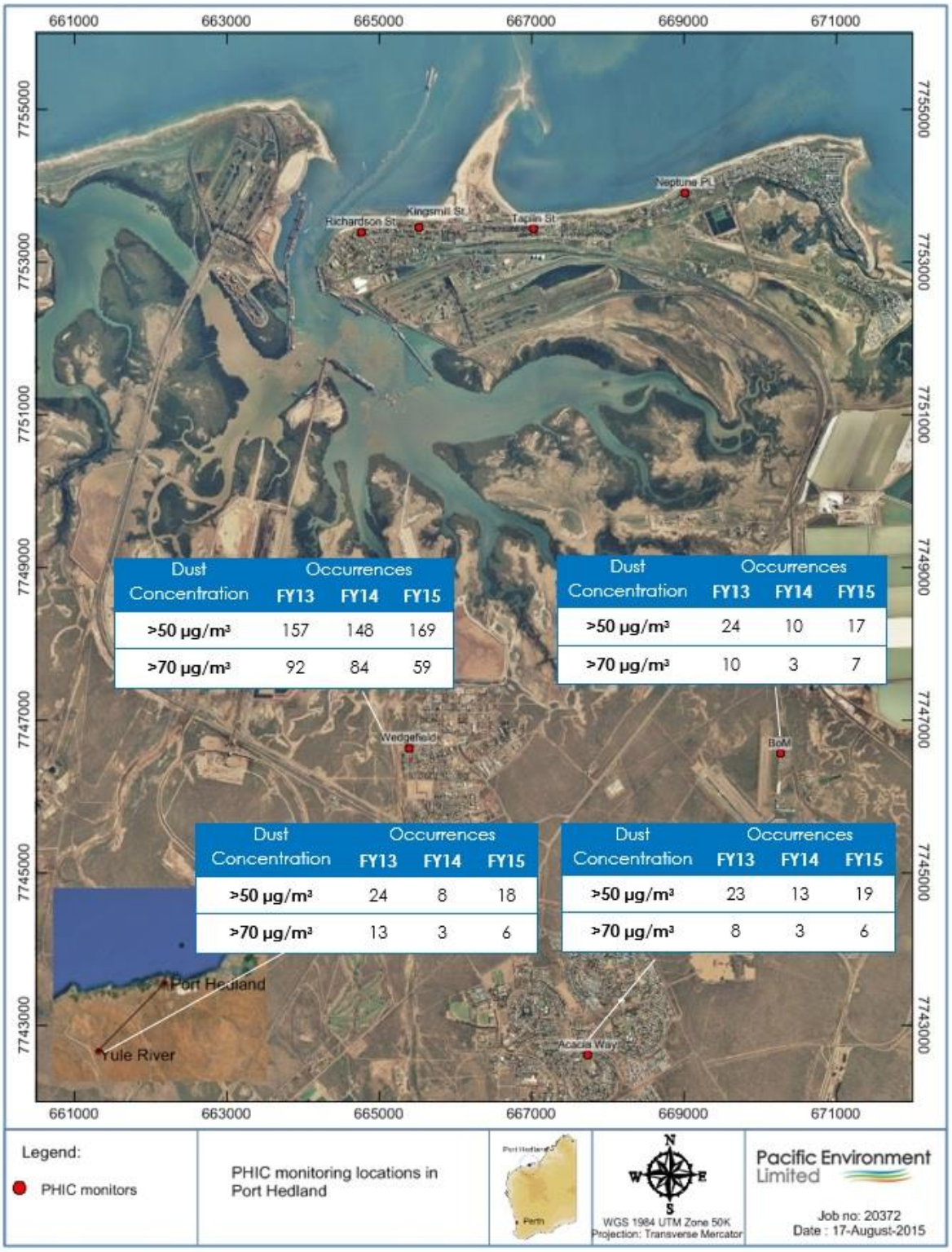


Figure ES-2: PHIC monitoring locations in Port Hedland – west end



Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	157	148	169
>70 µg/m³	92	84	59

Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	24	10	17
>70 µg/m³	10	3	7

Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	24	8	18
>70 µg/m³	13	3	6

Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	23	13	19
>70 µg/m³	8	3	6

Figure ES-3: PHIC monitoring locations in Port Hedland

MONITORED LEVELS OF PARTICLES (AS $PM_{2.5}$)

$PM_{2.5}$ was also monitored in four monitoring stations (Richardson Street, Taplin Street, BoM, and Acacia Way) throughout FY15. The $PM_{2.5}$ levels at all monitors have an annual average below the NEPM advisory reporting guidelines. The highest 24-hour averages of $PM_{2.5}$ was recorded at Taplin Street. The NEPM advisory reporting guidelines only include $PM_{2.5}$ as a goal for national guidance.

PRESENCE OF METALS IN MONITORED PARTICLES

PHIC monitored for the presence of metals in the particle samples (PM_{10}) at five locations throughout the year. One or more metals (e.g. copper, iron and manganese) were detected at each monitoring location. A summary of results for each station is presented in Appendix B.3.

KEY PHIC DUST MANAGEMENT ACTIVITIES COMPLETED IN FY15

During the FY15 reporting period, the PHIC Dust Working Group completed several key projects to better manage industry dust in Port Hedland. These included:

- Lidar Trial – From December 2014 to March 2015, PHIC undertook a 3 month Lidar trial to measure and better understand dust plume movements within the Port Hedland air shed. The trial assisted PHIC members to make well-informed decisions on how to reduce dust generation at their respective sites.
- Cumulative Air Model (CAM) – In consultation with the Department of Environment Regulation (DER), PHIC were able to finalise the consolidated CMA to standardise air emission modelling across all Port Hedland industry operations.

PHIC DUST MANAGEMENT PRIORITIES FOR THE YEAR AHEAD

The following priority projects are planned for the FY16 reporting year:

- Air Quality Monitoring - The monitoring network is managed by regular reviews and response to operational requirements. PHIC will continue to make relevant real-time air quality data accessible to the community via the monitoring website. PHIC will report results annually to the Taskforce, the next report being expected September 2016, presenting the monitored data for the 2015-2016 year.
- Lidar Trial Number 2 – To complement the existing PHIC monitoring program, continue to measure and observe dust plumes through Lidar technology over a fixed period to further define potential dust point sources within the Port Hedland air shed.

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1 INTRODUCTION

The Port Hedland Industries Council (PHIC) was established by industry in 2009 to develop an integrated approach to air quality (and noise) monitoring in Port Hedland, Western Australia. This has included the establishment of a network of ambient air quality monitoring stations, with the real-time data being accessible to the community via a monitoring website.

PHIC is responsible for eight ambient air quality monitoring stations in Port Hedland. These stations are primarily monitoring particles (less than 10 microns in aerodynamic diameter, PM_{10}). Fine particles (less than 2.5 microns in aerodynamic diameter, $PM_{2.5}$) are also monitored in five monitoring stations. There are three stations that also monitor for oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and total suspended particulates (TSP).

This annual ambient air quality monitoring report has been prepared for submission to the Port Hedland Dust and Noise Management Taskforce (Taskforce). This report will assist the Taskforce to assess the monitoring results obtained via the PHIC ambient monitoring network, and progress made in achieving the Taskforce specified interim guideline for PM_{10}. This report, covering monitoring for the 2014-2015 financial year (FY15), is the third of the annual reports.

There are multiple large exporters within the Port Hedland air shed with continuous operations through the port of Port Hedland in FY15, for example:

- Iron ore exports from the port have increased from 344 Million tonnes (Mt) in financial year (FY) 2014 to 446.9 Mt in FY15 (PPA, 2015).

In addition, ongoing construction activities, including earthworks have been carried out in the region, particularly in the Wedgefield Industrial Estate and at the town of Port Hedland, including:

- Construction of the South Hedland waste management facility
- Roads improvements at Wedgefield and South Hedland
- Airport re-development
- Residential and commercial development in Port Hedland and South Hedland
- Construction and expansion of industrial facilities.

To assist the Taskforce in its review, the analysis of the monitoring is presented in two ways, being an analysis according to:

- Monitoring station, to gain an understanding of what the air quality is like in that location generally
- Parameter monitored, to gain an understanding of air quality across the Port Hedland region.

2 MONITORING NETWORK OVERVIEW

The Port Hedland Air Quality and Noise Management Plan (DSD, 2010) identified the need for the establishment of an 'independent, comprehensive air quality monitoring regime' in Port Hedland. The Taskforce considered this type of monitoring regime would provide for industry to measure its performance against targets, and the data collected would inform and guide future industry and community planning.

Through industry co-operation, PHIC now has an appropriate ambient air quality network in place. The network was designed with the objectives of the Taskforce's plan in mind. The network includes eight ambient air quality monitoring sites, with monitored data viewable to the community via a public website.

The monitoring stations were independently audited during the 2013-2014 year. The key finding of the audit was that monitoring station siting, and the positioning of the monitoring instrumentation, was in accordance with the associated method and standard, as far as practical. The monitoring program was also found to be producing data sets that were useful for their intended purposes (PEL, 2013). There was no substantial change to the monitoring network during FY15.

2.1 Monitoring Locations

The eight monitoring site locations are shown in Figure 2-1. The Richardson Street, Kingsmill Street, Taplin Street, and Neptune Place monitoring locations are within urban or residential land use areas of Port Hedland. The Wedgefield monitoring location is within a light industrial area that does contain some residences referred to as 'caretaker' residences. The Acacia Way monitoring station is positioned within South Hedland and serves as a representative site for the population based in South Hedland. The Bureau of Meteorology (BoM) and Yule River locations are relatively distant to industrial and related activities, and populations, and both serve as background monitoring locations.

Table 2-1: PHIC Monitoring locations in Port Hedland

Data from all the PHIC monitoring stations has been analysed and presented in this report. Based on the relative positioning of the monitoring sites, Taplin Street and BoM are used to conduct the analysis of high PM_{10} events (see Section 5 of this report). The BoM monitoring station, located approximately 1 km north-east of the Port Hedland airport runway, is treated as a site indicative of background concentrations of air quality, that is, air quality that is reflective of natural emission levels. The BoM monitoring station is shown in Figure 2-2.

The Taplin Street monitoring station is located in a position that is likely to be impacted by emissions from various industry operations in the Port Hedland area. This monitoring station is also positioned with adequate line of site to nearby industry operations, and is shown in Figure 2-3. It is this location at which the Taskforce has set the Port Hedland Air Management Assessment Criteria (DSD, 2010).

Figure 2-2: BoM Monitoring Station (PEL, 2013)

Figure 2-3: Taplin Street Monitoring Station(PEL, 2013)

2.2 Parameters Monitored

The parameters monitored at the each PHIC monitoring sites are listed in Table 2-1.

Table 2-1: Sites and parameters monitored

Monitoring Station	Parameter
Richardson Street	PM_{10} (including metals) and $PM_{2.5}$
Kingsmill Street	PM_{10}
Taplin Street	PM_{10} (including metals), $PM_{2.5}$, NO_X and SO_2
Neptune Place	PM_{10}
Bureau of Meteorology (BoM)	PM_{10} (including metals), $PM_{2.5}$, NO_X and SO_2
Wedgefield	PM_{10} (including metals)
Acacia Way	PM_{10} (including metals), $PM_{2.5}$, NO_X and SO_2
Yule River	PM_{10} and $PM_{2.5}$

The relevance of monitoring each parameter is briefly described in the following subsections.

2.2.1 Particles (as PM_{10} and $PM_{2.5}$)

The most common metrics for measuring particles are PM_{10} and $PM_{2.5}$, which correspond to particles having an aerodynamic diameter of 10 µm or less and 2.5 µm or less respectively. Particles smaller than 2.5 µm in diameter are often referred to as 'fine', and particles between 2.5 µm and 10 µm in diameter are often referred to as 'coarse'.

It is well accepted nationally and internationally that monitoring for PM_{10} is a good method of determining the community's exposure to potentially harmful dust. The PM_{10} and $PM_{2.5}$ metrics are

important from a health perspective. With normal nasal breathing, particles with an aerodynamic diameter between 10 µm and 100 µm are deposited in the extra-thoracic part (nose, mouth and throat) of the respiratory tract. These are then usually easily eliminated by the body through expiration or by ingestion. However, most of the particles in the 5-10 µm range are deposited in the proximity of the larynx and enter the thoracic region, and particles smaller than 2.5 µm can penetrate deep into the human respiratory system. Ultrafine particles (those with a diameter of less than 0.1 µm) can enter into the alveolar region and pass through tissue barriers.

The NEPM specifies an ambient standard (based on the protection of human health) of 50 µg/m^3 for PM_{10}, (24-hour average) with exceedances not occurring more than 5 days per year. The Taskforce has specified an interim guideline of 70 µg/m^3 for PM_{10} (24 hour average) with 10 exceedances per year. This guideline is determined at the Taplin Street monitoring station (DSD, 2010). NEPM also provides an advisory reporting guidelines and goal for $PM_{2.5}$. The goal is to gather sufficient data nationally to facilitate a review of the standard.

In this report, PM_{10} and $PM_{2.5}$ reported in comparison to these criteria and guidelines. An analysis of the events recorded at Taplin Street (where PM_{10} is above 70 µg/m^3) is included to understand the contributing factors to the high concentrations.

2.2.2 Metals (in PM_{10})

Metals are emitted into the atmosphere through both natural and anthropogenic processes. The processing of minerals, incineration of metallic objects, combustion of fuel containing metal additives and the wear of motor vehicle tyres and brakes result in the emission of metals with particulate matter (EA, 2002). Natural processes causing metal emissions include weathering of rocks and wind-blown dust. When inhaled, metals attached to particulate matter may deposit deep within the lungs. Epidemiological studies have established relationships between inhaled particulate matter and morbidity and mortality, including research centred in Western Australia (DoE, 2003).

Heavy metals associated with PM_{10} include, iron (Fe), vanadium (V), chromium (Cr), cobalt (Co), nickel (Ni), manganese (Mn), copper (Cu), selenium (Se), barium (Ba), gallium (Ga), caesium (Cs), europium (Eu), tungsten (W) and gold (Au) exist in PM_{10} in ambient air. Calcium (Ca), aluminium (Al), titanium (Ti), magnesium (Mg), scandium (Sc), lanthanum (La), hafnium (Hf) and thorium (Th) exist predominantly in the coarse fraction (EA, 2002).

Analysed metals in the PHIC monitoring network include chromium (III), chromium, copper, iron and manganese. In this report, the detection of metals within the particle sample is reported where detection (above the Limit of Reporting) has occurred. The dates and statistics of the metals concentrations detected in the PHIC monitoring network are presented in Appendix B.3.

2.2.3 Oxides of Nitrogen (as NO_x)

Oxides of nitrogen (NO_x) is the term used to describe nitrogen oxide (NO) and nitrogen dioxide (NO_2) in combination. In the atmosphere, NO is oxidized to NO_2. NO and NO_2 exist in a complex equilibrium in the atmosphere, influenced by the presence of atmospheric oxidants, the concentration and speciation of present Volatile Organic Compounds (VOCs), sunlight and other factors. This complex atmospheric chemistry and the prevalence of sources complicate the evaluation of NO_x. The major health concerns are association with prolonged exposure to NO_2. Adverse impacts include bronchitis in asthmatic children, reduced lung function growth, irritation to the lungs and lower resistance to respiratory infections such as influenza (DEP, 2000).

The NEPM specifies an ambient standard for NO_2 of 0.12 ppm (1-hour average), with exceedances not occurring more than 1 day per year, and of 0.03 ppm (annual average) with no exceedances allowed per year.

2.2.4 Oxides of Sulfur (as SO_2)

Sulfur dioxide (SO_2) is the key member of a family of oxides of sulfur (SO_x). These gases form from the oxidation of sulfur when sulfur containing fuels are burnt.

The major health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defences and aggravation of existing cardiovascular disease. SO_2 is also a major precursor to acid rain, which is associated with the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility (DEP, 2000).

The NEPM specifies hourly, daily and annual ambient standards for SO_2 of 0.2 ppm (1-hour average), with exceedances not occurring more than 1 day per year, 0.08 ppm (24- hour average), with also exceedances not occurring more than 1 day per year and of 0.02 ppm with no exceedances allowed during the year.

Although NO_x and SO_x are being monitored in Port Hedland to determine the relative change in its ambient concentration over time, recent PHIC review of the monitored data for NOx and SO_x showed that the levels are considerably below the NEPM criteria and as a result, it is expected that PHIC will remove monitors stations at BoM and Acacia Way in the near future with NO_x and SO_x monitoring at Taplin street still remaining in place.

2.3 Monitoring Methods

The monitoring methods for each parameter in the PHIC monitoring network are listed in Table 2-5. This includes the type of equipment in use at each site, as well as the measurement standard or method applicable to the monitoring equipment in use.

Table 2-5: Sites and parameters monitored

Parameter	Equipment	Measurement Standard	Site
PM_{10} and $PM_{2.5}$	ThermoBAM	AS/NZS 3580.9.11:2008 & AS/NZS 3580.9.3:2003 – BAM 1020/THERMO/HVAS	BoM and Acacia Way
PM_{10} and $PM_{2.5}$	BAM	AS/NZS 3580.9.11:2008 & AS/NZS 3580.9.3:2003 – BAM 1020/THERMO/HVAS	Richardson Street, Taplin Street and Yule River (PM_{10} and $PM_{2.5}$); Kingsmill Street, Neptune Place and Wedgefield (PM_{10} only)
PM_{10}	High Volume Air Sampler 3000	AS/NZS 3580.9.11:2008 & AS/NZS 3580.9.3:2003 – BAM 1020/THERMO/HVAS	BoM, Acacia Way Richardson Street, Taplin Street and Wedgefield
NO_X	Ecotech ML9841	AS/NZS 3580.4.1:2008 & AS/NZS 3580.5.1:2011 – NO_x & SO_2	BoM, Taplin Street, Acacia Way
SO_2	Ecotech EC9850	AS/NZS 3580.4.1:2008 & AS/NZS 3580.5.1:2011 – NO_x & SO_2	BoM, Taplin Street, Acacia Way
Metals	Hi-Vol	iMET1HVICP: Metals on high volume filters by acid digestion and ICPAES (USEPA method I.O. 3.1) iMET2HVICP: Elements on high volume filters as µg/m^3 calculated from ICPAES metals and/or Cr(VI) by colourimetry and client supplied air volume iMET2HVEXT: 1/9th strip of the filter that has been extracted with 20mL of Milliq water and analysed for Mg, Na, K and Ca analysis by ICPAES (see Appendix B.3 for limit of reporting)	Richardson Street, Taplin Street, BoM, Wedgefield, Acacia Way

2.4 Criteria for Assessing Monitored Data

Data from the PHIC monitoring network has been analysed and compared to the criteria summarised in Table 2-6. The data review is considered on the timeframe of midnight to midnight (i.e. a calendar day). Data availability has been reviewed consistent with the approach outlined in the NEPM supporting materials. Where, annual compliance is based on data that are at least 75% complete in each calendar quarter in addition to an annual availability of 75% based on the valid hourly data. Additionally, average concentrations are considered to be valid only if it is based on at least 75% of the expected samples in the averaging period. Data capture rates higher than 95% are desirable (PRC, 2001).

PM_{10}, NO_2 and SO_2 are compared to the standards and guidelines specified in the NEPM (NEPC, 1998). In addition for particles, PM_{10} has been compared to the interim air quality target specified by the Taskforce. The detection of metals within the particle samples has also been reported.

Table 2-6: Parameters and assessment criteria

Parameter	Assessment Criteria	Reference
PM_{10}	50 µg/m³ 24-hour average 70 µg/m³ 24-hour average (east of Taplin Street)	NEPM Taskforce
$PM_{2.5}$	50 µg/m³ 24-hour average 8 µg/m³ 1-year average	NEPM (Advisory reporting standards and goal)
Metals (in PM_{10})	Detected or not-detected*	Based on analytical method level of detection
NO_2	0.12 ppm 1-hour average 0.03 ppm 1-year average	NEPM
SO_2	0.20 ppm 1-hour average 0.08 ppm 24-hour average 0.02 ppm 1-year average	NEPM

* Note: Industry is currently reviewing the toxicology of manganese ores which may lead to a review of the relevant World Health Organisation (WHO) guideline values

2.4.1 Ambient air quality PM_{10} Events

Additional analysis of individual cases where high PM_{10} concentrations were recorded within the reported monitored data will be presented in Section 5. Each case is referenced as a dust "event" which is defined as a 24-hour average PM_{10} level higher than 70 µg/m³ at Taplin Street. An "event" will be considered an "exceedance" where it can be demonstrated to be a result of industry activity and not a result of elevated background concentrations. An elevated background concentration is determined at the BoM station, and considered to be a 24-hour average PM_{10} higher than 60 µg/m³

2.5 Data processing

The data preparation for the PHIC monitoring network is consistent with the PHIC data handling procedure which has been reviewed and considered to be adequate for this purpose by the Department of Environment and Regulation (Appendix A). In addition, the definitions and conventions that are relevant to the reporting and interpretation of the data are consistent with those applied through the state and commonwealth reporting for NEPM (PRC, 2001; PRC, 2002).

3 AIR QUALITY MONITORING DATA – COMPARISON TO CRITERIA

This section details the data analysis interpretation of the monitored ambient PM_{10} (including metals in PM_{10}), NO_x and SO_2 and $PM_{2.5}$ concentrations from the eight ambient monitoring stations in the network. Monitored data are compared to relevant criteria (as described in Section 2.4).

The results are presented for the reporting year, as summaries by:

- parameter (Section 3.1)
- monitoring station or location (Section 3.2).

Performance against the assessment criteria is recorded as either:

- met
- not met
- not demonstrated, as a result of inadequate data recovery or data quality, or
- not applicable (when comparison is made to the Taskforce criteria for sites other than Taplin Street).

The number of events recorded where results are higher than the relevant assessment criteria is also stated. For PM_{10}, a comparison is also provided to the number of high background events in the region.

The data statistics for each monitored parameter at each site are also reported, in terms of:

- percentage of data recovered
- percentage of data usable.

The timeframes covered by the quarterly analysis are:

- Quarter 1 (Q1) being 1/7/2014 – 30/9/2014
- Quarter 2 (Q2) being 1/10/2014 – 31/12/2014
- Quarter 3 (Q3) being 1/1/2015 – 3/31/2015
- Quarter 4 (Q4) being 1/4/2015 – 30/6/2015

A summary of data recovery is provided in Table 3-1. As it can be seen in the table the data recovery over the last quarter of the year at Neptune Place was less than 75% (value shown in blue).

Table 3-1: Summary of Data Recovery for 2014-2015

Monitoring Station	Parameter	Data Availability (% of hours)				
		Q1	Q2	Q3	Q4	Annual
Richardson Street	PM_{10}	91%	94%	88%	96%	92%
	$PM_{2.5}$	91%	94%	90%	97%	93%
Kingsmill Street	PM_{10}	98%	97%	90%	76%	90%
Taplin Street	PM_{10}	94%	91%	92%	94%	93%
	$PM_{2.5}$	94%	93%	91%	94%	93%
	NO_x	95%	93%	92%	95%	94%
	SO_2	95%	93%	92%	95%	94%
Neptune Place	PM_{10}	92%	92%	91%	74%	87%
Bureau of Meteorology	PM_{10}	97%	94%	98%	96%	96%
	$PM_{2.5}$	87%	90%	85%	83%	86%
	NO_x	95%	94%	92%	95%	94%
	SO_2	95%	94%	92%	95%	94%
Wedgefield	PM_{10}	100%	100%	94%	100%	98%
Acacia Way	PM_{10}	98%	99%	96%	98%	98%
	$PM_{2.5}$	92%	97%	92%	98%	95%
	NO_x	94%	94%	92%	94%	93%
	SO_2	94%	93%	92%	94%	93%
Yule River	PM_{10}	97%	93%	94%	90%	94%
	$PM_{2.5}$	87%	95%	93%	92%	91%

3.1 Comparison by Parameter

The following series of figures and tables interpret the monitored data by parameter across the network.

To better illustrate the period where dust events occurred particles (PM_{10}) are presented according to the daily averages instead of the monthly averages, as illustrated in the previous financial year report, and to demonstrate variability in the results (Section 3.1.1). PM_{10} results are also compared to the NEPM and Taskforce criteria. Also, the statistical summary of detected metals is presented in Appendix B.3. NO_2 monitoring is presented for comparison to the 1-hour and annual NEPM criteria (Section 3.1.4). SO_2 monitoring is presented for comparison to the 1-hour, 24-hour and annual NEPM criteria (Section 3.1.5).

3.1.1 Comparison for Particles (as PM_{10})

The following series of figures (Figure 3-1 to Figure 3-8) shows PM_{10} for each monitoring site as a daily average over the reporting year. Each monitoring station recorded elevated concentration from time to time, noting that achievement of the criteria is determined at Taplin Street.

- Richardson Street: Figure 3-1
- Kingsmill Street: Figure 3-2
- Taplin Street: The monitoring results for this station are presented in Figure 3-3 along with the dust events (i.e. days above the Taskforce criteria of 70 µg/m3)
- Neptune Place: Figure 3-4
- Bureau of Meteorology (BoM): The monitoring results for this station are presented in Figure 3-5 along with the corresponding days when dust events where registered at Taplin Street in order to illustrate background- related events.
- Wedgefield: Figure 3-6
- Acacia Way: Figure 3-7
- Yule River: Figure 3-8

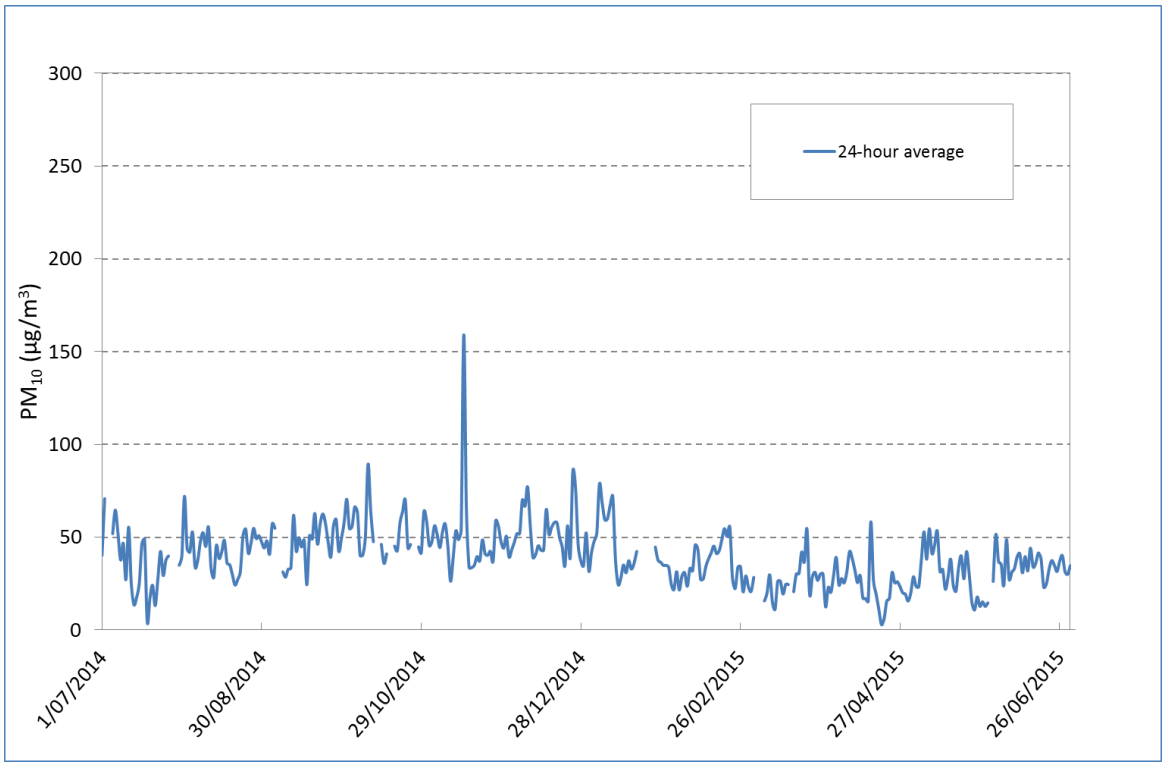


Figure 3-1: 24-hour Average PM_{10} at Richardson Street

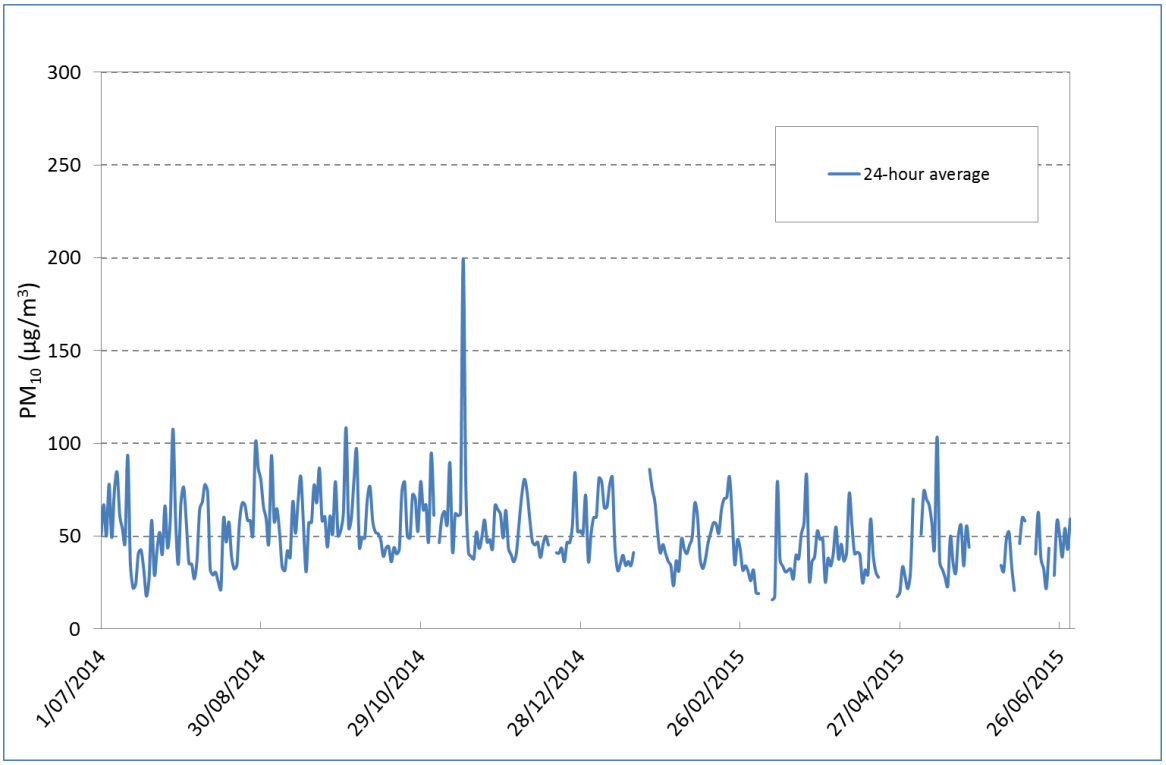


Figure 3-2: 24-hour Average PM_{10} at Kingsmill Street

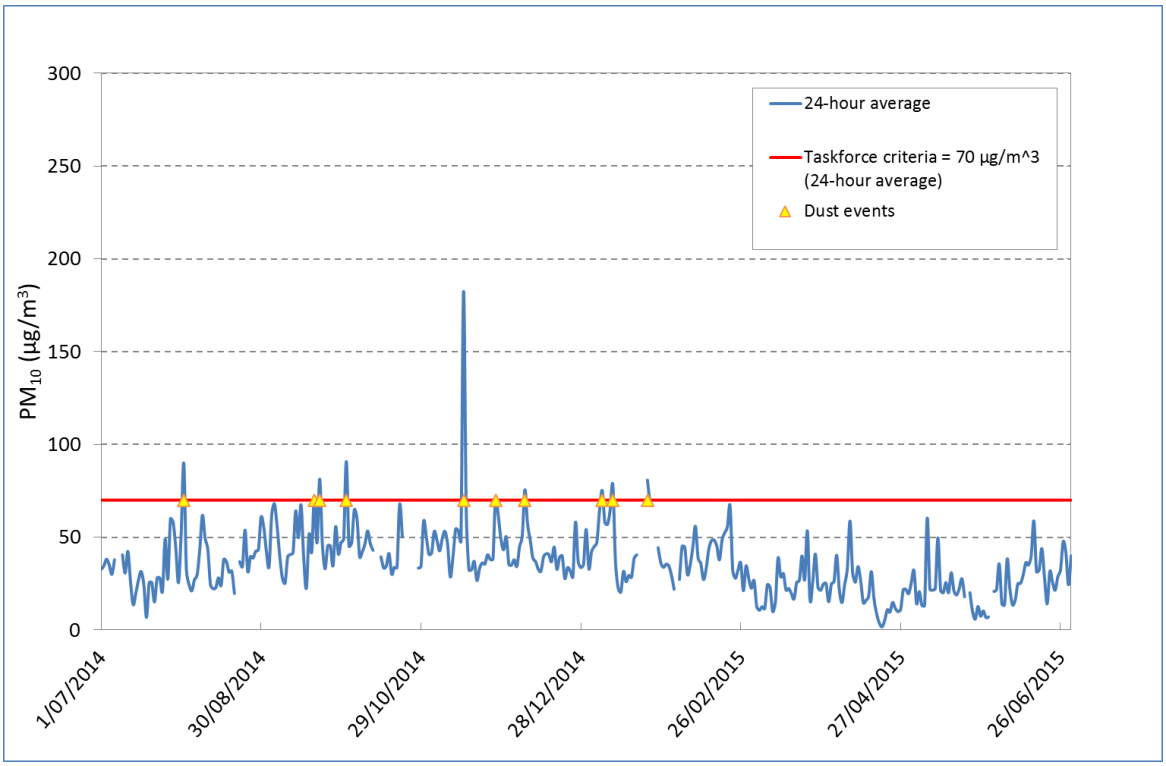


Figure 3-3: 24-hour Average PM_{10} at Taplin Street

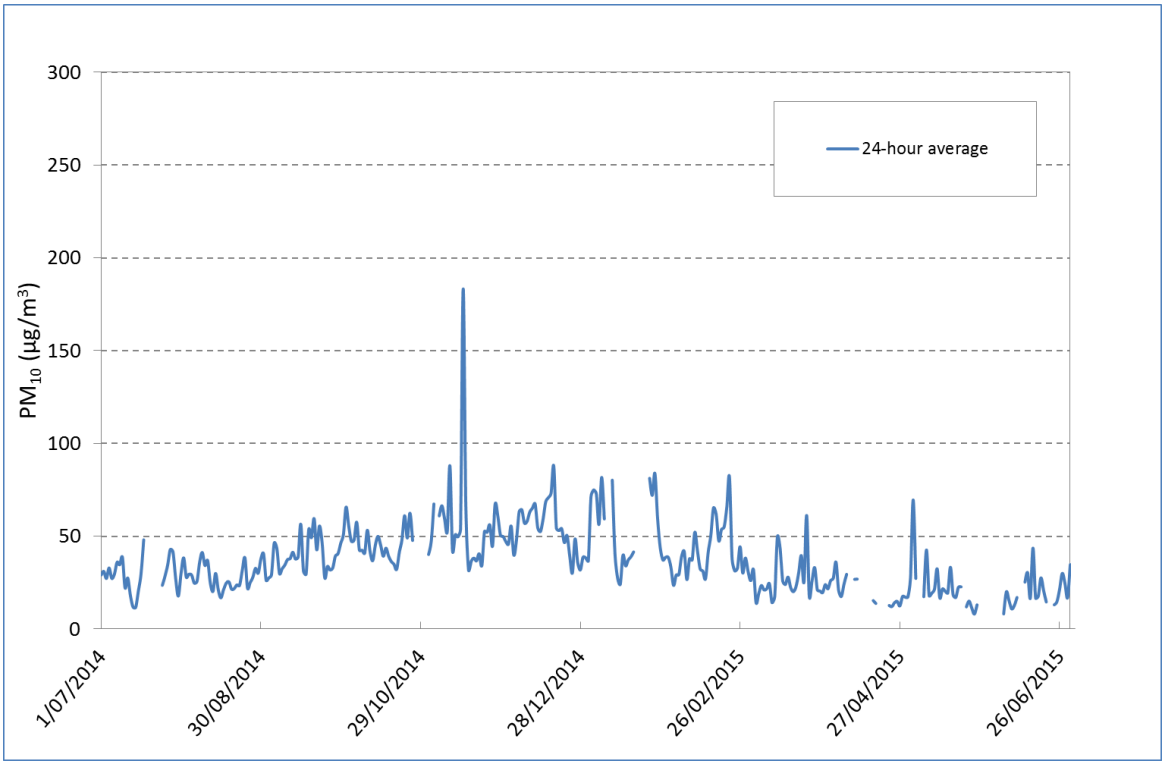


Figure 3-4: 24-hour Average PM_{10} at Neptune Place

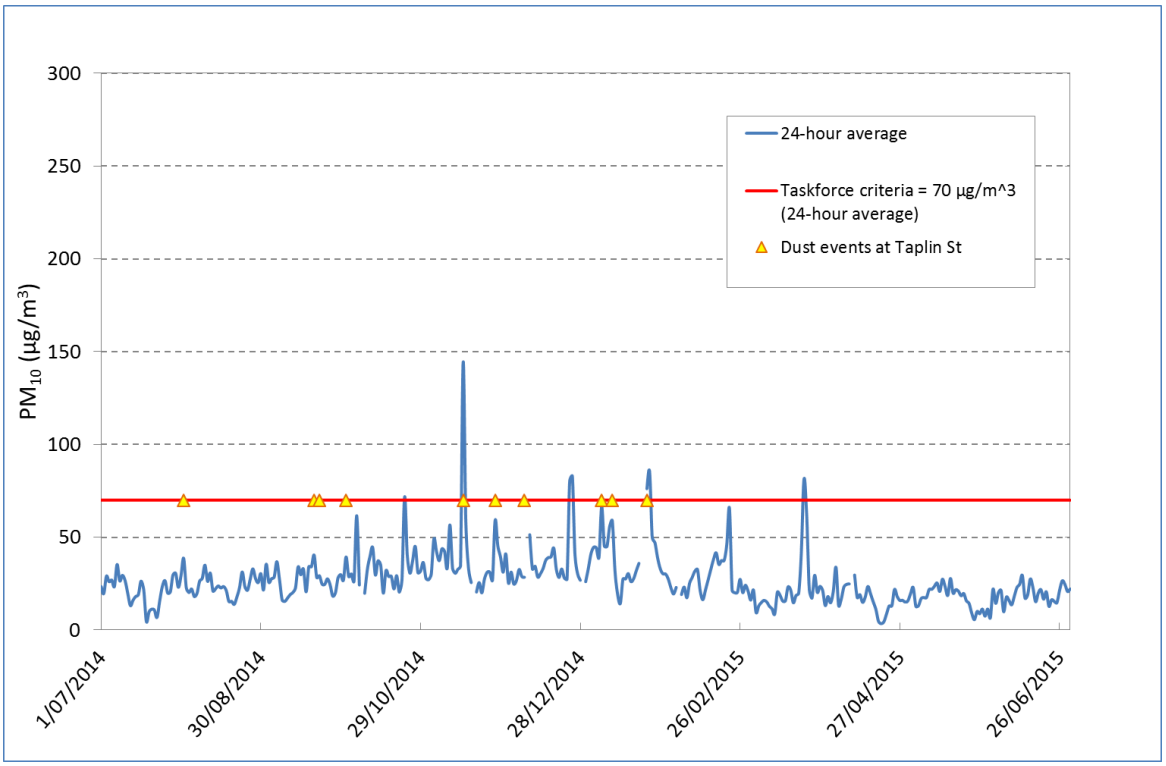


Figure 3-5: 24-hour Average PM_{10} at Bureau of Meteorology

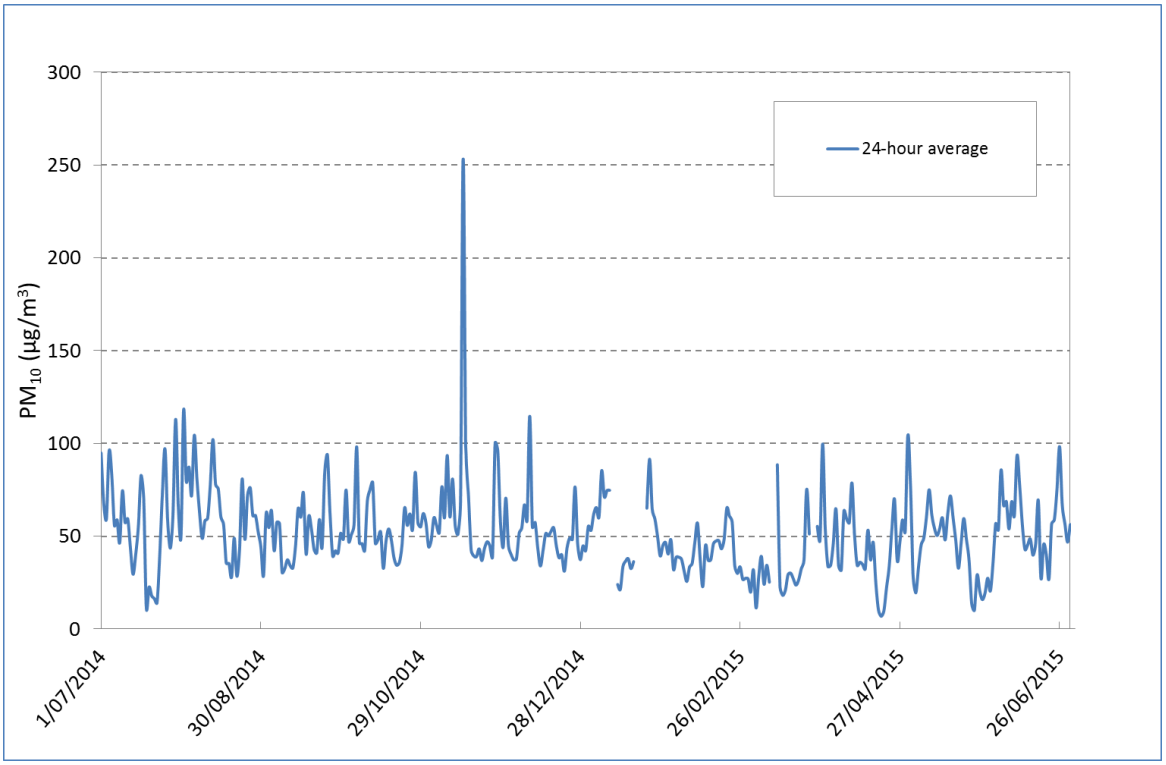


Figure 3-6: 24-hour Average PM_{10} at Wedgefield

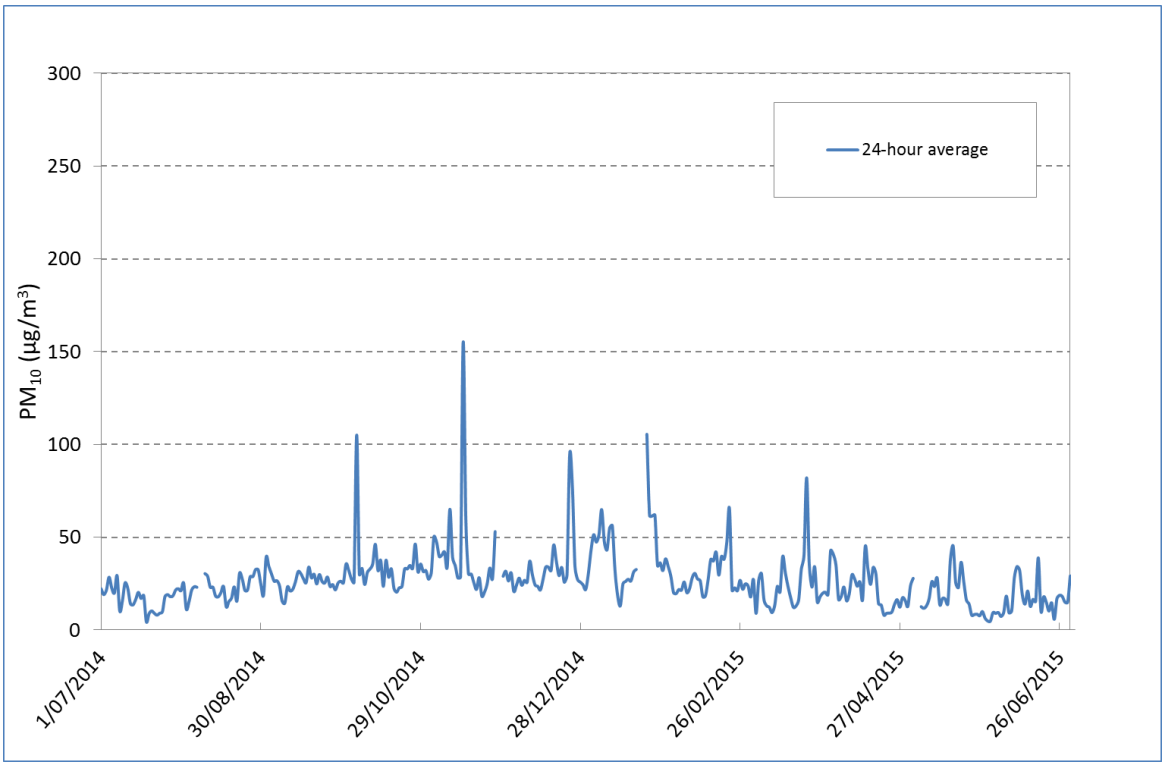


Figure 3-7: 24-hour Average PM_{10} at Acacia Way

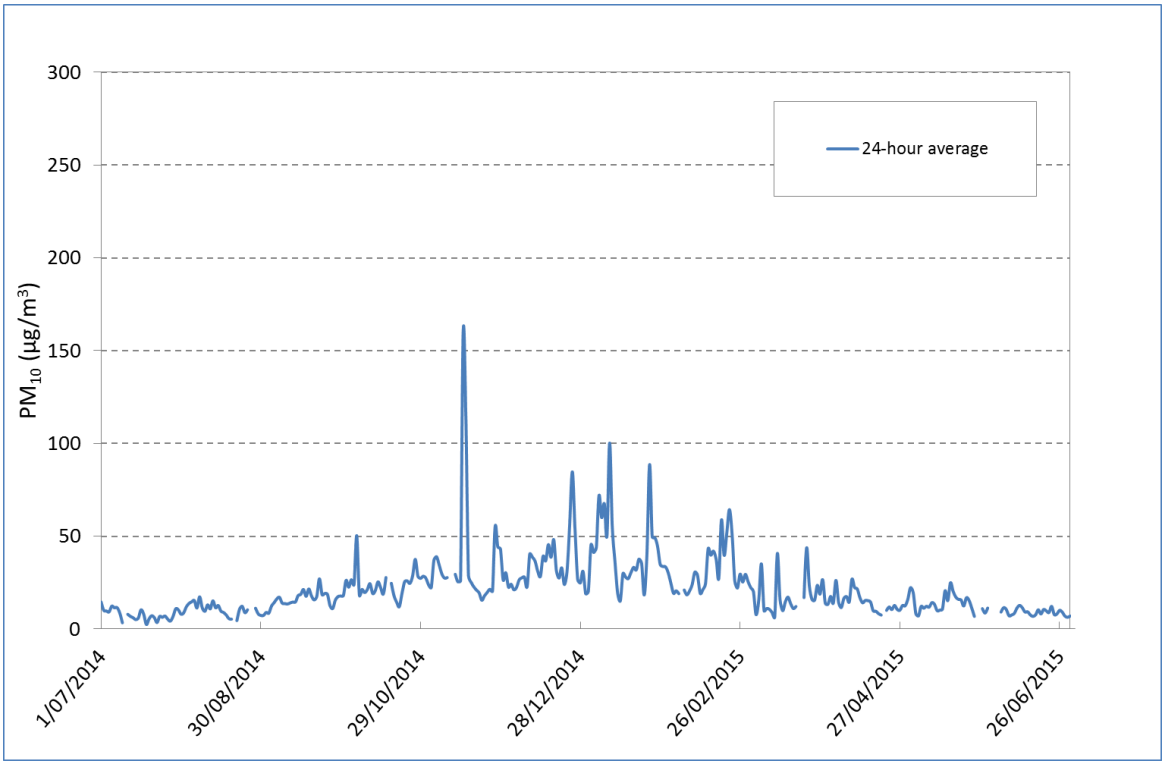


Figure 3-8: 24-hour Average PM_{10} at Yule River

Dust events (i.e. 24-hour average PM_{10} level higher than 70 µg/m^3 at Taplin Street) are shown in Figure 3-9, with ten dust events noted for the reporting year. Comparing the results for BoM and Taplin Street monitors assists in understanding where the relative contribution is coming from, and if the Taskforce interim guideline has been achieved.

Analysis shows that three dust events for Taplin Street correspond to days when the BoM station is recording a high background event. Analysis of wind directions and wind speeds at the time shows that seven dust events for Taplin Street are likely to be a result of industrial activities (see Section 5).

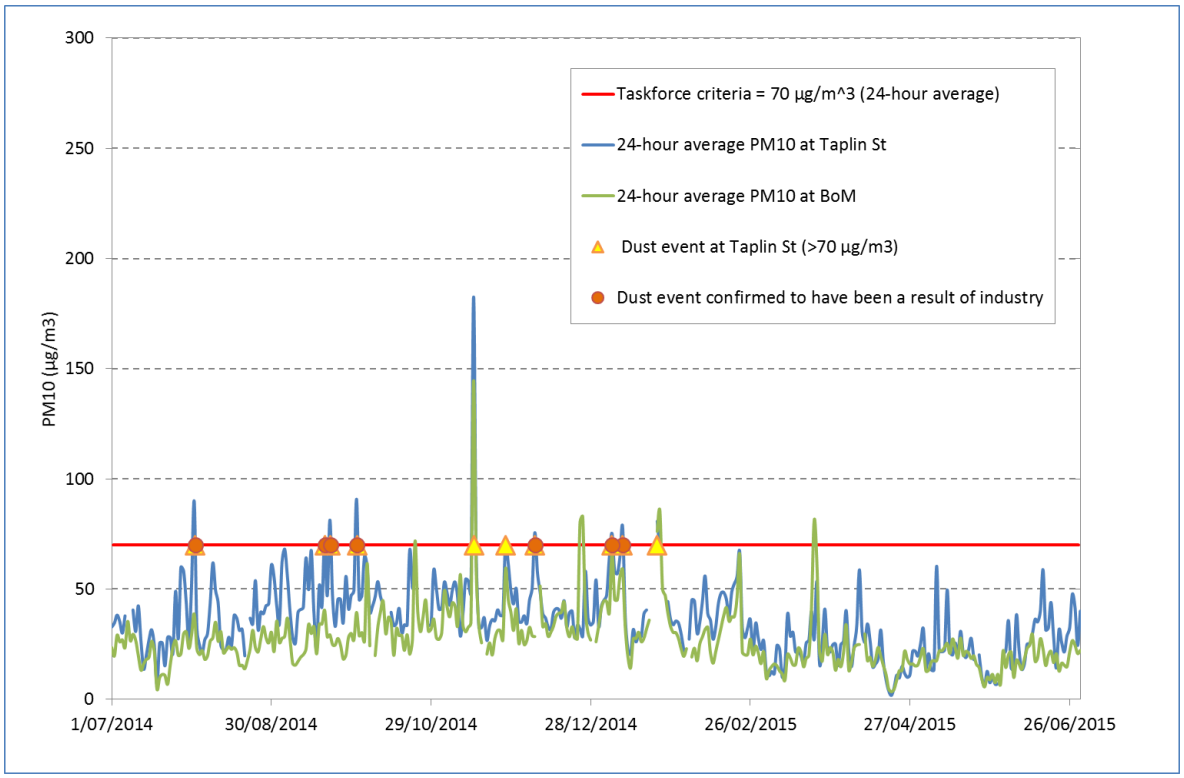


Figure 3-9: 24-hour Average PM_{10} – comparison of Taplin Street with Bureau of Meteorology

The extent of PM_{10} monitoring across the network is shown in Table 3-2. This table shows the amount of PM_{10} data available for analysis in the year. The percentage of data availability is reported on a quarterly and annual basis. A suitable level of data recovery for reliable analysis is 75% with 95% being desirable (PRC, 2001). The number of days that data was recovered from each site for the year is also reported. PM_{10} has been assessed at each site as either meeting or not meeting the NEPM criteria. The sites where data recovery was below the 75% target, assessment was marked as not determined. The Taskforce criteria have been assessed at Taplin Street and Neptune Place only.

Table 3-2: Summary for PM_{10}

Monitoring Station	Data Availability (percent)					Data Recovered (no. of days)	Number of Occurrences above criteria		Performance against criteria	
	Q1	Q2	Q3	Q4	Annual	Annual	(NEPM)	(Taskforce)*	(NEPM)	(Taskforce)
Richardson Street	91%	94%	88%	96%	92%	337	79	N/A	Not met	N/A
Kingsmill Street	98%	97%	90%	76%	90%	329	156	N/A	Not met	N/A
Taplin Street	94%	91%	92%	94%	93%	338	55	10	Not met	Met
Neptune Place	92%	92%	91%	74%	87%	319	67	14	Not determined	Not determined
Bureau of Meteorology	97%	94%	98%	96%	96%	351	17	N/A	Not met	N/A
Wedgefield	100%	100%	94%	100%	98%	359	169	N/A	Not met	N/A
Acacia Way	98%	99%	96%	98%	98%	357	19	N/A	Not met	N/A
Yule River	97%	93%	94%	90%	94%	342	18	N/A	Not met	N/A
Criteria									50 µg/m³ (24-hour average) – 5 times a year	70 µg/m³ (24-hour average) at Taplin and East of Taplin (Neptune) – 10 times a year

Note: N/A denotes non applicable. The Taskforce PM10 criterion only applies west of Taplin Street
Not determined denotes that data availability was below 75% in which case not reliable assessment can be drawn.

3.1.1.1 Comparison between FY 15, FY14 and FY13

The 24-hour average PM_{10} for Taplin Street and BoM in FY13, FY14 and FY15 are presented in Figure 3-10, Figure 3-11 and Figure 3-12 respectively.

Compared to FY13, the 24-hour averages PM_{10} at both Taplin Street and BoM monitors have less exceedances of the 24-hour average PM_{10} greater than 70 µg/m³ in FY15. On the other hand, compared to FY14, the 24-hour averages PM_{10} at both Taplin Street and BoM monitors have more exceedances of 24-hour average PM_{10} greater than 70 µg/m³ in FY15 as shown in Table 3-3 .

In addition, the number of exceedance for the 24-hour average PM_{10} greater than 50 µg/m³ and 70 µg/m³ for all stations in the PHIC monitoring network are presented in Figure 3-13 and Figure 3-14. Compared to FY14, most stations recorded a greater number of dust events in PM_{10} higher than 70 µg/m³ except for Wedgefield (Table 3-3) (i.e. most of the stations recorded increases in the number of dust events from 22% to 163%, except at Wedgefield which number of dust events decreased in a 30% compared to the previous financial year). Similarly in terms of exceedances in 24-hour average PM_{10} greater than 50 µg/m³, all stations recorded a higher number of exceedances this time with increases ranging from 14% to 168%.

Table 3-3: Number of exceedances recorded at the monitoring stations FY13 to FY15

	Richardson St	Kingsmill St	Taplin St	Neptune Pl	BoM	Wedgefield	Acacia Way
Exceedances greater than 70 µg/m3							
FY13	23	29	17	11	10	92	8
FY14	9	19	6	8	3	84	3
FY15	11	50	10	14	7	59	6
% FY13-FY15	-52%	72%	-41%	27%	-30%	-36%	-25%
% FY14-FY15	22%	163%	67%	75%	133%	-30%	100%
Exceedances greater than 50 µg/m3							
FY13	74	89	48	25	24	157	24
FY14	50	98	48	25	10	148	13
FY15	79	156	55	67	17	169	19
% FY13-FY15	7%	75%	15%	168%	-29%	8%	-21%
% FY14-FY15	58%	59%	15%	168%	70%	14%	46%

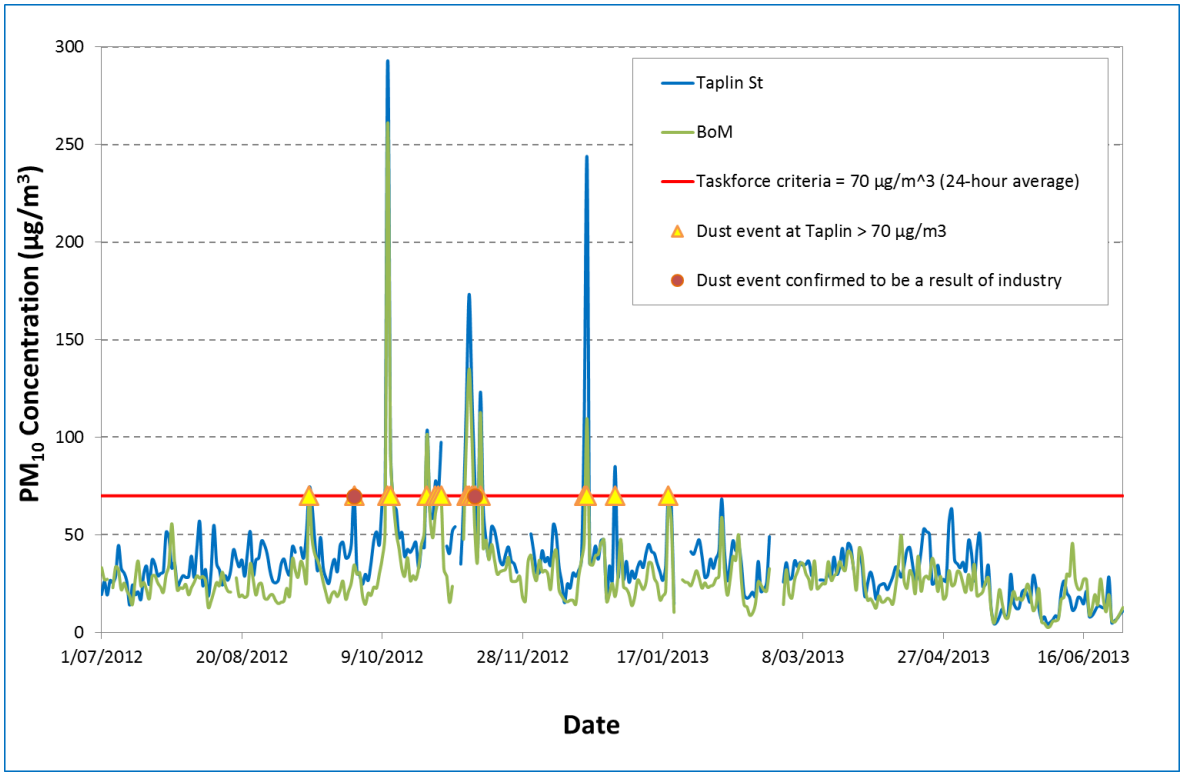


Figure 3-10: 24-hour Average PM_{10} – comparison of Taplin Street with Bureau of Meteorology 2012-2013 (FY13)

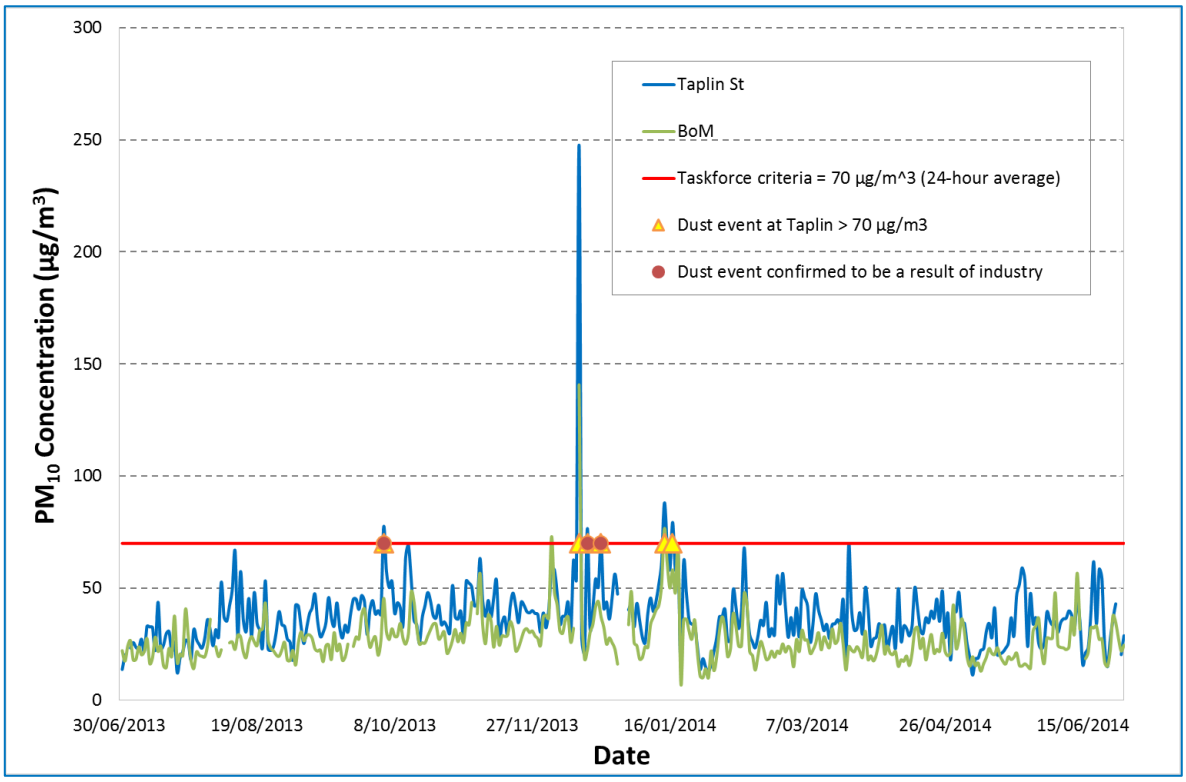


Figure 3-11: 24-hour Average PM_{10} – comparison of Taplin Street with Bureau of Meteorology 2013-2014 (FY14)

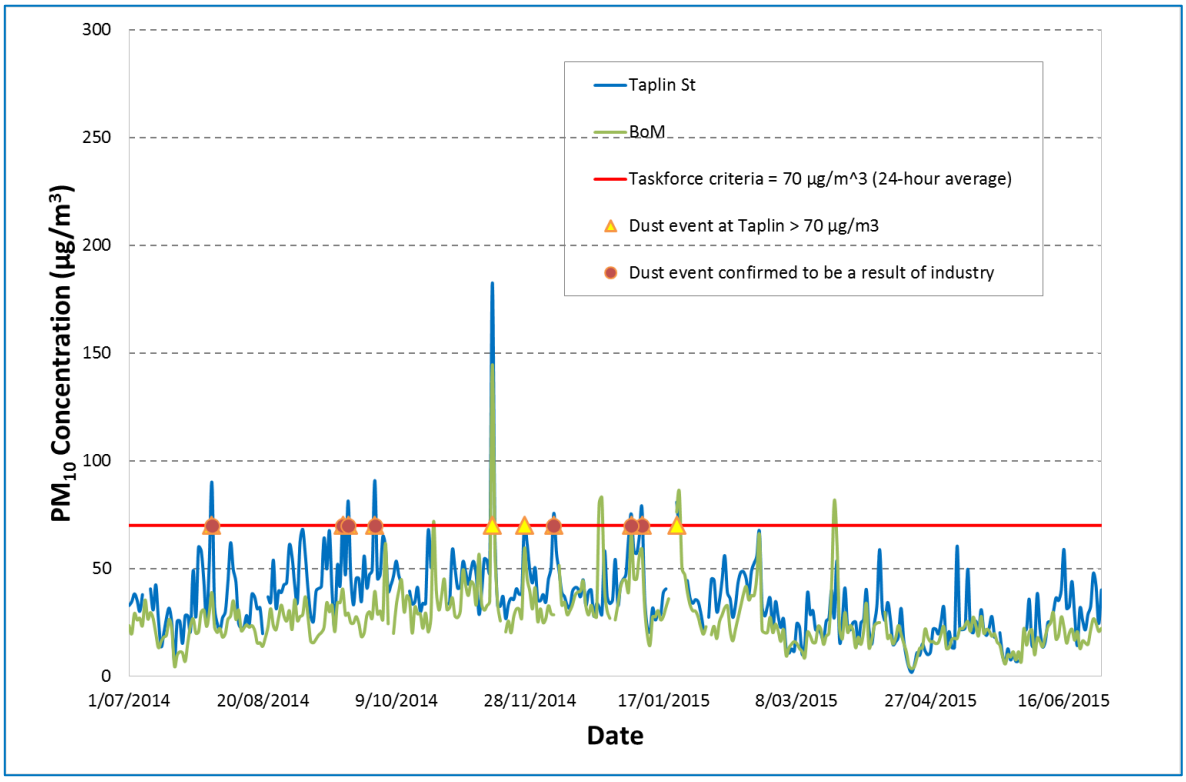


Figure 3-12: 24-hour Average PM_{10} – comparison of Taplin Street with Bureau of Meteorology 2014-2015 (FY15)

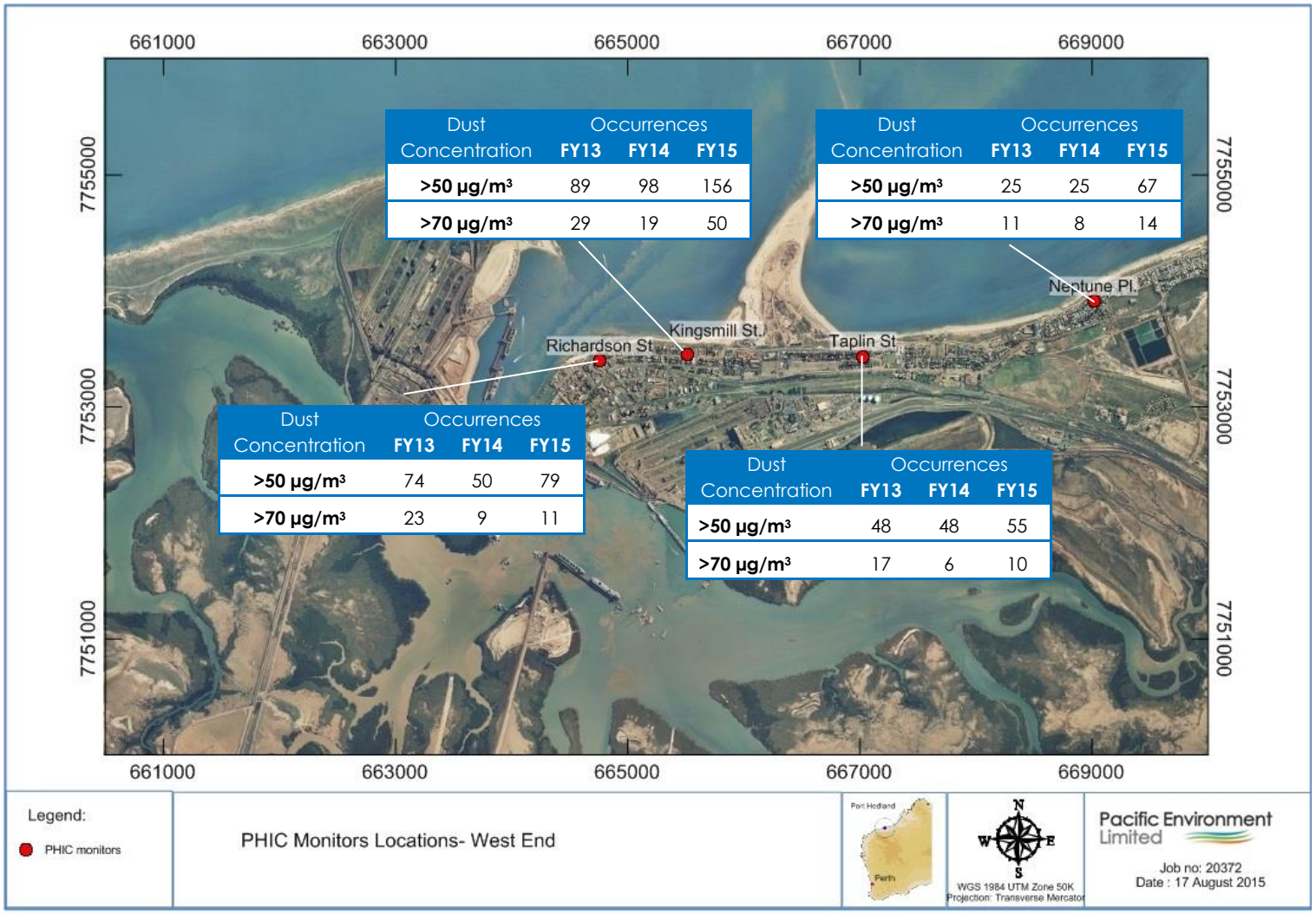
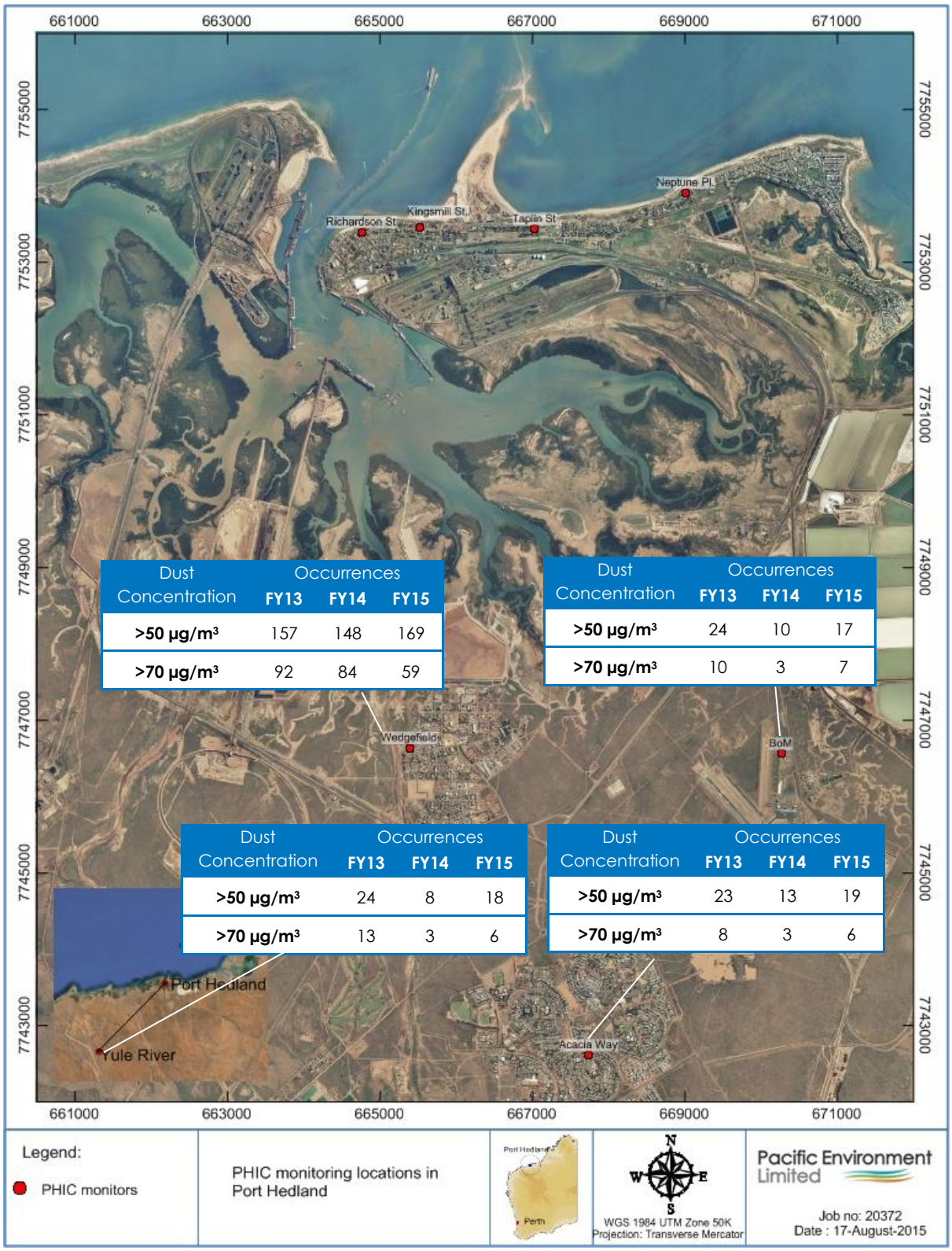


Figure 3-13: PHIC Monitoring locations in Port Hedland (west end) – Exceedance Summary (FY13 to FY15)



Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	157	148	169
>70 µg/m³	92	84	59

Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	24	10	17
>70 µg/m³	10	3	7

Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	24	8	18
>70 µg/m³	13	3	6

Dust Concentration	Occurrences FY13	FY14	FY15
>50 µg/m³	23	13	19
>70 µg/m³	8	3	6

Figure 3-14: PHIC Monitoring locations in Port Hedland – Exceedance Summary (FY13 to FY15)

3.1.2 Summary for particles as $PM_{2.5}$

The extent of $PM_{2.5}$ monitoring in the network is shown in Table 3-4. This table shows the amount of $PM_{2.5}$ data available for analysis in the year at the five sites where this parameter is measured. A suitable level of data recovery for reliable analysis is 75% with 95% being desirable (PRC, 2001). $PM_{2.5}$ has been assessed at each site as either meeting or not meeting the 24-hour and annual NEPM advisory reporting standards and goads. Statistical summaries of $PM_{2.5}$ metals are presented in Appendix B.4.

Table 3-4: Summary for $PM_{2.5}$

Monitoring Station	Data Availability Rate (% of hours)				Data Recovered (% of hours)	Annual Mean	Number of occurrences above criteria		Performance against criteria*	
	Q1	Q2	Q3	Q4	Annual	(µg/m³)	NEPM 24-hour	NEPM 1-year	NEPM 24-hour	NEPM 1-year
Richardson Street	91%	94%	90%	97%	93%	9	0	0	met	met
Taplin Street	94%	93%	91%	94%	93%	12	2	0	N/A	met
Bureau of Meteorology	87%	90%	85%	83%	86%	8	0	0	met	met
Acacia Way	92%	97%	92%	98%	95%	6	0	0	met	met
Yule River	87%	95%	93%	92%	91%	8	0	0	met	met
Criteria									25 µg/m³ 24-hour average	8 µg/m³ 1-year average

*Note: The NEPM PM2.5 advisory reporting standards do not include maximum allowable exceedances; therefore performance criteria are not applicable if there are occurrences higher than the nominated reporting standards.

3.1.3 Summary of Metals in Particles

The detection of metals in particle monitoring is shown in Table 3-5. Particles are measured at five of the eight monitoring stations. The total number of monitoring days are reported here for each station. Statistical summaries and limit of reporting for metals are presented in Appendix B.3.

Table 3-5: Summary for Metals in PM_{10}

Monitoring Station	Total number of monitoring days
Richardson Street	59
Taplin Street	59
Bureau of Meteorology	59
Wedgefield	53
Acacia Way	57

3.1.4 Summary for Oxides of Nitrogen

The extent of NO_x monitoring in the network is shown in Table 3-6. This table shows the amount of NO_x data available for analysis in the year at the three sites where this parameter is measured. The percentage of data availability is reported on a quarterly and annual basis. A suitable level of data recovery for reliable analysis is 75% with 95% being desirable (PRC, 2001). The number of hours in the year that data was recovered from each site is also reported. NO_2 (as a component of NO_x) has been assessed at each site as either meeting or not meeting the 1-hour and annual NEPM criteria.

Table 3-6: Summary for NO_2

Monitoring Station	Data Availability Rate (% of hours)				Data Recovered (% of hours)	Annual Mean	Number of Occurrences above criteria	Performance against criteria	
	Q1	Q2	Q3	Q4	Annual	(ppm)		NEPM 1-hour	NEPM 1-year
Taplin Street	95%	93%	92%	95%	94%	0.007	0	Met	Met
Bureau of Meteorology	95%	94%	92%	95%	94%	0.005	0	Met	Met
Acacia Way	94%	94%	92%	94%	93%	0.004	0	Met	Met
Criteria								0.12 ppm 1-hour average	0.03 ppm 1-year average

3.1.5 Summary for Sulfur Dioxide

The extent of SO_2 monitoring in the network is shown in Table 3-7. This table shows the amount of SO_2 data available for analysis in the year at the three sites where this parameter is measured. The percentage of data availability is reported on a quarterly and annual basis. A suitable level of data recovery for reliable analysis is 75% with 95% being desirable (PRC, 2001). The number of hours in the year that data was recovered from each site is also reported. SO_2 has been assessed at each site as either meeting or not meeting the 1-hour, 24-hour and annual NEPM criteria.

Table 3-7: Summary for SO_2

Monitoring Station	Data Availability Rate (% of hours)				Data Recovered (% of hours)	Annual Mean	Number of Occurrences above criteria	Performance against criteria		
	Q1	Q2	Q3	Q4	Annual	(ppm)		NEPM 1-hour	NEPM 24-hour	NEPM 1-year
Taplin Street	95%	93%	92%	95%	94%	0.0016	0	Met	Met	Met
Bureau of Meteorology	95%	94%	92%	95%	94%	0.0002	0	Met	Met	Met
Acacia Way	94%	93%	92%	94%	93%	0.0001	0	Met	Met	Met
Criteria								0.20 ppm 1-hour average	0.08 ppm 24-hour average	0.02 ppm 1-year average

3.2 Comparison by Location

The following series of tables show the monitored data (PM_{10}, NO_2 and SO_2) for each monitoring station. Comparison is again made to the relevant assessment criteria for the relevant timeframe.

3.2.1 Richardson Street

The Richardson Street monitoring location is within an urban or residential land use area of Port Hedland. Particles and metals in particles are monitored at this site. The comparison of the Richardson Street monitoring results to the relevant criteria is shown in Table 3-8.

Table 3-8: Summary for Richardson Street

Monitoring Station Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	79	Not met
	70 µg/m³	24-hour average[a]	11	N/A
$PM_{2.5}$	25 µg/m³	24-hour average[b]	0	N/A
	8 µg/m³	1-year average[b]	0	N/A

[a] Taskforce criteria set for Taplin Street monitor to the east. Not applicable to this monitoring station.
[b] The NEPM PM2.5 advisory reporting standards do not include maximum allowable exceedances.

3.2.2 Kingsmill Street

The Kingsmill Street monitoring location is within an urban or residential land use area of Port Hedland. Particles and metals in particles are monitored at this site. The comparison of the Kingsmill Street monitoring results to the relevant criteria is shown in Table 3-9.

Table 3-9: Summary for Kingsmill Street

Monitoring Station Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	156	Not met
	70 µg/m³	24-hour average[a]	50	N/A

[a] Taskforce criteria set for Taplin Street monitor to the east. Not applicable to this monitoring station.

3.2.3 Taplin Street

The Taplin Street monitoring location is within an urban or residential land use area of Port Hedland. Particles and metals in particles are monitored at this site with the Taskforce specifying the interim guideline for this location. Both NO_x and SO_2 are also monitored at Taplin Street. The comparison of the Taplin Street monitoring results to the relevant criteria is shown in Table 3-10.

Table 3-10: Summary for Taplin Street

Monitoring Station Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	55	Not met
	70 µg/m³	24-hour average	10	Met
NO_2	0.12 ppm	1-hour average	0	Met
	0.03 ppm	1-year average	0	Met
SO_2	0.20 ppm	1-hour average	0	Met
	0.08 ppm	24-hour average	0	Met
	0.02 ppm	1-year average	0	Met
$PM_{2.5}$	25 µg/m³	24-hour average[a]	2	N/A
	8 µg/m³	1-year average[a]	0	N/A

[a] The NEPM $PM_{2.5}$ advisory reporting standards do not include maximum allowable exceedances.

3.2.4 Neptune Place

The Neptune Place monitoring location is within an urban or residential land use area of Port Hedland, and is to the east of the Taplin Street monitoring station. Particles and metals in particles are monitored at this site. It should be noted that data availability for the last quarter of the year did not reach the 75% required as explained in section 2.4 , therefore performance against criteria was not determined due to lack of reliability on the data. The comparison of the Neptune Place monitoring results to the relevant criteria is shown in Table 3-11.

Table 3-11: Summary for Neptune Place

Monitoring Station Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	67	not determined
	70 µg/m³	24-hour average	14	not determined

3.2.5 Bureau of Meteorology

The BoM monitoring location is relatively distant to industrial and related activities, and populations, and acts as a background monitoring locations Port Hedland. Particles and metals in particles are monitored at this site. Both NO_x and SO_2 are also monitored at the BoM site. The comparison of the BoM monitoring results to the relevant criteria is shown in Table 3-12.

Table 3-12: Summary for Bureau of Meteorology

Monitoring Station Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	17	Not met
	70 µg/m³	24-hour average[a]	7	N/A
NO_2	0.12 ppm	1-hour average	0	Met
	0.03 ppm	1-year average	0	Met
SO_2	0.20 ppm	1-hour average	0	Met
	0.08 ppm	24-hour average	0	Met
	0.02 ppm	1-year average	0	Met
$PM_{2.5}$	25 µg/m³	24-hour average[b]	0	N/A
	8 µg/m³	1-year average[b]	0	N/A

[a] Taskforce criteria set for Taplin Street monitor to the east. Not applicable to this monitoring station; and
[b] The NEPM PM2.5 advisory reporting standards do not include maximum allowable exceedances.

3.2.6 Wedgefield

The Wedgefield monitoring location is within a light industrial area that also allows for care-taker residences. Particles and metals in particles are monitored at this site. The comparison of the Wedgefield monitoring results to the relevant criteria is shown in Table 3-13. The Wedgefield site recorded the highest number of PM_{10} events in the year.

Table 3-13: Summary for Wedgefield

Monitoring Station / Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	169	Not met
	70 µg/m³	24-hour average[a]	59	N/A

[a] Taskforce criteria set for Taplin Street monitor to the east. Not applicable to this monitoring station.

3.2.7 Acacia Way

The Acacia Way monitoring location is within an urban or residential land use area of South Hedland. Particles and metals in particles are monitored at this site. Both NO_x and SO_2 are also monitored at Acacia Way. The comparison of the Acacia Way monitoring results to the relevant criteria is shown in Table 3-14.

Table 3-14: Summary for Acacia Way

Monitoring Station / Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	19	Not met
	70 µg/m³	24-hour average[a]	6	N/A
NO_2	0.12 ppm	1-hour average	0	Met
	0.03 ppm	1-year average	0	Met
SO_2	0.20 ppm	1-hour average	0	Met
	0.08 ppm	24-hour average	0	Met
	0.02 ppm	1-year average	0	Met
$PM_{2.5}$	25 µg/m³	24-hour average[b]	0	N/A
	8 µg/m³	1-year average[b]	0	N/A

[a] Taskforce criteria set for Taplin Street monitor to the east. Not applicable to this monitoring station.
[b] The NEPM PM2.5 advisory reporting standards do not include maximum allowable exceedances.

3.2.8 Yule River

The Yule River monitoring location is significantly distant to industrial and related activities, and populations, and acts as a background monitoring location for Port Hedland. Particles and metals in particles are monitored at this site. The comparison of the Yule River monitoring results to the relevant criteria is shown in Table 3-15.

Table 3-15: Summary for Yule River

Monitoring Station / Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	18	Not met
	70 µg/m³	24-hour average[a]	6	N/A
$PM_{2.5}$	25 µg/m³	24-hour average[b]	0	N/A
	8 µg/m³	1-year average[b]	0	N/A

[a] Taskforce criteria set for Taplin Street monitor to the east. Not applicable to this monitoring station.
[b] The NEPM PM2.5 advisory reporting standards do not include maximum allowable exceedances.

4 ANALYSIS OF AIR QUALITY MONITORING

This section details the data analysis and statistical interpretation of the monitored ambient PM_{10} (including metals in PM_{10}), NO_2 and SO_2 concentrations from the eight ambient monitoring stations in the network.

The results are presented as graphical summaries by parameter and demonstrate the trend analysis of historical data (where available) (Appendix C). The following statistics for each parameter monitored in the network is shown:

- maximum
- 99th percentile
- 98th percentile
- 95th percentile
- 90th percentile
- 50th percentile
- minimum

4.1 Trends

As this is the third year of full reporting, preliminary annual trends were established for the monitoring network for PM_{10}, NO_2 and SO_2 concentrations. It should be noted that $PM_{2.5}$ annual trends cannot be established as FY15 is only the second year of full reporting for this parameter.

4.1.1 Particles (as PM_{10})

In general, the maximum 24-hour average PM_{10} concentration at most monitoring stations, showed a decreasing trend over the past three years. The exception in this pattern is BoM where the maximum decreased by 46% between FY13 to FY14 and then increased by 2% in FY15. (Appendix C.1)

4.1.1 Nitrogen Dioxide (NO_2)

The maximum 1-hour average NO_2 concentration at most monitoring stations, showed a decreasing trend over the past three years. The exception to this pattern is Taplin Street which demonstrates an increasing pattern with the monitored levels being increased by 26% between FY13 to FY15 (Appendix C.1). It should be noted that this increment still places the 1-hour average NO_2 concentration over the past three financial years at 64% below the NEPM criteria.

Similar pattern have been observed for the annual average where NO_2 concentration at most monitoring stations demonstrated a decreasing tendency between FY13 and FY15 except for Taplin Street where the annual average increased by 16% over the same period. Similarly to the maximum hourly average, this increment still places the annual average NO_2 concentration over the past three financial years at 75% below the NEPM criteria.

4.1.1 Sulfur Dioxide (SO_2)

The maximum 1-hour average SO_2 concentration has shown variable behaviour across the monitoring stations. At Taplin Street and Acacia Way the maximum 1-hour average decreased by 16% and 36% respectively between FY13 to FY14 and then increased by 11% and 1.2% respectively in FY15. At BoM the maximum 1-hour average shows a decreasing trend over the past three years.

In relation to the maximum 24-hour average SO_2 concentration there is again a tendency for variability. At Taplin Street the maximum 24-hour average SO_2 concentration increased by 46% from FY13 to FY15. At BoM the maximum 24-hour average SO_2 concentration decreased by 32% between FY13 to FY14 and then increased by 40% in FY15. This behaviour is in contrast to that observed at Acacia Way where

the maximum 24-hour average SO_2 concentration increased by 55% between FY13 to FY14, and then subsequently decreasing by 12% in FY15. It should be noted that, besides this variability the maximum 1 - hour and 24- hour SO_2 concentration have remained 78% and 88% below the NEPM criteria respectively over the past three financial years.

Additionally, the annual average SO_2 concentration have shown an increasing pattern at Taplin Street and BoM over the past three years, in contrast to the pattern observed at Acacia way where concentrations have remained steady over the same period of time. It should be noted that this increment still places the annual average NO_2 concentration over the past three financial years at 92% below the NEPM criteria.

5 ANALYSIS OF AMBIENT AIR QUALITY "EVENTS"

The data analysis presented in Section 3 and Section 4 of this report shows that there were occasions throughout the reporting period when elevated levels of particles (PM_{10}) were recorded across the monitoring network. These occasions are referred to as an "event", and are determined by comparing the monitored level to the PM_{10} criteria prescribed by the Taskforce (at Taplin Street). Further analysis of the data then supports a determination of the event as being either an exceedance, or as a result of a background event.

5.1 Number of PM_{10} "Events"

There are a total of ten PM_{10} events recorded at Taplin Street that were subject to further evaluation to identify the likely contributing cause of the events.

The Taskforce interim air management criterion of 70 µg/m^3 (24 hour average) is prefaced with an allowance of 10 exceedances per calendar year, and is expected to be met east of Taplin Street (DSD, 2012). As outlined in section 2.4.1, where the event can be attributable to industry emissions, and not a result of elevated background concentrations in the region, then the event would be considered an exceedance of the Taskforce criterion.

Analysis of the data showed that there were ten days when levels recorded at the Taplin Street monitoring station were above the criterion specified by the Taskforce (i.e. 70 µg/m^3 24-hour average) as summarized in Table 5-1. To determine if the event is attributable to industry activity or not, background dust levels are also taken into account for comparison along with the wind speed and wind direction data at Taplin Street at the time the event occurred. PM_{10} data at the BoM monitor station is considered to reflect the natural dust emission levels due to its location and distance from the industrial activities in Port Hedland region. The date when a dust event occurred, the 24-hour average PM_{10} levels at Taplin Street and BoM, and the inferred cause of the dust event are presented in Table 5-1.

Table 5-1: PM_{10} concentration recorded at Taplin Street and BoM sites during dust events

Date	Taplin St (µg/m^3)	BoM (µg/m^3)	Difference (µg/m^3)	Inferred cause
1/08/2014	90	39	51	Non background
19/09/2014	72	40	32	Non background
21/09/2014	81	29	52	Non background
1/10/2014	91	39	51	Non background
14/11/2014	182	144	38	Background
26/11/2014	71	59	12	To be investigated
7/12/2014	76	28	47	Non background
5/01/2015	75	67	9	Non Background
9/01/2015	78	59	19	To be investigated
22/01/2015	81	76	5	Background

Note: Difference = Taplin Street - BoM (µg/m3) and all data has been rounded to the nearest whole number

Primary analysis shows that two dust events for Taplin Street correspond to days with a high background event at BoM. In addition, on 26/11/2015 and 9/01/2015, the difference between the 24 hour average PM_{10} levels at Taplin Street and BoM is less than 20 µg/m^3. The relatively high background dust levels present at BoM (59 µg/m^3) on these occasion leaves a relatively small buffer before the criterion is exceeded. This indicates that high regional background dust levels may have partially contributed to these dust events, primary from the drift spoil area located north-west of the Taplin Street monitor near the spoil bank. However, at the same time, these dust events could also be potentially caused by the

emissions from nearby industrial operations. Therefore, these days were marked in Table 5-1 as to be investigated.

Further investigations were conducted to identify the potential sources contributing to the inferred non-background dust and those who required further investigation (i.e. 26/11/2015 and 9/01/2015). This analysis is demonstrated in section 5.1.1 to section 5.1.9

5.1.1 01/08/2014 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 01/08/2014 is shown in Figure 5-1 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west to south east at wind speeds from 2 to 3 m/s.

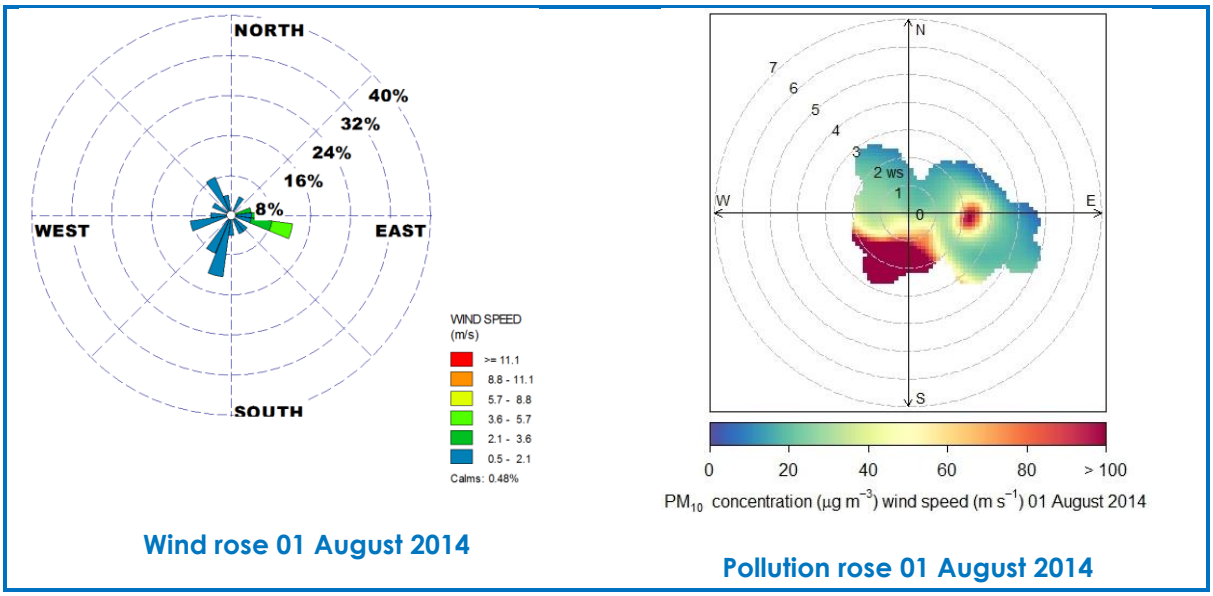


Figure 5-1: Wind and pollution roses at Taplin Street monitor on 01/08/2014 - PM_{10} concentration on suspected non background related dust event.

Additionally, the hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street on 01/08/2014 are shown in Figure 5-2. The hourly average PM_{10} concentration recorded at BoM is also plotted as a background PM_{10} reference. Wind directions from south-easterly through to north-westerly (i.e. 115° to 290° from Taplin Street) is considered to be the arc of influence by industrial activities in the Port Hedland region (shaded as light green in Figure 5-2).

During this dust event the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at the Taplin Street was above 70 µg/m^3, particularly from 2:00 am to 4:30 am and from 9:00 pm to midnight. It was noted that the wind speed was relatively low (i.e.1 to 2.2 m/s) during these periods which prevented the dispersion of the accumulated dust in the atmosphere. It is also worth noting that the hourly PM_{10} data at BoM are missing at 10:00 am and 10:00 pm. Nevertheless, it is suggested that this dust event is potentially caused by the presence of atmospheric inversion conditions at night and influenced by the emissions from nearby industrial operations. An atmospheric inversion occurs during winter months when normal atmospheric conditions (cool air above, warm air below) become inverted. An inversion acts as cap on the upward movement of air from the layers below. Therefore, the dispersion of air pollutants is limited under this condition.

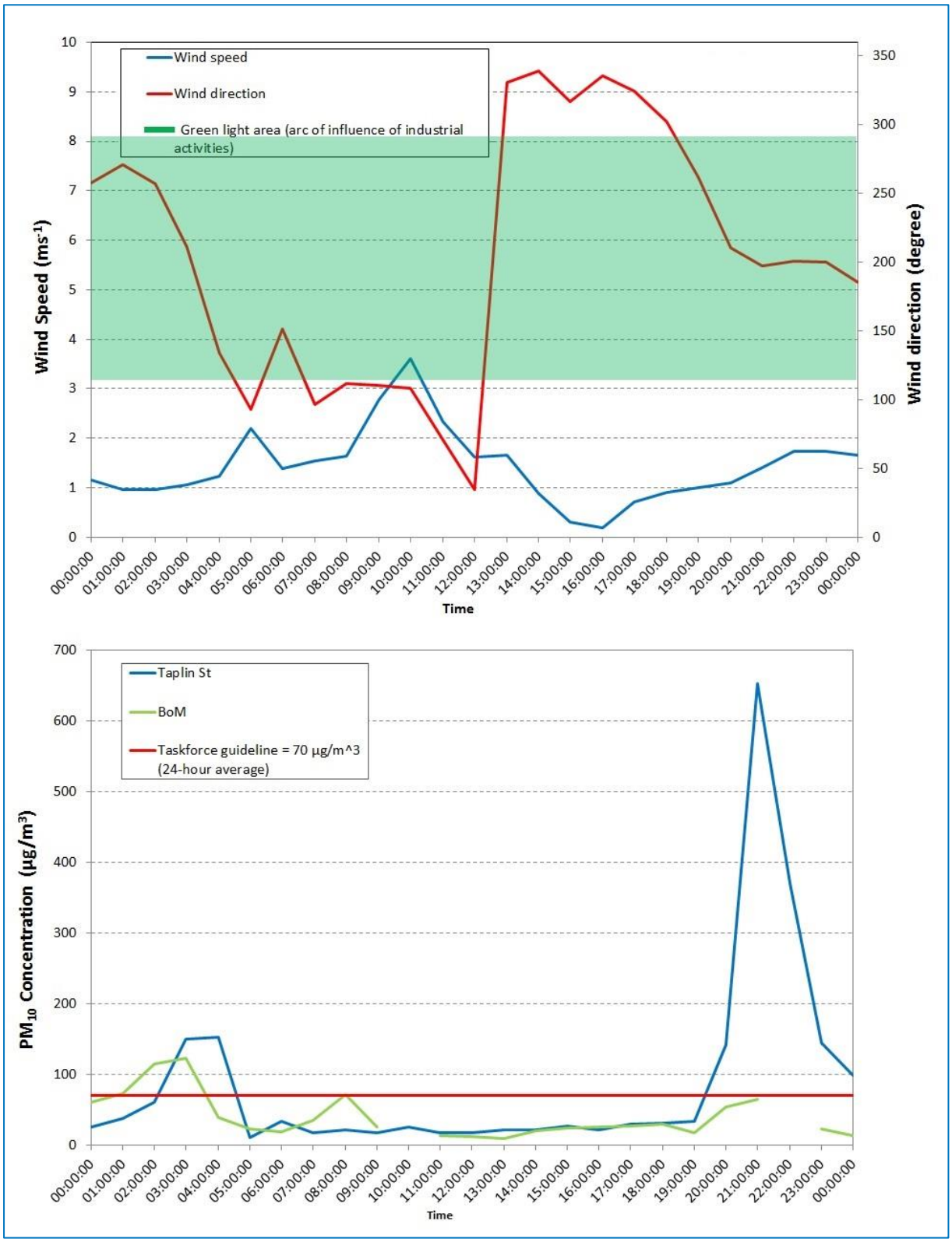


Figure 5-2: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 01/08/2014.

5.1.2 19/09/2014 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 19/09/2014 is shown in Figure 5-3 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west and some from north east at relatively low wind speeds, (i.e. 1-4 m/s).

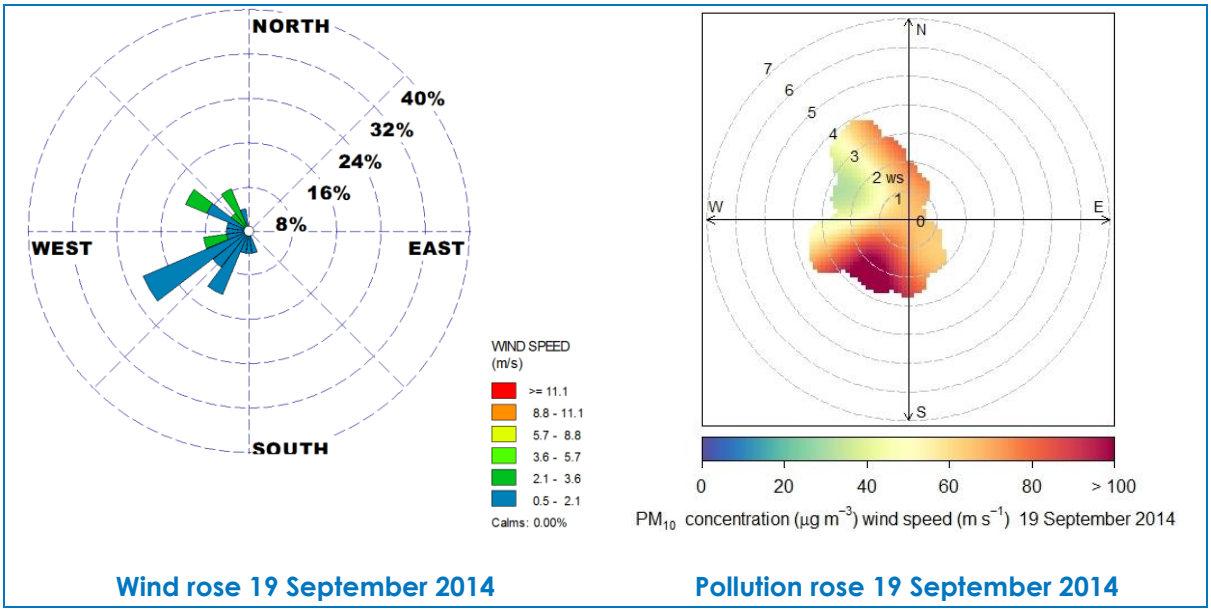


Figure 5-3: Wind and pollution roses at Taplin Street monitor on 19/09/2014 - PM_{10} concentration on suspected non background related dust event.

Additionally, the hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 19/09/2014 are shown in Figure 5-4. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-4.

During this dust event, the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at Taplin Street exceeded 70 µg/m^3 between 3:00 am to 9:00 am and 6:00 pm to 9:00 pm. The wind speed was 1.5 to 2 m/s during these period. It is highly likely that this dust event is attributable to industrial activities in the Port Hedland region.

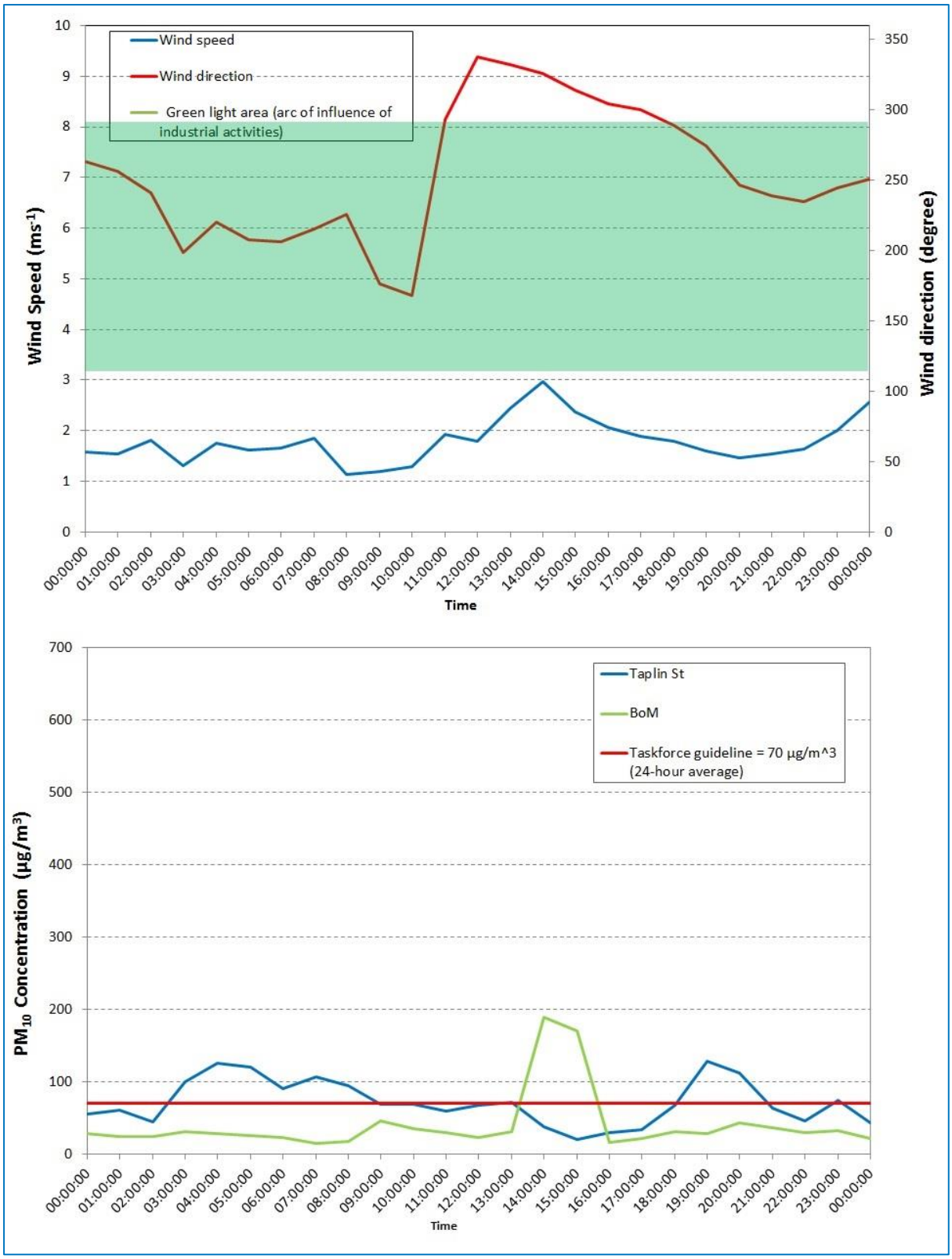


Figure 5-4: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 19/09/2014.

5.1.3 21/09/2014 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 21/09/2014 is shown in Figure 5-5 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west to north- east at wind speeds ranging from 4 to 6 m/s.

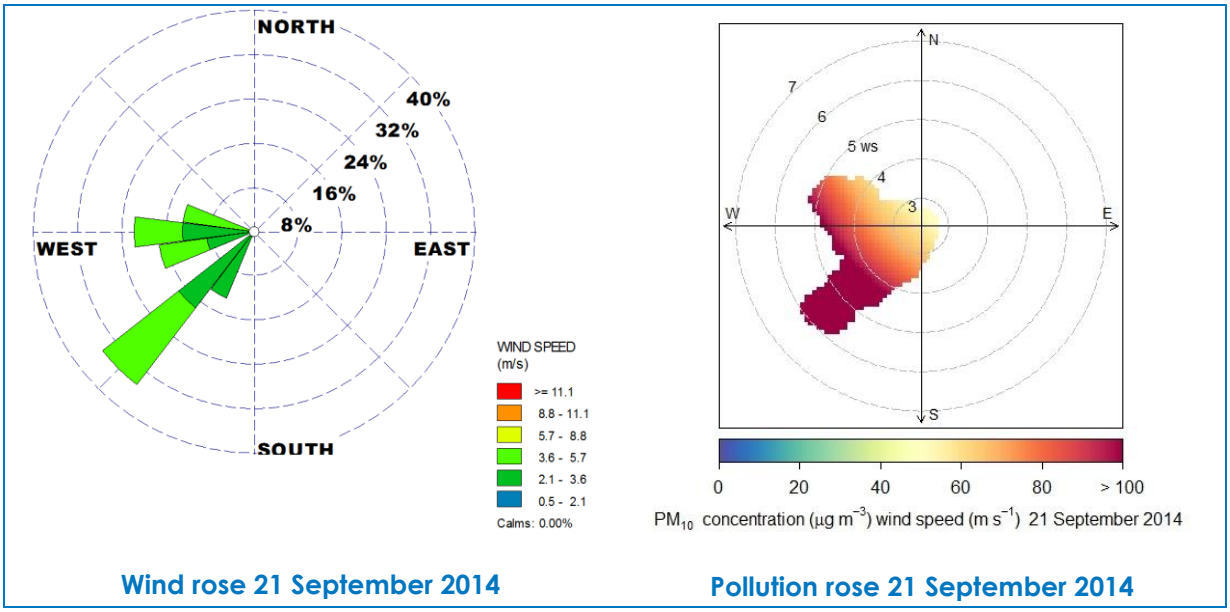


Figure 5-5: Wind and pollution roses at Taplin Street monitor on 21/09/2014 - PM_{10} concentration on suspected non background related dust event.

Additionally, the hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 21/09/2014 are shown in Figure 5-6. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-6.

During this dust event, the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at Taplin Street exceeded 70 µg/m^3 between 1:00 am to midday. The wind speed was between 2.9 to 4.5 m/s during this period. It is highly likely that this dust event is attributable to industrial activities in the Port Hedland region.

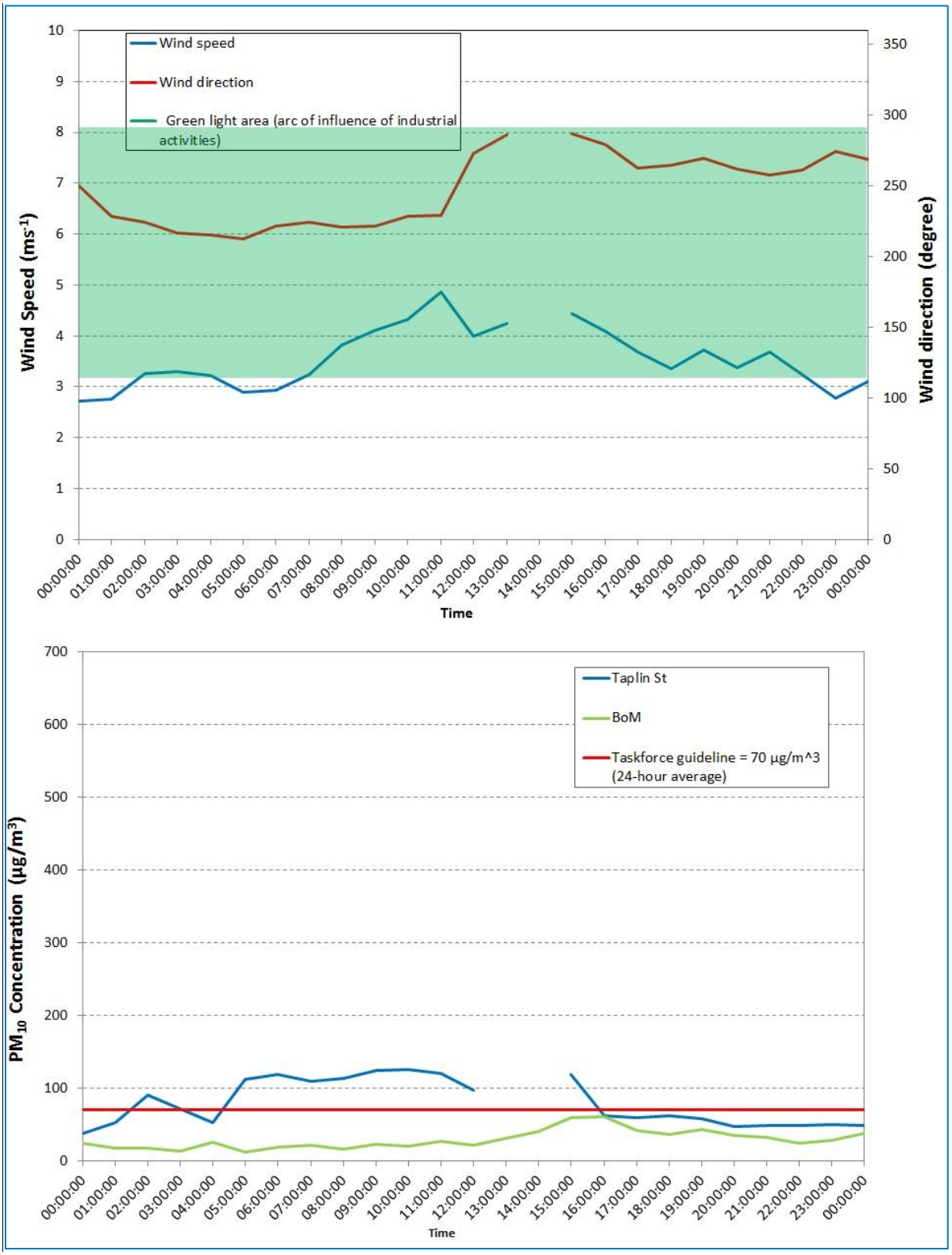


Figure 5-6: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 21/09/2014.

5.1.4 01/10/2014 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street data on 01/10/2014 is shown in Figure 5-7 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution

roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west and some from north west at wind speeds that ranges from 2-6 m/s.

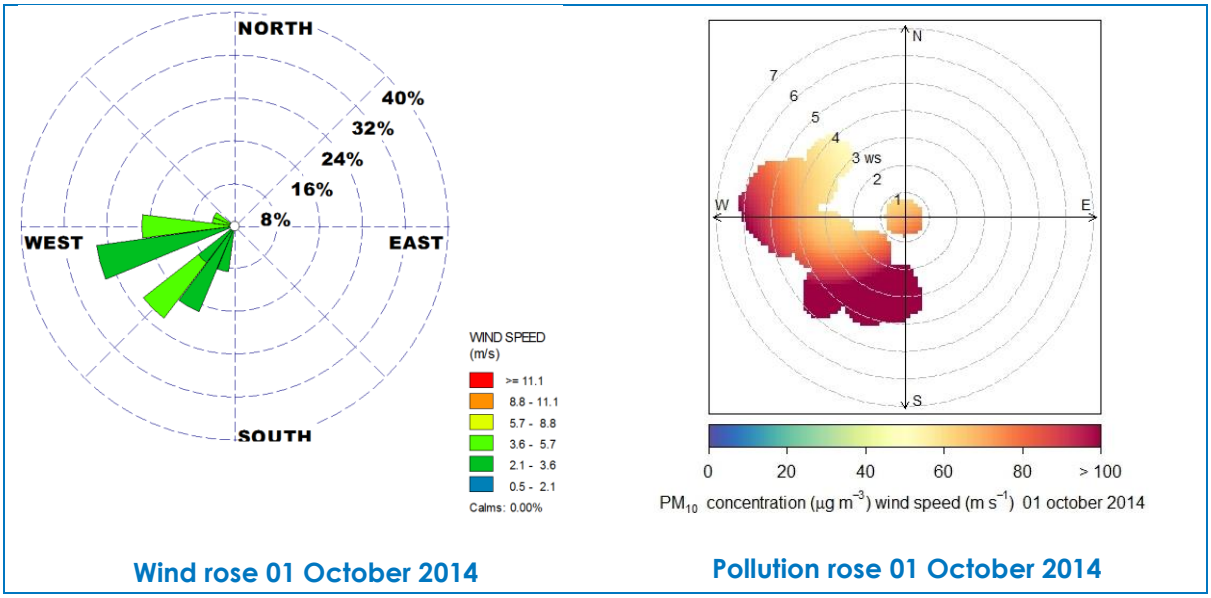


Figure 5-7: Wind and pollution roses at Taplin Street monitor on 01/10/2014 PM_{10} concentration on suspected non background related dust event.

Additionally, the hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 01/10/2014 are shown in Figure 5-8. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-8.

During this dust event, the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at Taplin Street exceeded 70 µg/m^3 between 1:00 am to 10:00 am. The wind speed during this period was between 2.9 to 3.5 m/s. It is highly likely that this dust event is attributable to industrial activities in the Port Hedland region. Also worth noting that the PM_{10} data as well as the wind direction and wind speed at Taplin Street are missing at 6:00 pm, while the PM_{10} data at BoM is missing at 10:00 am, 6:00 pm and 10:00 pm.

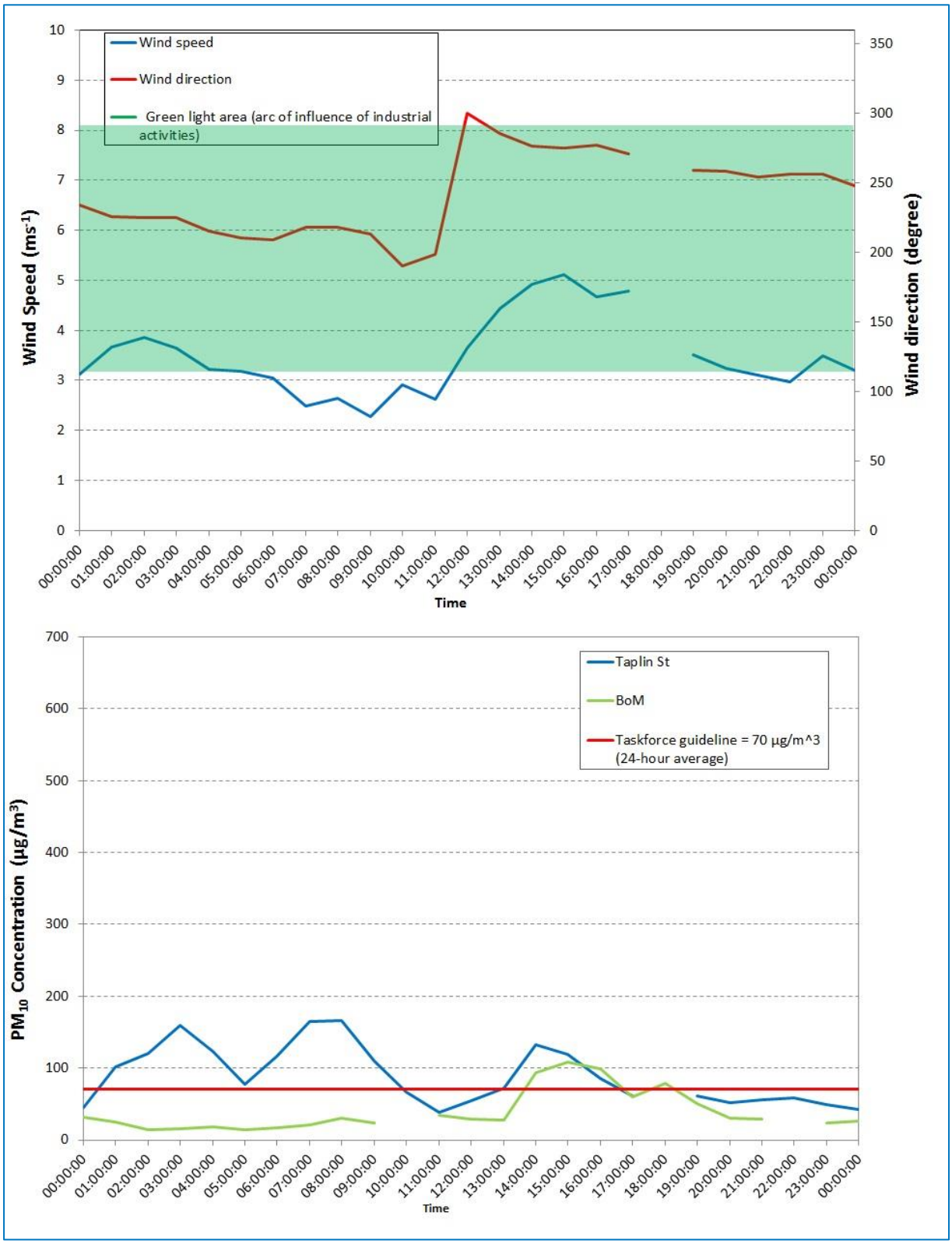


Figure 5-8: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 01/10/2014.

5.1.5 07/12/2014 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 07/12/2014 is shown in Figure 5-9 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west to south east at wind speeds that ranges from 3 to 4 m/s and some from north west at higher wind speeds, (i.e. 5-6 m/s).

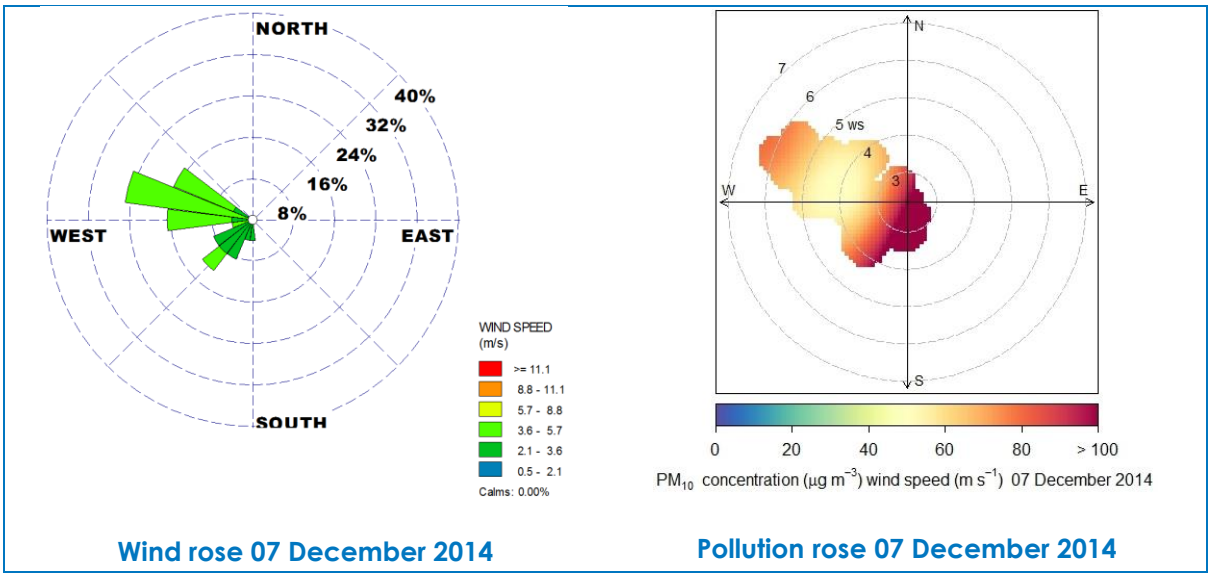


Figure 5-9: Wind and pollution roses at Taplin Street monitor on 07/12/2014 - PM_{10} concentration on suspected non background related dust event.

The hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 07/12/2014 are shown in Figure 5-10. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-10.

During this dust event, the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at Taplin Street exceeded 70 µg/m^3 between 3:00 am to 9:00 am. The wind speed during this period was between 2.8 to 3.5 m/s. It is highly likely that this dust event is attributable to industrial activities in the Port Hedland region. It is worth noting that the PM_{10} data at BoM is missing from 2:00 pm to 5:00 pm.

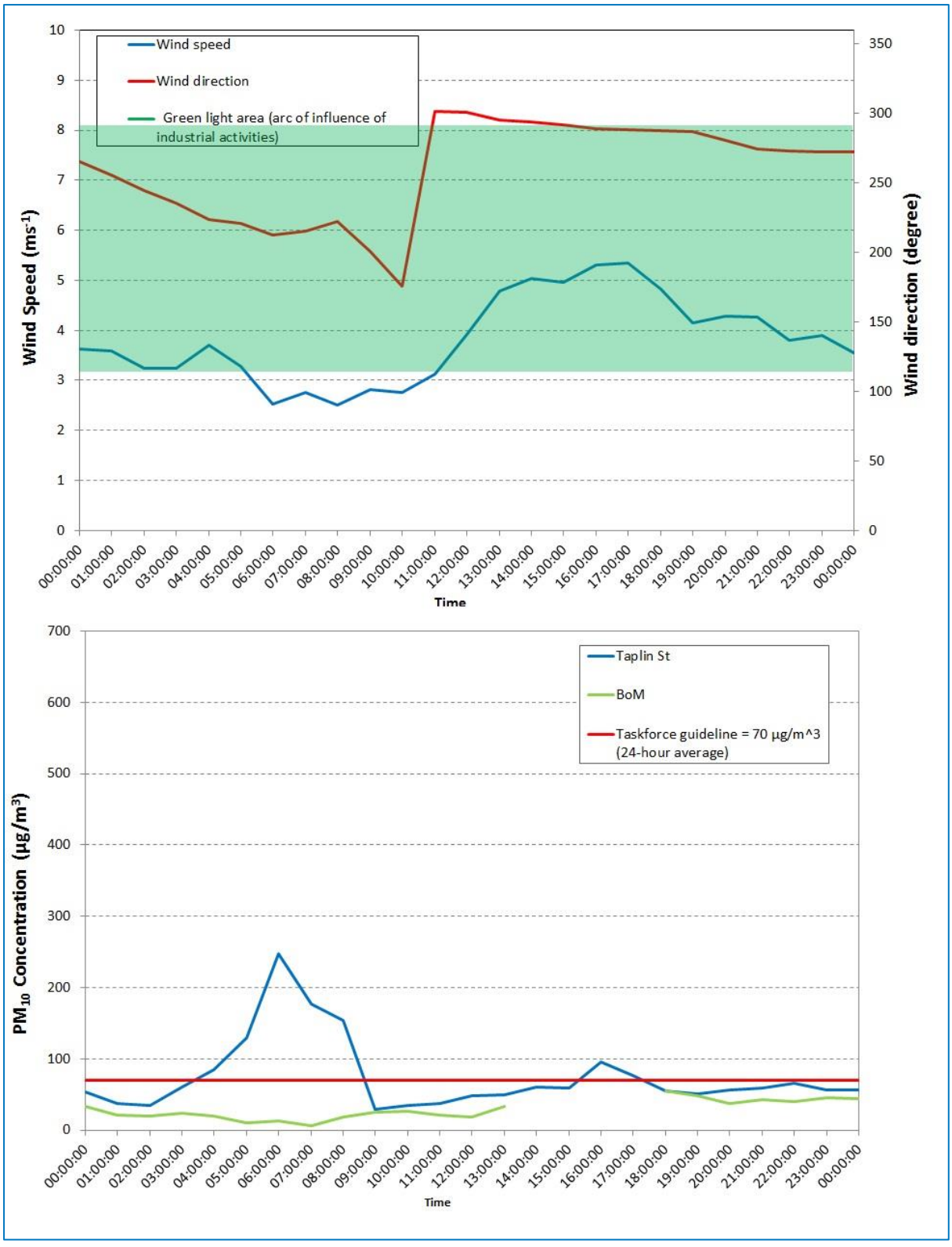


Figure 5-10: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 07/12/2014.

5.1.6 05/01/2015 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 05/01/2015 is shown in Figure 5-11 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west to south east at relatively low wind speeds, (i.e. 1-4 m/s).

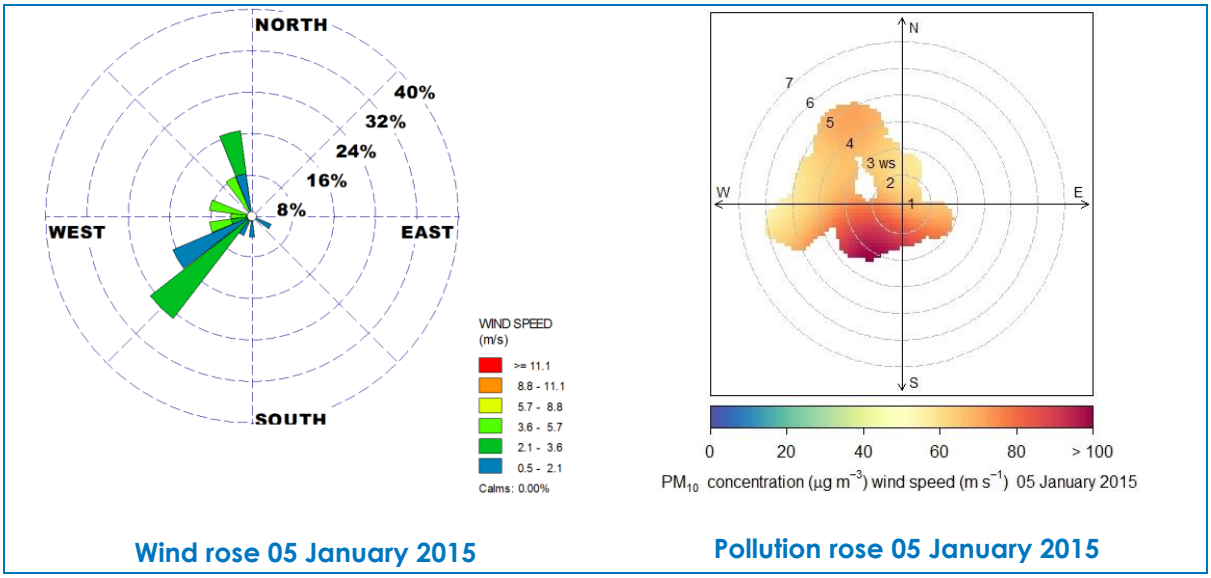


Figure 5-11: Wind and pollution roses at Taplin Street monitor on 05/01/2015 - PM_{10} concentration on suspected non background related dust event.

Additionally, the hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 05/01/2014 are shown in Figure 5-12. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-12.

During this dust event, the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at Taplin Street exceeded 70 µg/m^3 between midnight to 3:00 am 7:00pm to 9:00am and 10:00 pm to midnight. The wind speed was relatively low during this period. This dust event is potentially attributable to industrial activities in the Port Hedland region.

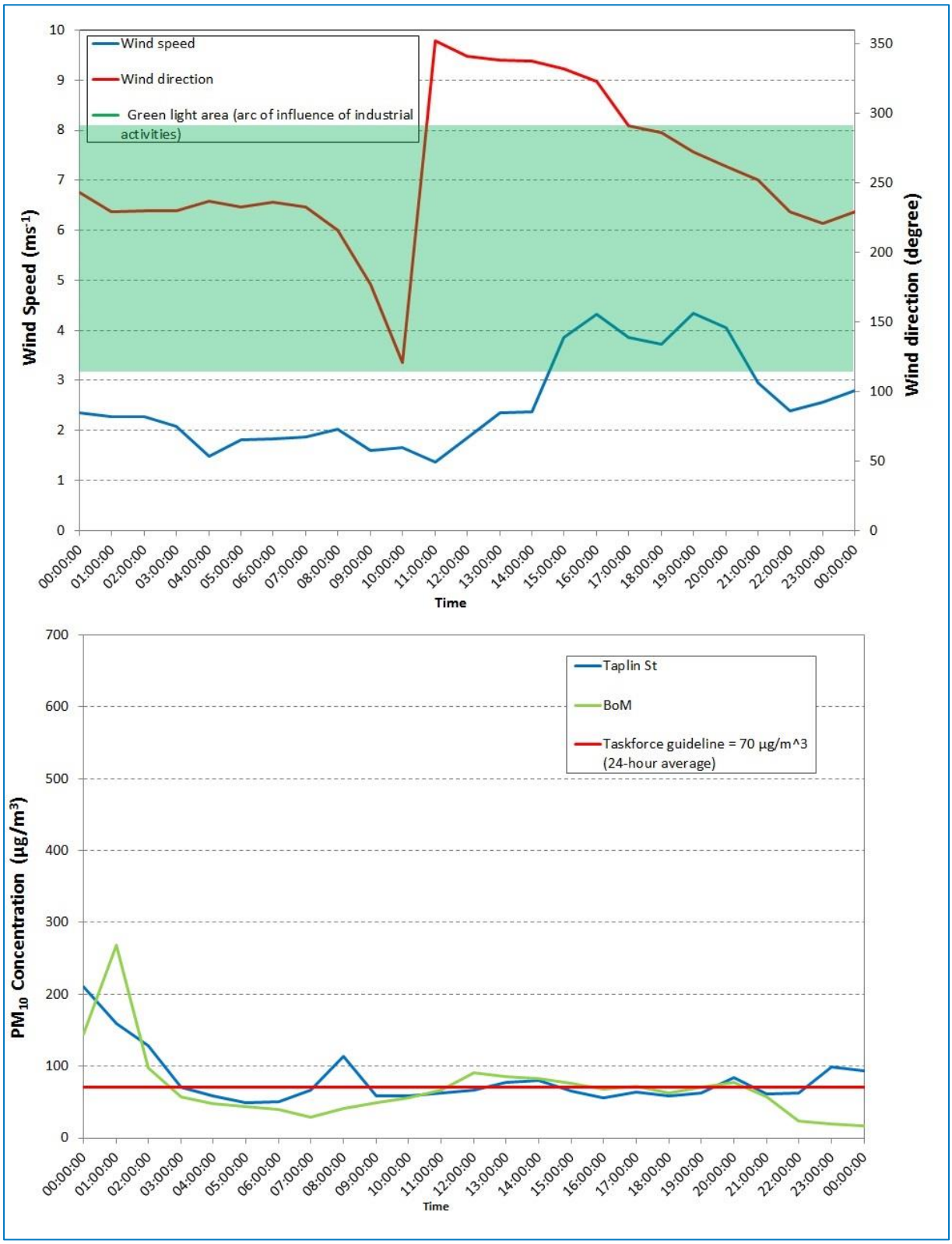


Figure 5-12: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 05/01/2015.

5.1.7 09/01/2015 (Non-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street using 10 minutes data on 9/01/2015 is shown in Figure 5-13 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- west to north east at wind speeds between 1 to 5 m/s

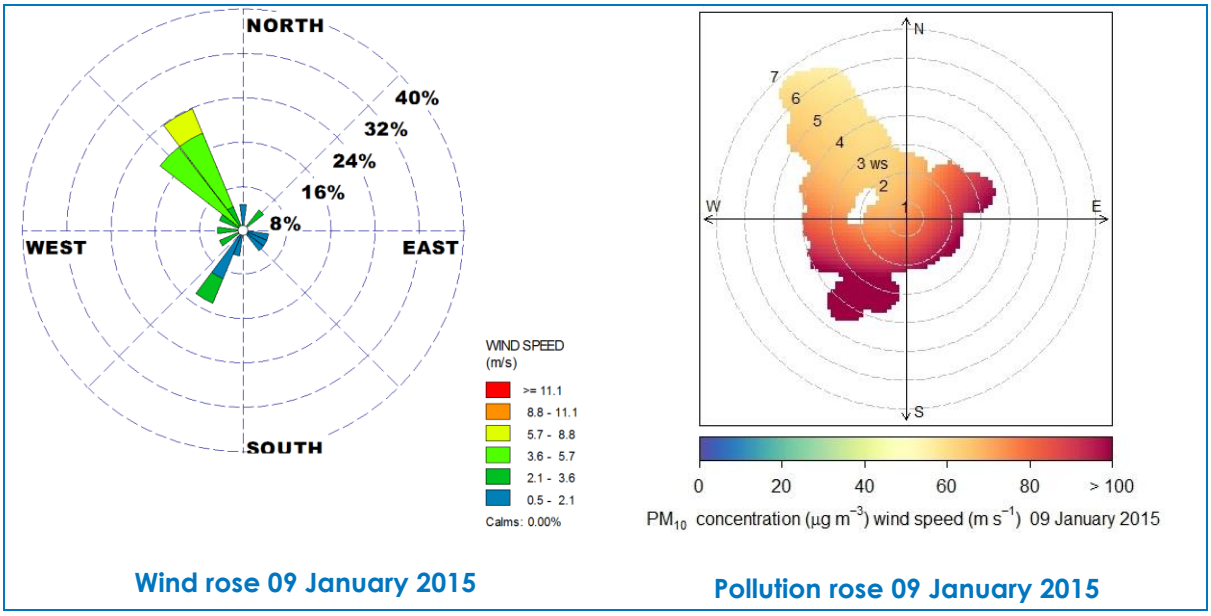


Figure 5-13: Wind and pollution roses at Taplin Street monitor on 09/01/2015- PM_{10} concentration on suspected non-background related dust event.

Additionally, the hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 09/01/2015 are shown in Figure 5-14. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-14.

During this dust event, the wind direction was within the arc of influence for industrial activities when the PM_{10} concentration at Taplin Street exceeded 70 µg/m^3 between 4:00 am to 7:00 am and between 9:00pm to midnight. The wind speed was relatively low during this period (i.e. 0.8 to 1.6 m/s). This dust event is potentially attributable to industrial activities in the Port Hedland region.

It is worth noting that the PM_{10} data and the wind direction data at Taplin Street are missing from 1:00am to 3:00 am and from 9:00 am to 11:00 am.

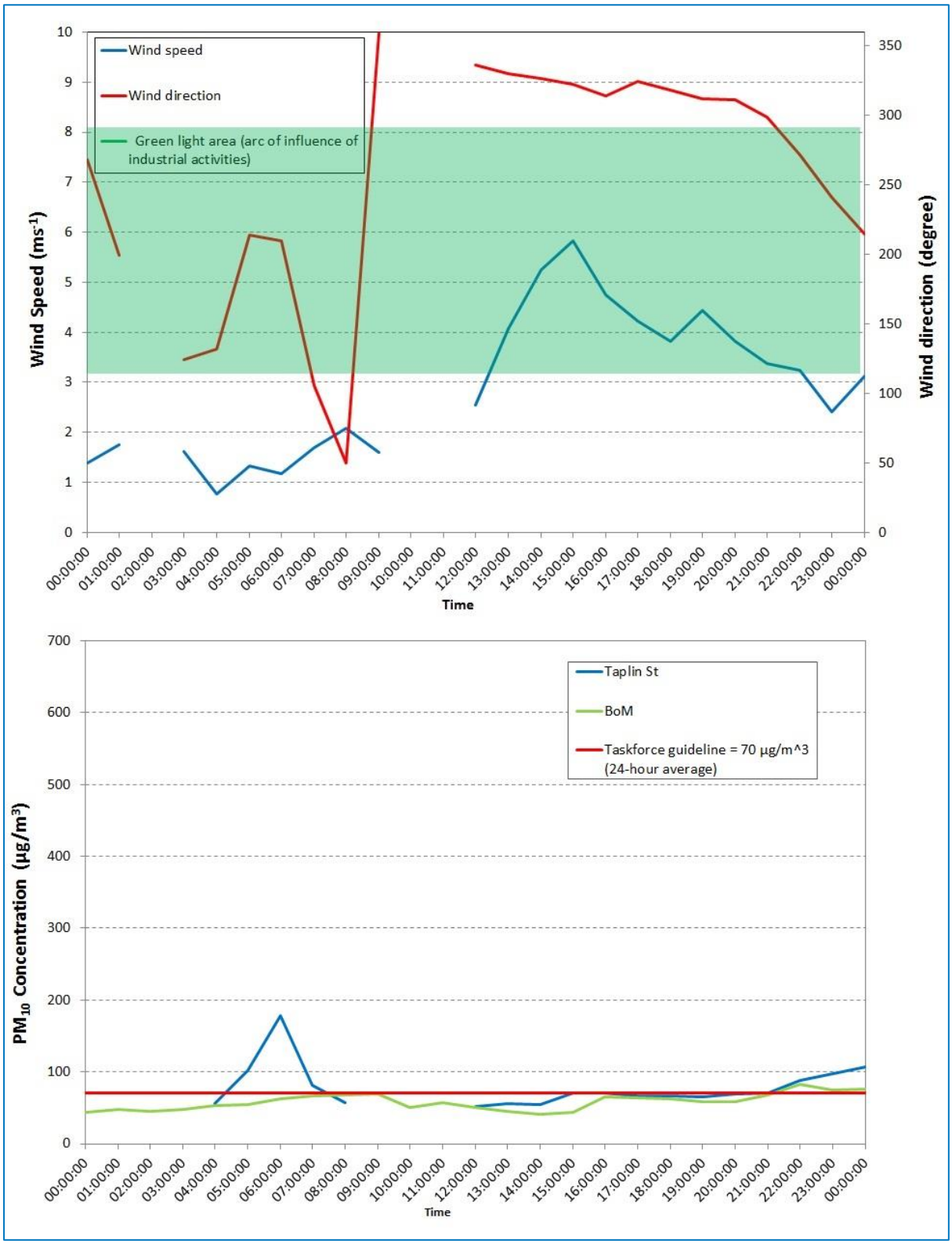


Figure 5-14: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 09/01/2015

5.1.8 26/11/2014 (Potential-background event)

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 26/11/2014 is shown in Figure 5-15 (Carslaw & Ropkins, 2012 and Carslaw, 2013). The wind and pollution roses presented in the figure indicates that the highest pollution levels occurred when the wind is from south- east to north east at wind speeds between 1 to 5 m/s. Similar plots for the remaining high concentration events associated to be background related are shown in Figure 5-17 for the reader reference.

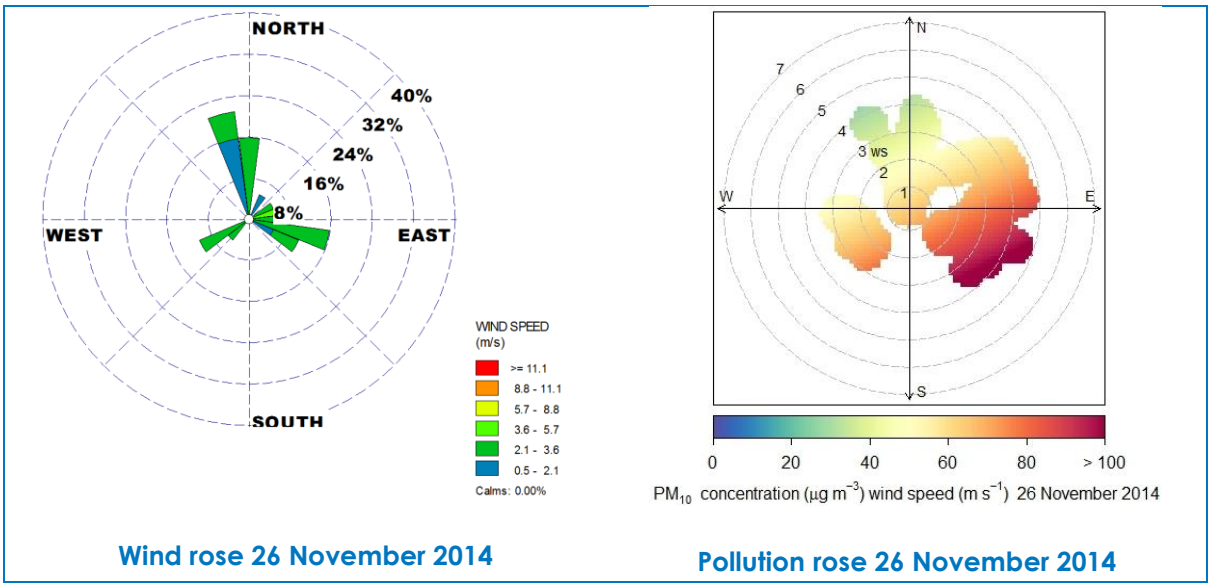


Figure 5-15: Wind and pollution roses at Taplin Street monitor on 26/11/2014 - PM_{10} concentration on suspected background related dust event.

The hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street together with the hourly average PM_{10} concentration recorded at BoM on 26/11/2014 are shown in Figure 5-16. The arc of influence by the industrial activities from Port Hedland is shaded as light green in Figure 5-16.

The levels of PM_{10} at the BoM monitor, as the background site, increased and reached a maximum in the same period as the PM_{10} levels at the Taplin Street monitor (1:00 am to 5:00 am). At that particular time, the wind direction was not within the arc of influence for industrial activities. Similarly to previous case, it should be noted that the PM_{10} data at Taplin Street are missing at 1:00 am and from 5:00 pm to 9:00 pm. The trend indicates that the dust event is highly likely to be caused by elevated background dust levels.

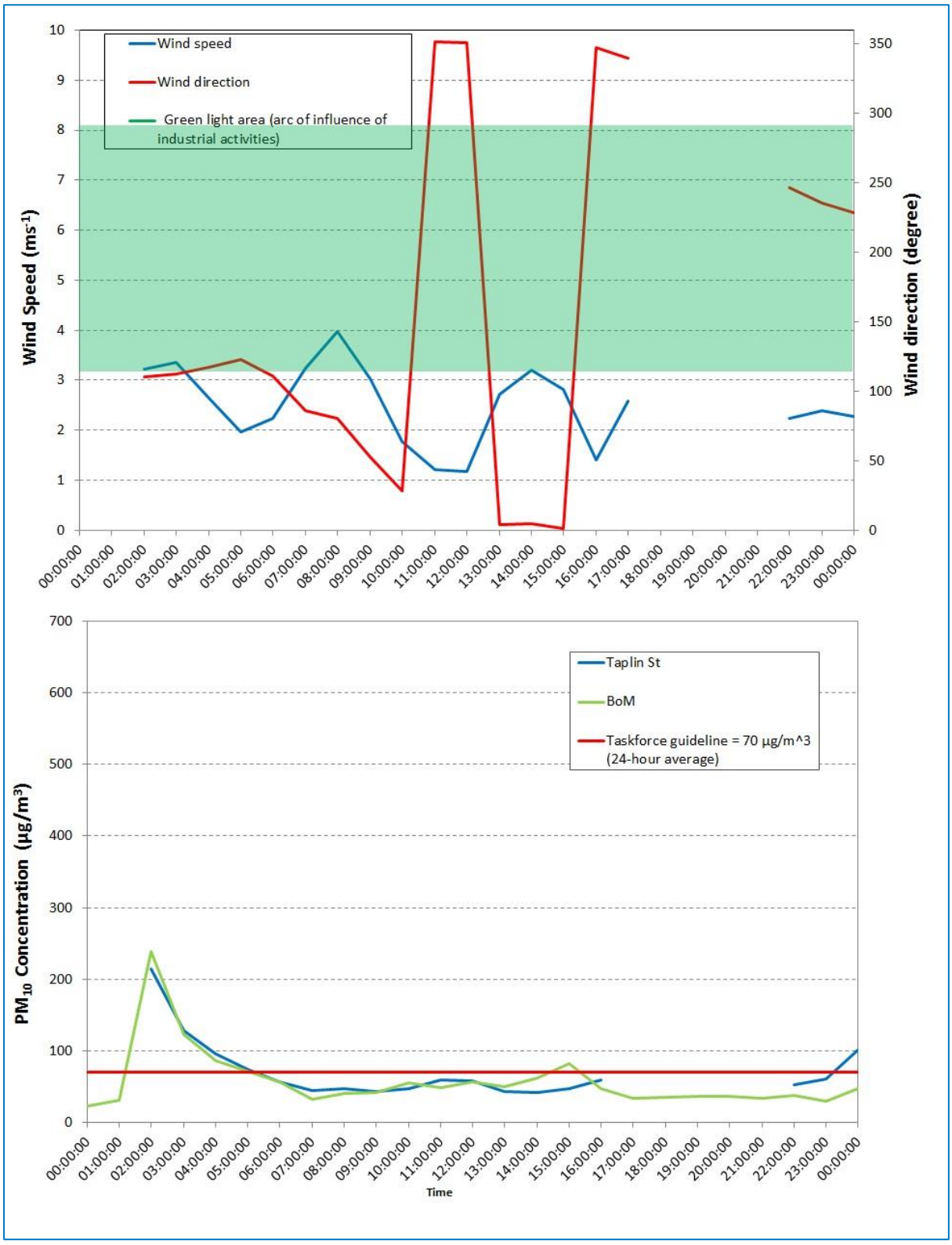


Figure 5-16: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 26/11/2014.

5.1.9 Other background events

The relationship between dust concentration, wind direction and wind speed at Taplin Street on 14/11/2014 and 22 /01/2015 are shown in Figure 5-17 (Carslaw & Ropkins, 2012 and Carslaw, 2013).

The wind and pollution roses presented in the figures on the 14/11/2014 indicates that the highest pollution levels occurred when the wind is from south- east at all ranges of wind speed (i.e. 1-7 m/s).

Moreover, the wind and pollution roses presented in the figures on the 22/01/2015 indicate that the highest pollution levels occurred when the wind is from west at wind speed around 3 m/s. It should be noted that pollution rose on this date indicates a localised source around the Taplin monitor.

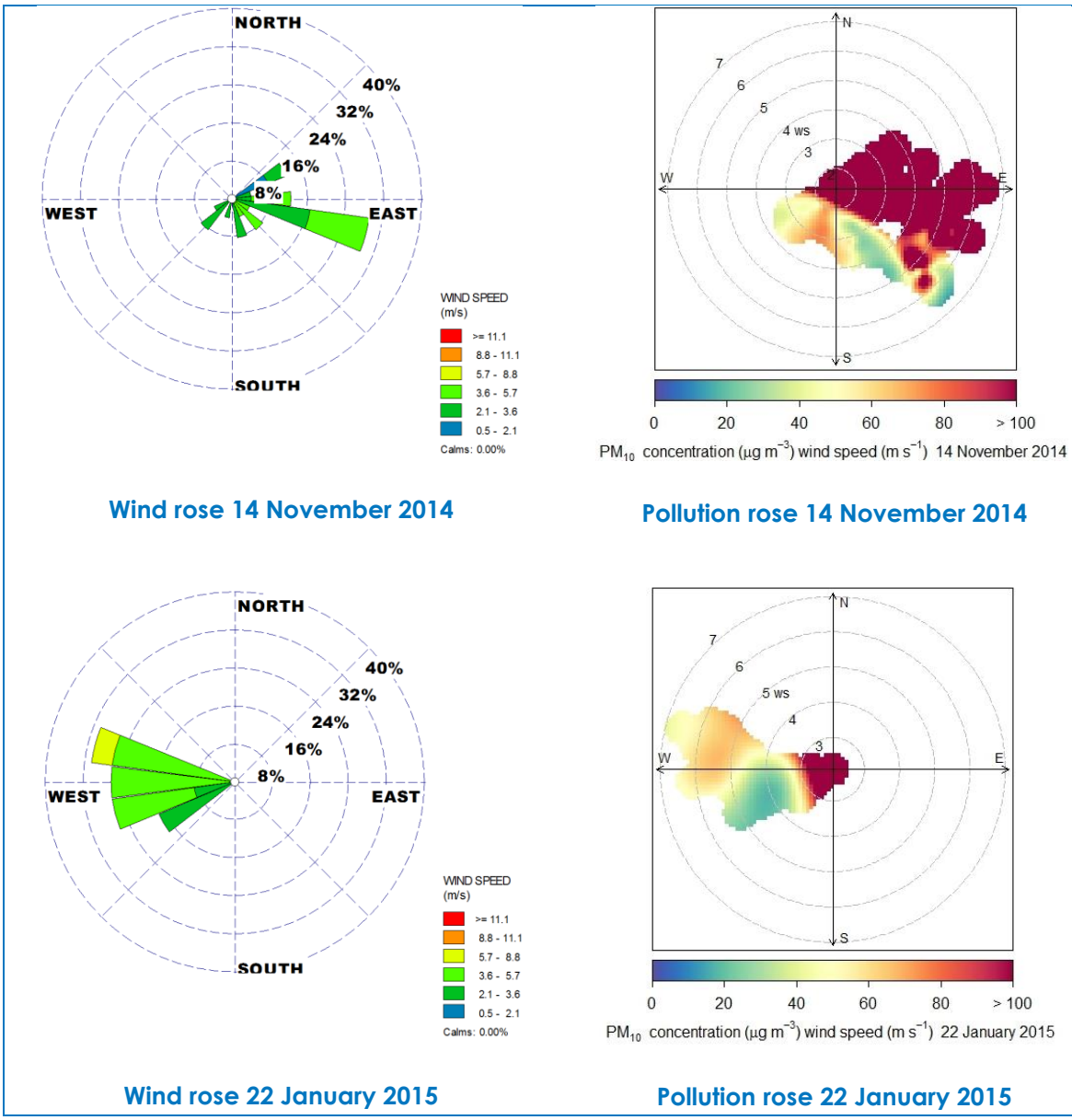


Figure 5-17: Wind and pollution roses at Taplin Street monitor - PM_{10} concentration on suspected background related dust events.

6 SUMMARY OF RESULTS

6.1 Monitoring Network Performance

Following the NEPM guideline on data collection and handling (PRC, 2001) as outlined in this report in section 2.4, the performance of the monitoring network during the year proved to be reliable, and annual data recovery of at least 75% was achieved for most monitored parameters at all monitoring stations. Data recovery of at least 75% was also achieved each quarter of the year for most of the parameters monitored at most remaining monitoring stations, except for PM_{10} monitoring at Neptune Place where data recovery for the last quarter of the year was 74%. The second lowest recovery was also encountered at the last quarter for PM_{10} at Kingsmill (76%). All other monitoring stations achieved greater than 80% recovery.

6.2 Monitored Levels of Oxides of Nitrogen

PHIC monitored oxides of nitrogen at three locations throughout the year (Taplin Street, Acacia Way and BoM monitoring stations). Oxides of nitrogen are being monitored in Port Hedland to determine the relative change in its ambient concentration over time.

During the year, nitrogen dioxide levels at the three monitoring stations are shown to be lower than the annual NEPM NO_2 standard. The 1-hour concentrations of nitrogen dioxide at all stations were also lower than the 1-hour NEPM NO_2 standard (i.e. 64% and 75% below the NEPM standard for 1-hour and annual average respectively). These standards were also met for the 2012-2013 and 2013-2014 financial years.

6.3 Monitored Levels of Sulfur Dioxide

PHIC monitored Sulfur dioxide at three locations throughout the year (Taplin Street, Acacia Way and BoM monitoring stations). Sulfur dioxide is being monitored to determine the relative change in its ambient concentration over time. Similarly to the 2012-2013 and 2013-2014 financial year findings, Sulfur dioxide levels are shown to be lower than the specified NEPM standards (i.e. 78%, 88% and 92% below for all 1-hour, 24-hour and annual NEPM criteria respectively).

6.4 Monitored Levels of Particles

PHIC monitored particles (PM_{10}) at all eight monitoring stations throughout the year. From time to time elevated levels of particles are recorded at each of the monitoring stations. The lowest number of events was recorded at BoM, and the highest number of events was again recorded at Wedgefield. Particle levels higher than the 24-hour NEPM criteria were recorded on 17 occasions at BoM and 169 occasions at Wedgefield. Last year PM_{10} recordings at BoM exceeded the 24-hour NEPM criteria on 10 occasions and at Wedgefield on 148 occasions.

Compared to last year, most stations recorded a greater number of occasions in PM_{10} higher than 70 $\mu g/m^3$ except Wedgefield which decreased in the number of events. In terms of exceedances in 24-hour average PM_{10} greater than 50 $\mu g/m^3$, all stations recorded greater number of occasions.

Monitoring at the BoM station demonstrates the relative background level of particles in the region. Elevated background levels of particles increases the likelihood that emissions from industrial activities within Port Hedland will contribute to high dust events. Comparing results at BoM and Taplin Street stations helps to understand where the relative contribution is coming from.

There were 10 days when particle levels recorded at the Taplin Street monitoring station were above the Taskforce criterion in contrast to 17days in FY13 and 6 in FY14. The number of occasions of 24-hour average PM_{10} concentration over 70 $\mu g/m^3$ were decreased by 41% compared to FY13 and increased

by 67% if compared to FY14. Analysis of the data shows that three of the events were attributable to the elevated background dust levels. The non-background events were likely to be caused by various factors including emissions from nearby industrial activities, wind erosion and the presence of inversion conditions.

$PM_{2.5}$ was also monitored in four monitoring stations (Richardson Street, Taplin St, BoM, and Acacia Way) throughout FY15. The $PM_{2.5}$ levels at all monitors have an annual average below the NEPM advisory reporting guidelines. The highest 24-hour averages of $PM_{2.5}$ was recorded at Taplin Street. The NEPM advisory reporting guidelines only include $PM_{2.5}$ as a goal for national guidance.

6.5 Presence of Metals in Monitored Particles

PHIC monitored for the presence of metals in the particle samples (PM_{10}) at five locations throughout the year. One or more metals were detected at levels above the limit of reporting on each monitoring day. A statistical summary of results for each station is presented in Appendix B.3. Metals are not monitored at Neptune Place or Kingsmill Street.

6.6 PHIC Monitoring Priorities for the Year Ahead

The monitoring operation is managed by regular reviews and response to operational requirements. PHIC will continue to make the real-time PM_{10} data accessible to the community via the monitoring website. PHIC have reviewed the data from the NO_x and SO_x monitoring network over the past three years, finding that the NO_x and SO_x levels are well below the regulatory standards. Therefore, PHIC plans to decommission the NO_x and SO_x monitoring stations at BoM and Acacia Way in the near future. PHIC will continue to report annually to the Taskforce on the results of PM_{10} (at all current locations) and NO_x and SO_x (at Taplin Street). The next report being expected in September 2016, presenting the monitored data for the 2015-2016 year.

7 REFERENCES

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Appendix A PHIC DATA HANDLING PROCEDURE

A.1 DISCLAIMER

Data handling procedure used in this study is only appropriate for this report. This PHIC data handling procedure has been reviewed and is considered to be adequate by the Department of Environment and Regulation.

A.2 SCREENING

The first step in the data cleaning process is to ensure that the raw ten minute is allocated to the correct timeline to ensure that correct averaging procedures can be applied. The process includes:

- Matching the raw 10-minute data to the corresponding timeline by using vlookup function in excel
- The raw data is then checked for missing or duplicate data. For example, there should be 52,560 10-minute data points from 1/7/2012 00:10 to 1/7/2013 00:00 at each monitoring station assuming 100% data availability; and
- Identify the total amount of data and locate the gaps of missing data for each monitoring station.

A.3 DATA NEAR DETECTION LIMITS

The detection limit for NO_2 and SO_2 in PHIC ambient monitoring network is 1 ppb. In some situations the concentration of NO_2 and SO_2 measured can be very close to zero, in which case the measured value may appears to be less than the detection limit or even records negative values (Table A-1).

Table A-1 Negative data from Taplin Street monitoring station

Date	SO_2 (ppb)	NO (ppb)	NO_2 (ppb)	NO_x (ppb)
6/09/2013 16:00	-1.3	-0.3	1.8	1.3
6/09/2013 17:00	-2.0	0.0	1.4	1.5
6/09/2013 18:00	-2.0	0.0	2.7	2.7
6/09/2013 19:00	-2.0	-0.2	2.3	2.0
6/09/2013 20:00	0.0	-0.1	6.9	6.8
6/09/2013 21:00	-2.0	-0.3	3.1	2.6
6/09/2013 22:00	-2.8	-0.3	4.4	4.1
6/09/2013 23:00	-2.0	2.3	8.0	9.9

In this case:

- Actual measured values (positive or negative) including values below detection limit are to be reported (PRC, 2001)
- Removing small negative measurements is not necessary (PRC, 2001); and
- Large negatives, however, are considered to be invalidated and to be removed as part of the validation process

A.4 CHECK FOR STRANGE PATTERNS

The raw data is then checked for potential erroneous patterns including:

- Identical readings (PM_{10}, SO_2, NO_2, wind speed and wind direction) for more than an hour (Table A-2)

Table A-2: Suspected data from Yule monitoring station

Time	PM_{10} (µg/m^3)
3/01/2013 14:50	107
3/01/2013 15:00	107
3/01/2013 15:10	107
3/01/2013 15:20	107
3/01/2013 15:30	107
3/01/2013 15:40	107
3/01/2013 15:50	1000
3/01/2013 16:00	1000
3/01/2013 16:10	1000
3/01/2013 16:20	1000
3/01/2013 16:30	1000
3/01/2013 16:40	1000
3/01/2013 16:50	1000
3/01/2013 17:00	1000
3/01/2013 17:10	1000
3/01/2013 17:20	1000
3/01/2013 17:30	1000
3/01/2013 17:40	1000

- Data before and after an extended period without any readings or intermittent (Table A-3). Check for monitor operating condition at the time. If it is only the logger failing intermittently, data should remain.

Table A-3: Suspected data from Yule monitoring station

Time	PM_{10} (µg/m³)
20/12/2012 22:30	
20/12/2012 22:40	
20/12/2012 22:50	1268.7
20/12/2012 23:00	1384.7
20/12/2012 23:10	1462.1
20/12/2012 23:20	
20/12/2012 23:30	
20/12/2012 23:40	1812
20/12/2012 23:50	1877.2
21/12/2012 0:00	
21/12/2012 0:10	
21/12/2012 0:20	
21/12/2012 0:30	
21/12/2012 0:40	2680.5
21/12/2012 0:50	
21/12/2012 1:00	
21/12/2012 1:10	3371.1
21/12/2012 1:20	
21/12/2012 1:30	3326.3
21/12/2012 1:40	

- Relatively low readings followed by a sudden jump to an extremely high reading then back to low reading (Table A-4). This is a manual process as sometimes the readings can be valid whilst other times the readings may be invalid.

Table A-4: Suspected data from Wedgefield monitoring station prior to data correction

Time	PM_{10} (µg/m³)
04/07/2012 06:10:00	29.40
04/07/2012 06:20:00	34.40
04/07/2012 06:30:00	39.50
04/07/2012 06:40:00	37.90
04/07/2012 06:50:00	34.20
04/07/2012 07:00:00	54.80
04/07/2012 07:10:00	1341.10
04/07/2012 07:20:00	0
04/07/2012 07:30:00	0
04/07/2012 07:40:00	0
04/07/2012 07:50:00	0
04/07/2012 08:00:00	0

A.5 DATA AVERAGING

The definitions and conventions that are relevant to the interpretation of the data are consistent with those applied through the state and commonwealth reporting for NEPM (PRC, 2001and 2002).

For valid averages, a minimum of 75% data availability for the averaging period is required, i.e. a valid 24-hour average requires eighteen hourly averages. ***Data which cannot meet this criterion will be excluded from the calculation.***

The order of averaging is that raw 10-minute data (PM_{10}, wind speed and wind direction) are converted to an hourly average first, and then the hourly PM_{10} further averaged to a 24-hour average. Details are as below:

- Hourly wind direction average is calculated by averaging the x and y components to obtain a vector average
- Five 10-minute averages or nine 5-minute averages are required for a valid hourly average
- Hourly average is referenced by the end time of the averaging period
- Annual averages are calculated from hourly average; and
- 24-hour averaging periods are referenced as midnight to midnight, and not 0900 to 0900; 24 hourly averages are calculated from hourly averages, i.e. from the 1st hour to the 24th hour of the day. Take 1 July 2012 as an example, the time stamp associated with the 24-hourly average is from 1/7/2012 00:10 to 2/7/2012 00:00 (Table A-5).

A.6 CHECK FOR OUTLIERS/INCONSISTENCIES

The 24-hour data is then checked for inconsistencies and outliers. If High Volume Air Sampler (HVAS) data is available for that station then the 1-hour BAM data is re-calculated to a 24-hour average from 09:00 to 09:00 (for correlation purposes only) and the following checks are performed:

- The ratio of the 24-hour averaged PM_{10} BAM data relative to the PM_{10} HVAS data is determined and checked to determine if the ratio falls between 0.5 and 2 times.
- The 24-hour averaged PM_{10} BAM data is plotted against the PM_{10} HVAS and checked for outliers (Figure A-1) A line of best fit is added to this data along with the R^2 and compared to the recommended correlation factor (0.98). The period in which outliers occurred is noted and investigated further.

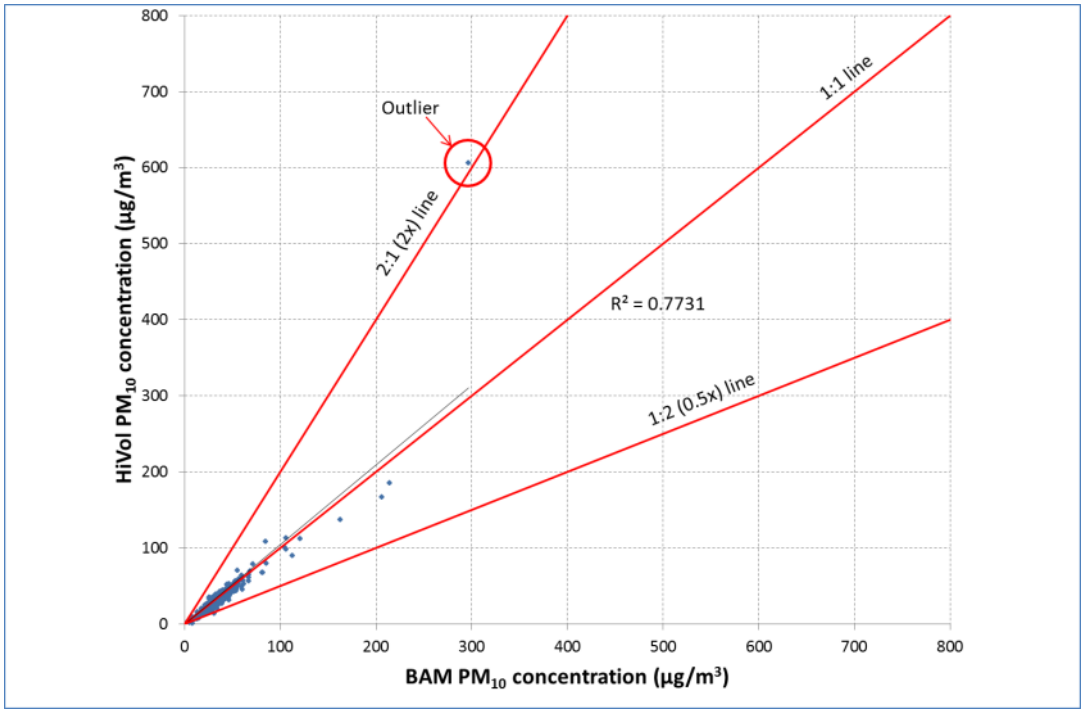


Figure A-1: Correlation of HiVol PM10 data to BAM PM_{10} at Taplin Street monitoring station (PHIC, 2014)

Outliers can be caused by many reasons, including:

- Instrument's fault
- Extreme weather
- High background dust levels; and
- No diagnosis, still suspect

The 10-minute and hourly averaged data contained within the time period of the outliers are checked taking these potential causes into account. The wind speed, wind direction, cyclone signal and background PM_{10} concentrations at the BoM monitoring site during the same time period as the suspect data occurred is also considered. The data is then determined to be either true or false. In the absence of the proof of instrument's fault, the data would be defined as true.

A.7 EDITING

Based on the findings of the previous component the following steps can be taken on the suspect data:

- Remove the data suspected to be false
- If data are found to be true, leave data unchanged

Appendix B SUMMARY OF DATA (2014-2015)

B.1 STATISTICS OF AIR QUALITY MONITORING DATA

This section shows the statistical summary of PM_{10}, NO_2 and SO_2 data in PHIC monitoring network.

Table B-1: Statistical summary for 24-hourly PM_{10} data of PHIC monitoring network (µg/m³)

	Richardson Street	Kingsmill Street	Taplin Street	Neptune Place	BoM	Wedgefield	Acacia Way	Yule River
Max	159	199	182	183	144	253	155	151
99th Percentile	78	103	78	83	82	108	89	82
98th Percentile	72	94	72	81	71	100	65	64
95th Percentile	65	82	62	67	50	93	50	50
50th Percentile	39	49	33	34	25	48	25	18
Minimum	3	16	0	8	3	7	4	3
>50	79	156	52	67	18	169	19	17
>70	11	50	8	14	8	59	6	6
Count	341	329	353	322	358	355	356	355
Recovery	93%	90%	97%	88%	98%	97%	98%	97%

Table B-2: Statistical summary for hourly NO_2 data of PHIC monitoring network (ppm)

	Taplin Street	BoM	Acacia Way
Maximum	0.0438	0.0318	0.0316
99th Percentile	0.0280	0.0209	0.0217
98th Percentile	0.0260	0.0183	0.0184
95th Percentile	0.0222	0.0143	0.0137
50th Percentile	0.0048	0.0029	0.0029
Minimum	0.0000	0.0000	0.0007
Annual average	0.0074	0.0047	0.0045
>0.12	0	0	0
Count	342	344	341
Recovery	94%	94%	93%

Table B-3: Statistical summary for hourly SO_2 data of PHIC monitoring network (ppm)

	Taplin Street	BoM	Acacia Way
Maximum	0.0418	0.0124	0.0085
99th Percentile	0.0159	0.0027	0.0018
98th Percentile	0.0128	0.0019	0.0011
95th Percentile	0.0084	0.0011	0.0008
50th Percentile	0.0005	0.0000	0.0000
Minimum	-0.0020	-0.0021	-0.0012
Annual average	0.0016	0.0002	0.0001
>0.2	0	0	0
Count	342	344	341
Recovery	94%	94%	93%

Table B-4: Statistical summary for 24-hourly SO_2 data of PHIC monitoring network (ppm)

	Taplin Street	BoM	Acacia Way
Maximum	0.0095	0.0021	0.0015
99th Percentile	0.0075	0.0014	0.0009
98th Percentile	0.0060	0.0012	0.0008
95th Percentile	0.0049	0.0009	0.0006
50th Percentile	0.0012	0.0001	0.0000
Minimum	-0.0008	-0.0011	-0.0009
>0.08	0	0	0
Count	353	355	350
Recovery	97%	97%	96%

B.2 "EVENT" DATE - PARTICLES

All occasions when the Taskforce PM_{10} criterion were exceeded and the PM_{10} levels in the PHIC monitoring network are listed in Table B-5.

The site exceeding the criterion is presented in red font.

Table B-6: Summary of exceedance dates and PM_{10} levels in PHIC monitoring network.

Date	Richardson Street	Kingsmill Street	Taplin Street	Neptune Place	BoM	Wedgefield	Acacia Way	Yule River
1/07/2014	40	51	33	29	24	95	22	15
2/07/2014	71	67	35	31	20	67	19	10
4/07/2014		78	35	33	26	96	29	9
5/07/2014	52	49	30	27	27	83	23	12
6/07/2014	65	75	38	30	23	56	20	12
7/07/2014	52	85		36	35	59	29	12
9/07/2014	47	54	41	39	30	74	16	3
11/07/2014	55	94	42	28	20	59	23	8
16/07/2014	47	43	32	30	26	83	17	10
17/07/2014	49	32	24	48	22	70	19	8
24/07/2014	29	40	21	24	24	72	10	6
25/07/2014	38	66	49	29	27	97	18	7
28/07/2014		108	58	42	30	62	18	7
29/07/2014		59	44	27	31	113	22	11
1/08/2014	72	77	90	38	39	118	25	9
2/08/2014	44	58	32	28	23	80	11	12
3/08/2014	42	35	24	30	20	87	15	14
4/08/2014	53	35	21	29	22	72	22	15
5/08/2014	34	27	27	25	18	104	23	15
6/08/2014	38	37	30	26	20	81	23	11
9/08/2014	45	78	50	34	35	58	30	10
10/08/2014	56	74	44	37	26	60	29	13
11/08/2014	33	32	25	25	31	78	23	11
12/08/2014	28	29	22	20	21	102	23	15
13/08/2014	46	31	23	30	22	78	18	12
14/08/2014	39	26	28	21	24	76	18	13
23/08/2014	51	68	34	32	31	81	28	12
25/08/2014	41	59	32	22	22	72	22	10
26/08/2014	47	58	40	25	27	76	29	
28/08/2014	49	100	43	33	28	61	33	11
29/08/2014	51	87	43	30	26	52	33	8
30/08/2014	47	80	61	38	30	44	25	7
3/09/2014	57	94	62	29	28	64	30	12
14/09/2014	45	82	68	57	30	60	30	19

Date	Richardson Street	Kingsmill Street	Taplin Street	Neptune Place	BoM	Wedgefield	Acacia Way	Yule River
15/09/2014	48	57	39	31	33	73	28	21
19/09/2014	63	78	72	60	40	43	30	16
21/09/2014	57	87	81	56	29	59	30	27
23/09/2014	57	61	33	28	25	85	25	19
24/09/2014	47	44	45	34	28	94	29	19
27/09/2014	60	79	56	39	20	42	22	16
1/10/2014	71	109	91	66	39	75	36	26
4/10/2014	66	81	65	48	26	56	26	24
5/10/2014	64	96	60	58	62	98	105	50
9/10/2014	89	70	53	53	33	69	31	21
10/10/2014	64	77	47	42	40	75	33	24
11/10/2014	48	58	43	37	45	79	36	19
22/10/2014	64	75	50	48	27	45	23	19
23/10/2014	70	79		61	72	65	33	26
26/10/2014		72		48	37	54	33	29
27/10/2014		70			45	85	46	38
29/10/2014	42	79	34	50	32	55	36	27
2/11/2014	48	95	42	47	30	48	31	22
6/11/2014	53	60	49	66	44	77	40	30
8/11/2014	45	56	46	53	33	94	34	28
9/11/2014	26	90	29	88	57	61	65	
10/11/2014	39	42	39	42	33	81	39	
14/11/2014	159	199	182	183	144	253	155	160
15/11/2014	65	77	65	66	58	99	59	115
16/11/2014	34	41	32	32	33	71	30	29
26/11/2014	59	67	71	67	59	100	53	55
27/11/2014	56	64	62	61	45	96		44
30/11/2014	51	64	50	47	41	71	32	30
6/12/2014	70	72	50	64	29	55	24	28
7/12/2014	67	81	76	57	28	67	27	28
8/12/2014	77	74	57	58		59	26	23
9/12/2014	56	59	49	63	51	115	37	40
16/12/2014	52	45	41	71	39	50	34	46
17/12/2014	55		37	73	40	53	32	39
18/12/2014	58		45	88	44	55	46	48
24/12/2014	39	47	32	39	80	49	95	57
25/12/2014	86	56	29	30	83	48	77	85
26/12/2014	77	84	58	49	40	77	34	54
30/12/2014	52	72	54	38	26	42	22	19
1/01/2015	42	51	42	71	41	53	43	45
2/01/2015	48	60	45	75	45	62	51	41

Date	Richardson Street	Kingsmill Street	Taplin Street	Neptune Place	BoM	Wedgefield	Acacia Way	Yule River
3/01/2015	52	60	47	73	44	65	47	44
4/01/2015	79	81	64	56	39	60	51	72
5/01/2015	69	79	75	82	67	85	65	60
6/01/2015	59	65	58	59	45	71	48	68
7/01/2015	60	66	57		45	75	43	50
8/01/2015	67	78	65		56	75	55	100
9/01/2015	72	82	78	80	59		56	55
22/01/2015			81		76	65	106	40
23/01/2015		86	67	81	85	92	62	89
24/01/2015		75		72	50	65	62	50
25/01/2015	45	68		84	47	59	62	49
20/02/2015	55	70	52	55	37	48	38	40
21/02/2015	50	71	56	66	46	65	47	52
22/02/2015	56	82	67	82	66	61	66	64
12/03/2015	26	79	39	50	20	89	24	41
22/03/2015	37	57	27	25	81	37	40	17
23/03/2015	55	83	53	61	62	75	82	44
29/03/2015	30	49	25	20	21	100	20	27
8/04/2015	42	73	59		25	57	20	15
9/04/2015	39	56	31			79	30	27
30/04/2015	16	22	20	17	16	104	13	16
1/05/2015	20	31	25	27	19	78	24	22
2/05/2015	29	70	32	70	23	28	28	20
6/05/2015	53	74	13	17	18	49	12	11
8/05/2015	55	67	22	18	22	75	17	12
11/05/2015	53	103	50	33	25	50	28	10
16/05/2015	38	50	31	33	28	72	38	25
4/06/2015	35	34	14		21	86	7	9
10/06/2015	39		25	17	23	93	34	11
11/06/2015	41	46	25		25	78	32	13
25/06/2015	32	58	29	15	15	75	17	8
26/06/2015	37	51	32	22	22	98	19	10

B.3 STATISTICS OF METALS CONCENTRATION

The following series of tables (Table B-7 to Table B-11) list the detected metal concentration statistics recorded at the respective monitoring stations. Measurements below the limit of reporting are not included in the calculation of averages. The Limit of Reporting of each metal is defined as 10 x standard deviation of multiple analyses of a standard at near zero concentration. The Limit of Reporting as an airborne concentration is based on standard sampling air volumes. Data on Chromium VI was not reported as this parameter cannot be practically measure with the equipment available.

Table B-7: Statistics of metal concentrations detected at Richardson Street (µg/m^3)

	Analysis Method	Chromium III iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP
Maximum		*	*	0.150	13.0	0.600
99th Percentile		*	*	0.113	11.1	0.397
98th Percentile		*	*	0.077	9.7	0.240
95th Percentile		*	*	0.053	8.3	0.181
50th Percentile		*	*	0.006	3.5	0.051
Average		*	*	0.013	4.3	0.073
Minimum		*	*	0.003	0.2	0.003
Limit of reporting		0.01	0.01	0.002	0.1	0.001
Number of days metals detected		-	-	43	59	59
Total number of monitoring days				59		

*values below limit detection

Table B-8: Statistics of metal concentrations detected at Taplin St (µg/m³)

	Analysis Method	Chromium III iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP
Maximum		*	*	0.015	7.4	0.110
99th Percentile		*	*	0.012	6.4	0.088
98th Percentile		*	*	0.010	5.6	0.072
95th Percentile		*	*	0.006	4.6	0.066
50th Percentile		*	*	0.004	1.2	0.025
Average		*	*	0.004	2.0	0.030
Minimum		*	*	0.002	0.1	0.003
Limit of reporting		0.01	0.01	0.002	0.1	0.001
Number of days metals detected		-	-	34	59	59
Total number of monitoring days				59		

*values below limit detection

Table B-9: Statistics of metal concentrations detected at BoM (µg/m³)

	Analysis Method	Chromium III iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP
Maximum		*	*	0.008	5.3	0.310
99th Percentile		*	*	0.008	3.4	0.304
98th Percentile		*	*	0.008	2.1	0.284
95th Percentile		*	*	0.008	1.9	0.164
50th Percentile		*	*	0.004	1.2	0.040
Average		*	*	0.004	1.2	0.065
Minimum		*	*	0.002	0.1	0.008
Limit of reporting		0.01	0.01	0.002	0.1	0.001
Number of days metals detected		-	-	36	59	59
Total number of monitoring days				59		

*values below limit detection

Table B-10: Statistics of metal concentrations detected at Wedgefield (µg/m³)

	Chromium III	Chromium	Copper	Iron	Manganese
Analysis Method	iMET2HVICP	iMET2HVICP	iMET2HVICP	iMET2HVICP	iMET2HVICP
Maximum	*	*	0.016	6.5	0.330
99th Percentile	*	*	0.016	5.7	0.283
98th Percentile	*	*	0.015	5.0	0.238
95th Percentile	*	*	0.012	4.7	0.182
50th Percentile	*	*	0.006	2.5	0.065
Average	*	*	0.006	2.7	0.082
Minimum	*	*	0.002	0.1	0.003
Limit of reporting	0.01	0.01	0.002	0.1	0.001
Number of days metals detected	-	-	45	53	53
Total number of monitoring days			53		

*values below limit detection

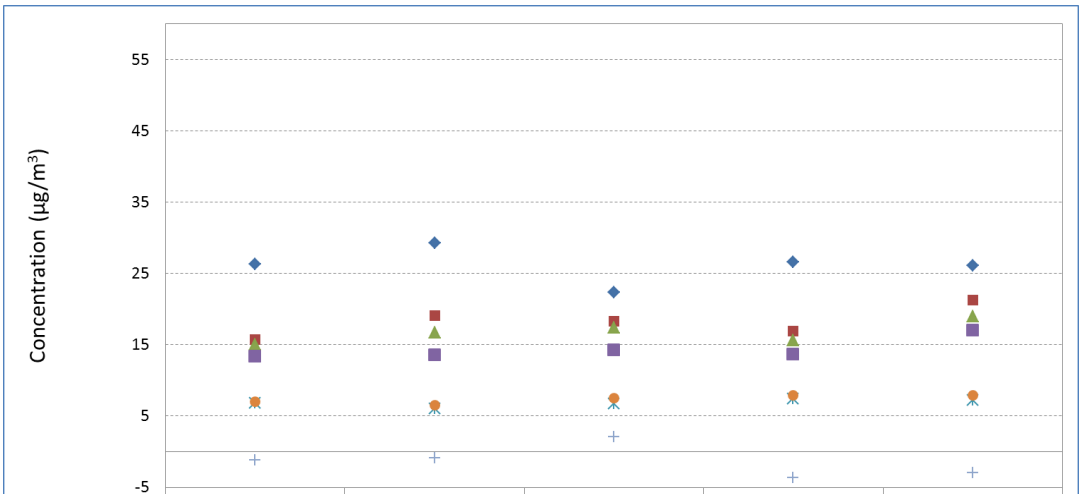
Table B-11: Statistics of metal concentrations detected at Acacia Way (µg/m³)

Analysis Method	Chromium III iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP
Maximum	*	*	0.049	6.4	0.100
99th Percentile	*	*	0.044	3.8	0.073
98th Percentile	*	*	0.038	1.7	0.049
95th Percentile	*	*	0.022	1.4	0.033
50th Percentile	*	*	0.003	0.7	0.015
Average	*	*	0.006	0.9	0.017
Minimum	*	*	0.002	0.2	0.002
Limit of reporting	0.01	0.01	0.002	0.1	0.001
Number of days metals detected	-	-	14	57	58
Total number of monitoring days			57		

*values below limit detection

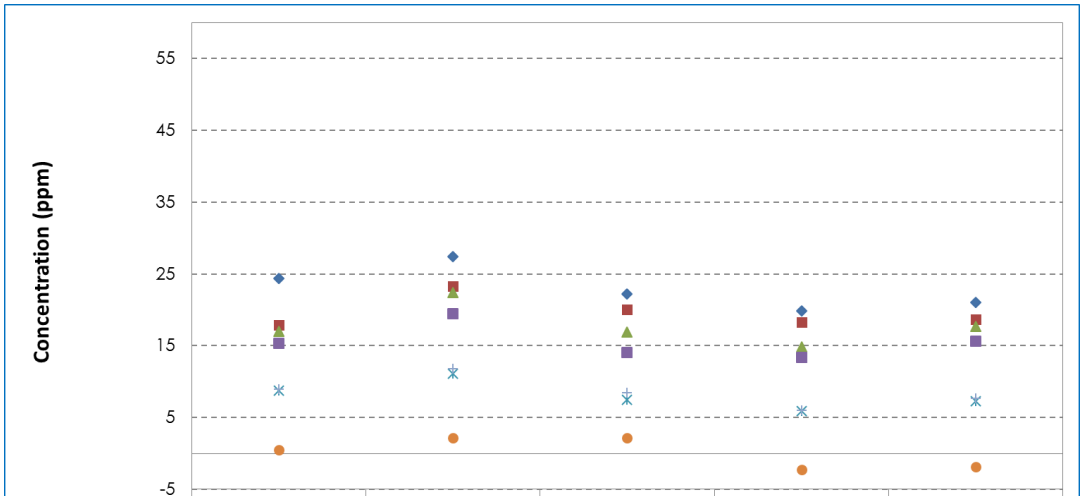
B.4 STATISTICS OF PM2.5 CONCENTRATION.

$PM_{2.5}$ concentration statistics recorded at the respective monitoring stations are shown in Figure B-1 for the 2013-2014 and in Figure B-2 for the 2014-2015 financial years.



	Richardson St	Taplin St	BoM	Acacia Way	Yule River
Maximum	26	29	22	27	26
99th Percentile	16	19	18	17	21
98th Percentile	15	17	17	16	19
95th Percentile	13	14	14	14	17
50th Percentile	7	6	7	7	7
Annual Average	7.06	6.54	7.48	7.88	7.96
Minimum	-1	-1	2	-4	-3

Figure B-1: Statistical summary of 24-hour and annual averages of $PM_{2.5}$ concentration in FY14



	Richardson Street	Taplin Street	BoM	Acacia Way	Yule River
Maximum	24	27	22	20	21
99th Percentile	18	23	20	18	19
98th Percentile	17	22	17	15	18
95th Percentile	15	19	14	13	16
50th Percentile	9	11	7	6	7
Minimum	1	2	2	-2	-2
annual average	8.96	11.84	8.44	6.04	7.66

Figure B-2: Statistical summary of 24-hour and annual averages of $PM_{2.5}$ concentration in FY15

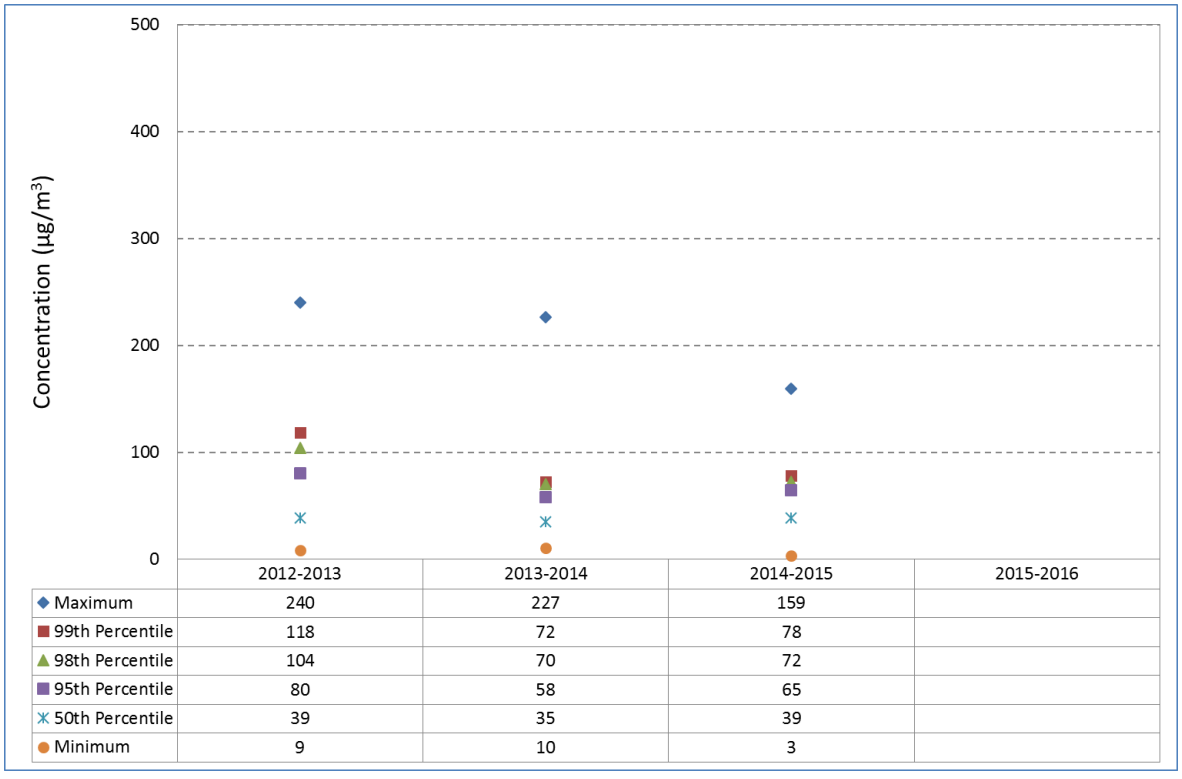
Appendix C ANALYSIS OF AIR QUALITY MONITORING GRAPHS (2014-2015)

This section provides the graphs from data analysis and statistical interpretation of the monitored ambient PM_{10} (including metals in PM_{10}), NO_2 and SO_2 concentrations from the eight ambient monitoring stations in the network, as outlined in Section 4.

The results are presented as graphical summaries by parameter and demonstrate the trend analysis of historical data (where available). The following statistics for each parameter monitored in the network is shown:

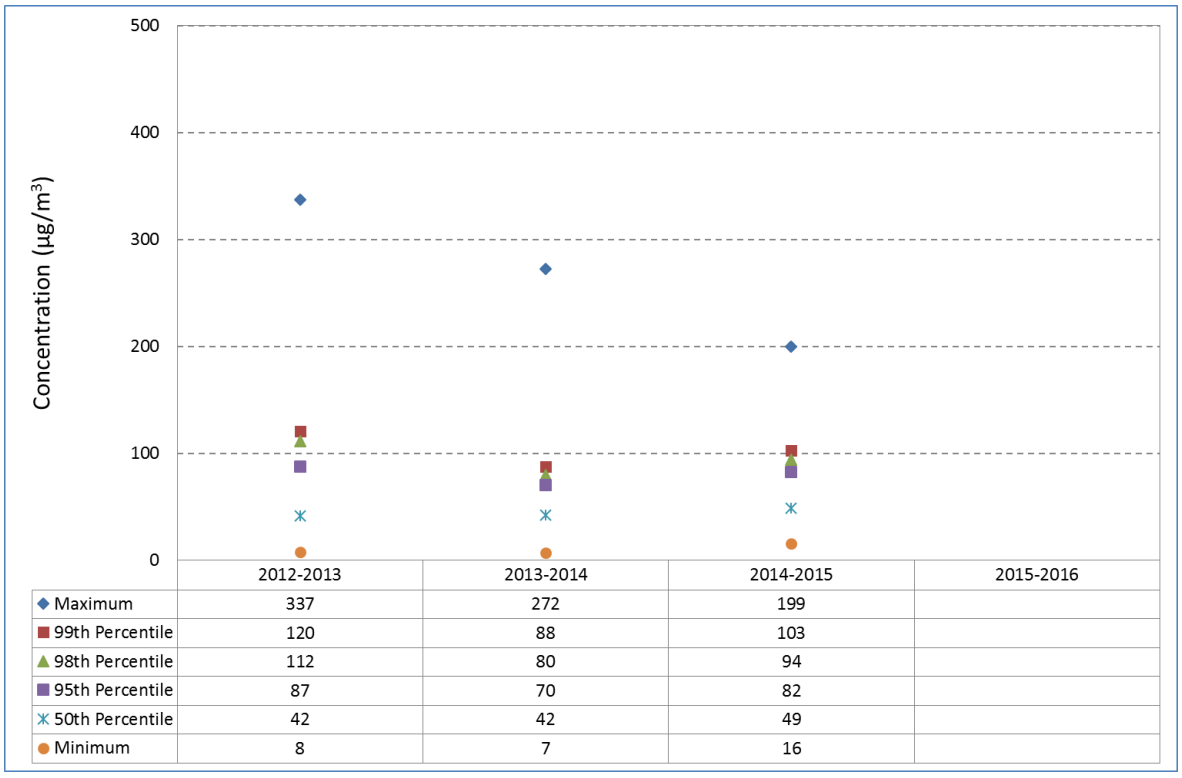
- maximum
- 99th percentile
- 98th percentile
- 95th percentile
- 90th percentile
- 50th percentile
- minimum

C.1 PARTICLES (AS PM_{10})



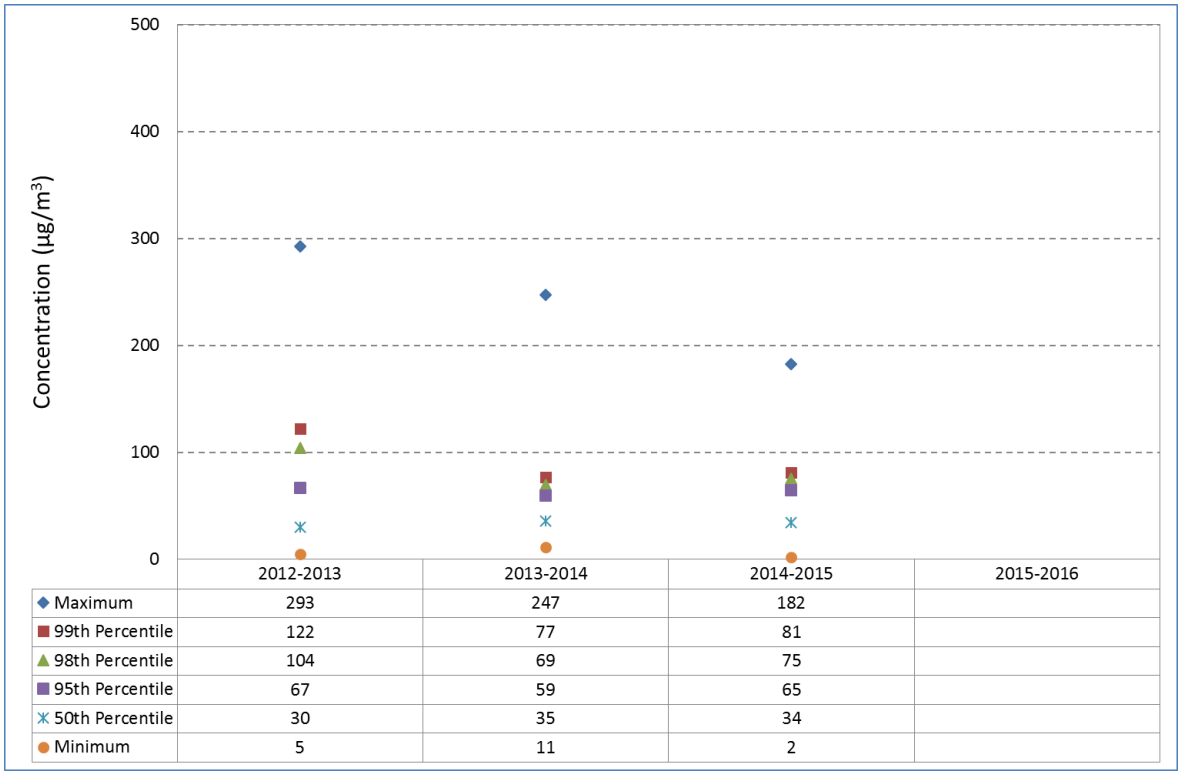
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	240	227	159	
99th Percentile	118	72	78	
98th Percentile	104	70	72	
95th Percentile	80	58	65	
50th Percentile	39	35	39	
Minimum	9	10	3	

Figure C-1: 24-hour PM_{10} at Richardson Street



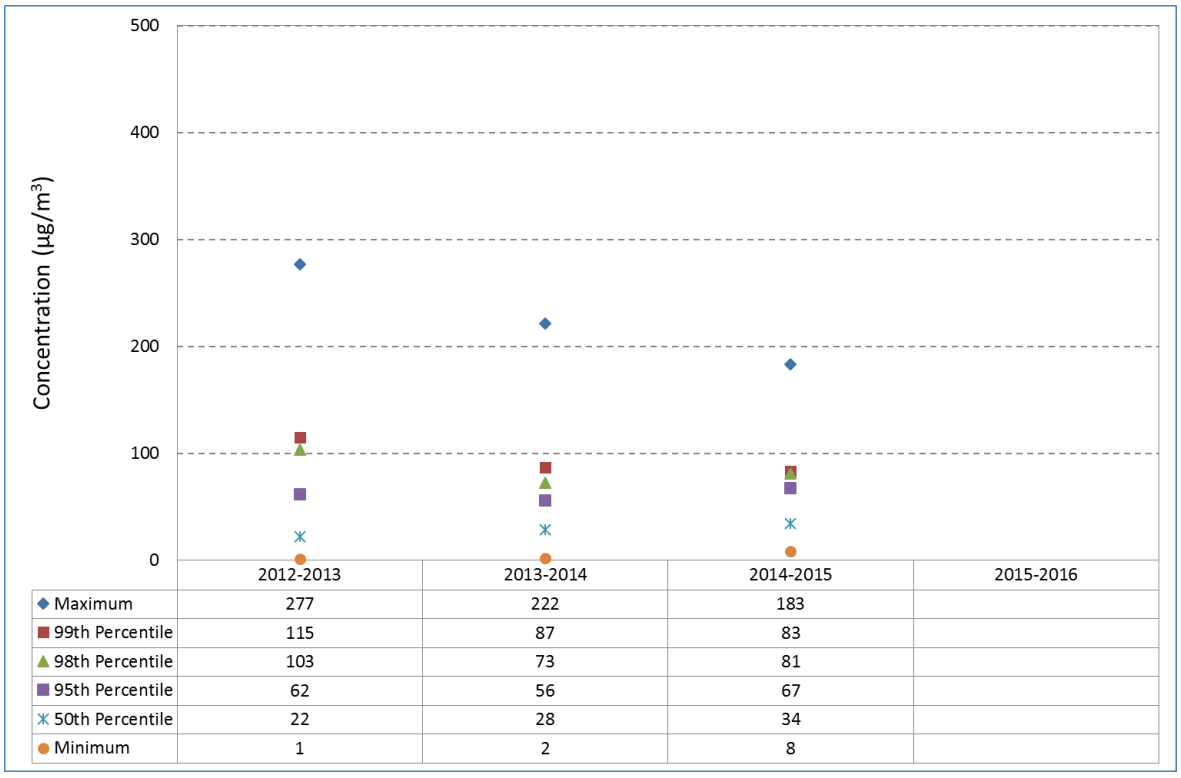
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	337	272	199	
99th Percentile	120	88	103	
98th Percentile	112	80	94	
95th Percentile	87	70	82	
50th Percentile	42	42	49	
Minimum	8	7	16	

Figure C-2: 24-hour PM_{10} at Kingsmill Street



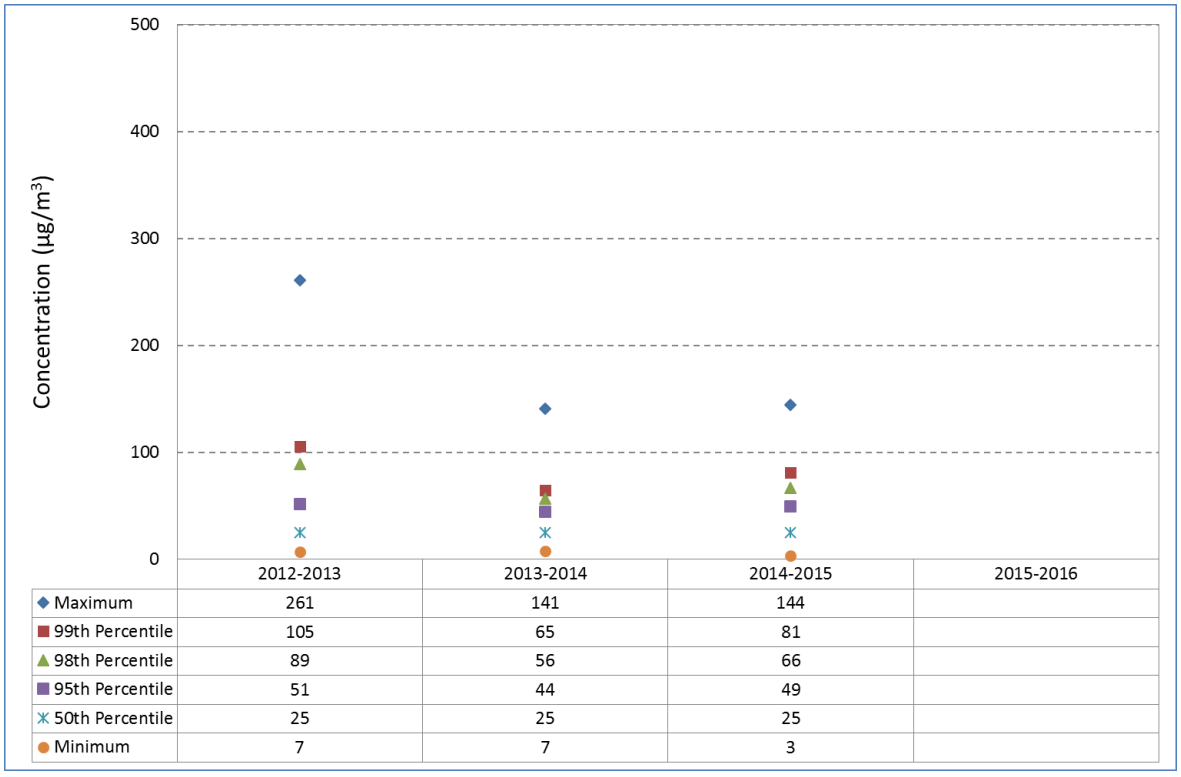
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	293	247	182	
99th Percentile	122	77	81	
98th Percentile	104	69	75	
95th Percentile	67	59	65	
50th Percentile	30	35	34	
Minimum	5	11	2	

Figure C-3: 24-hour PM_{10} at Taplin Street



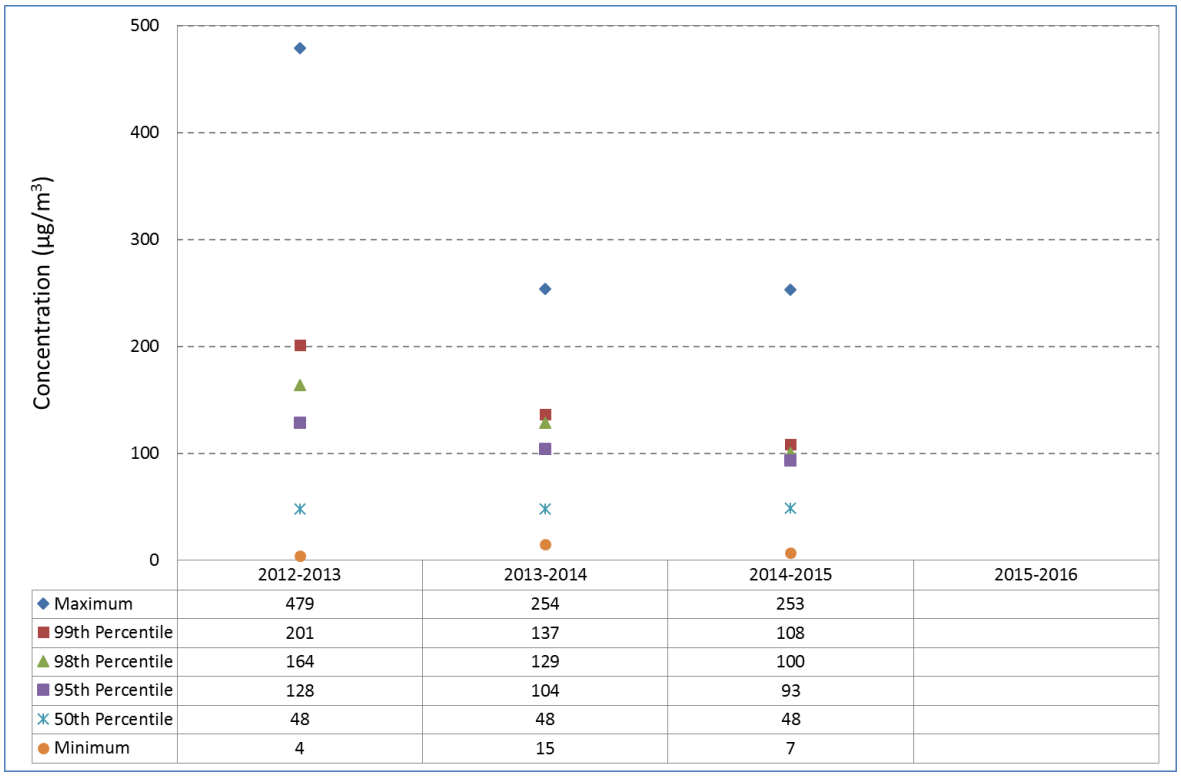
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	277	222	183	
99th Percentile	115	87	83	
98th Percentile	103	73	81	
95th Percentile	62	56	67	
50th Percentile	22	28	34	
Minimum	1	2	8	

Figure C-4: 24-hour PM_{10} at Neptune Place



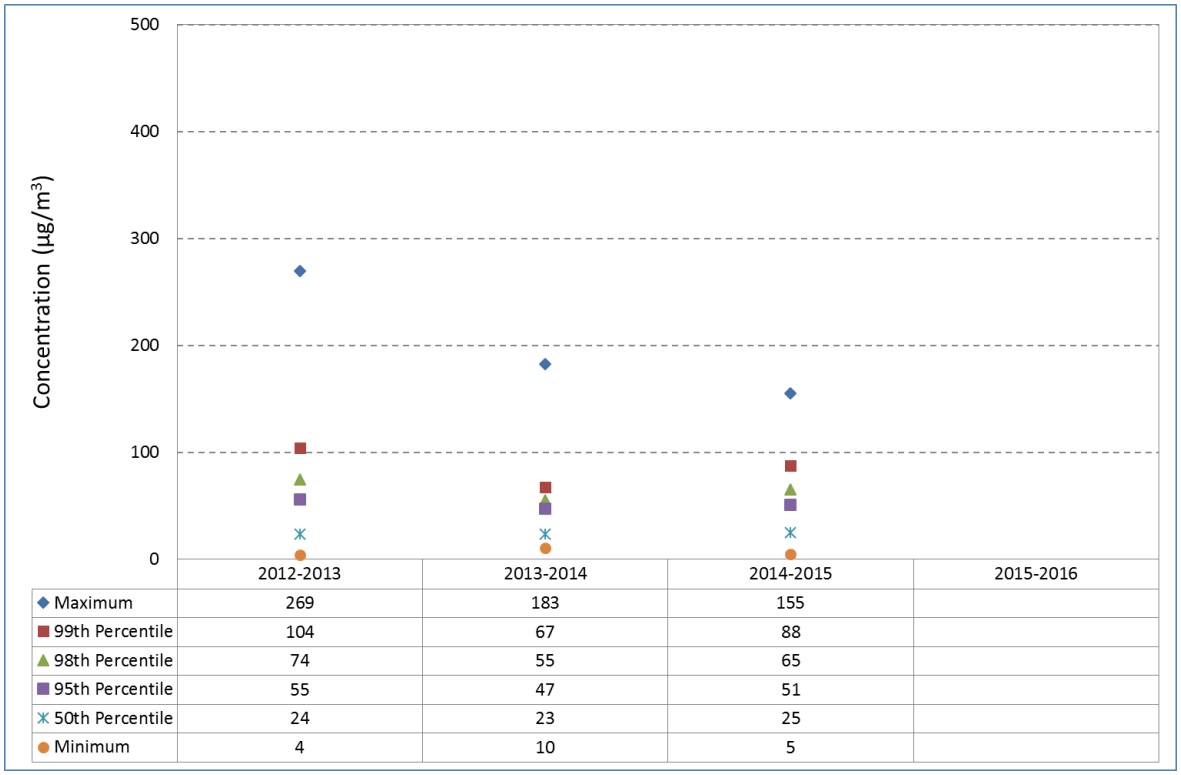
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	261	141	144	
99th Percentile	105	65	81	
98th Percentile	89	56	66	
95th Percentile	51	44	49	
50th Percentile	25	25	25	
Minimum	7	7	3	

Figure C-5: 24-hour PM_{10} at Bureau of Meteorology



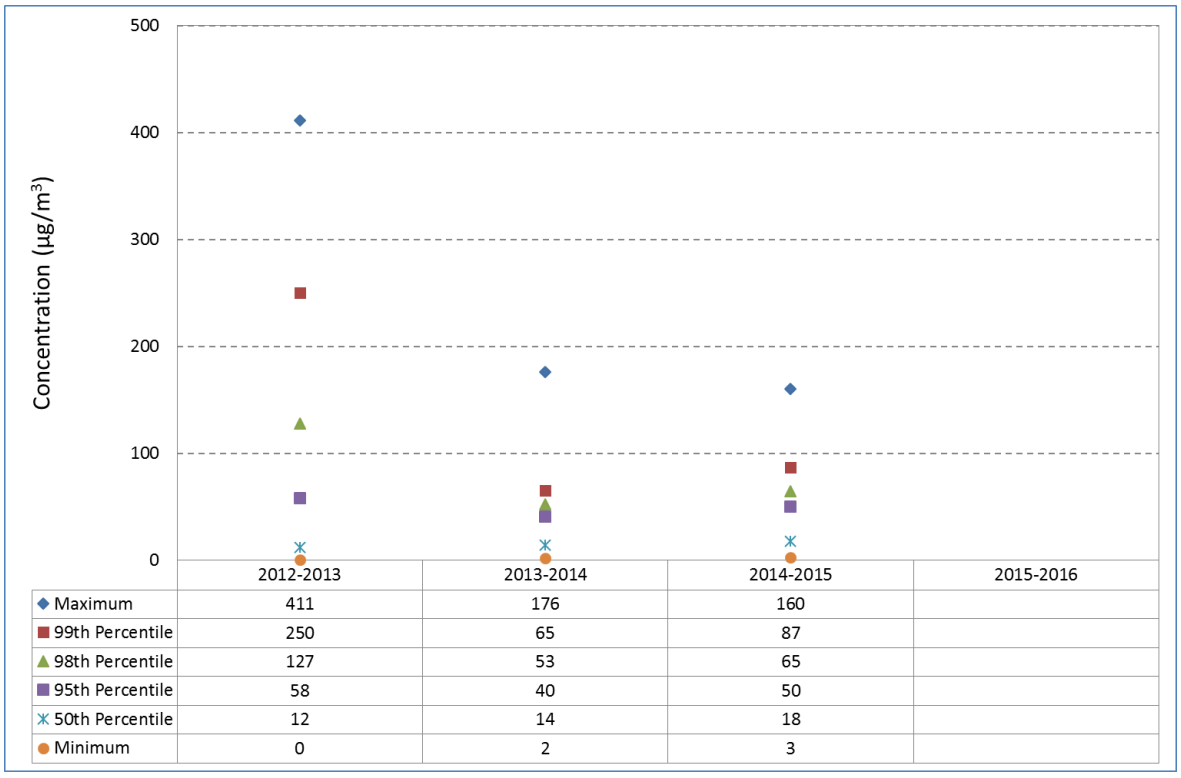
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	479	254	253	
99th Percentile	201	137	108	
98th Percentile	164	129	100	
95th Percentile	128	104	93	
50th Percentile	48	48	48	
Minimum	4	15	7	

Figure C-6: 24-hour PM_{10} at Wedgefield



	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	269	183	155	
99th Percentile	104	67	88	
98th Percentile	74	55	65	
95th Percentile	55	47	51	
50th Percentile	24	23	25	
Minimum	4	10	5	

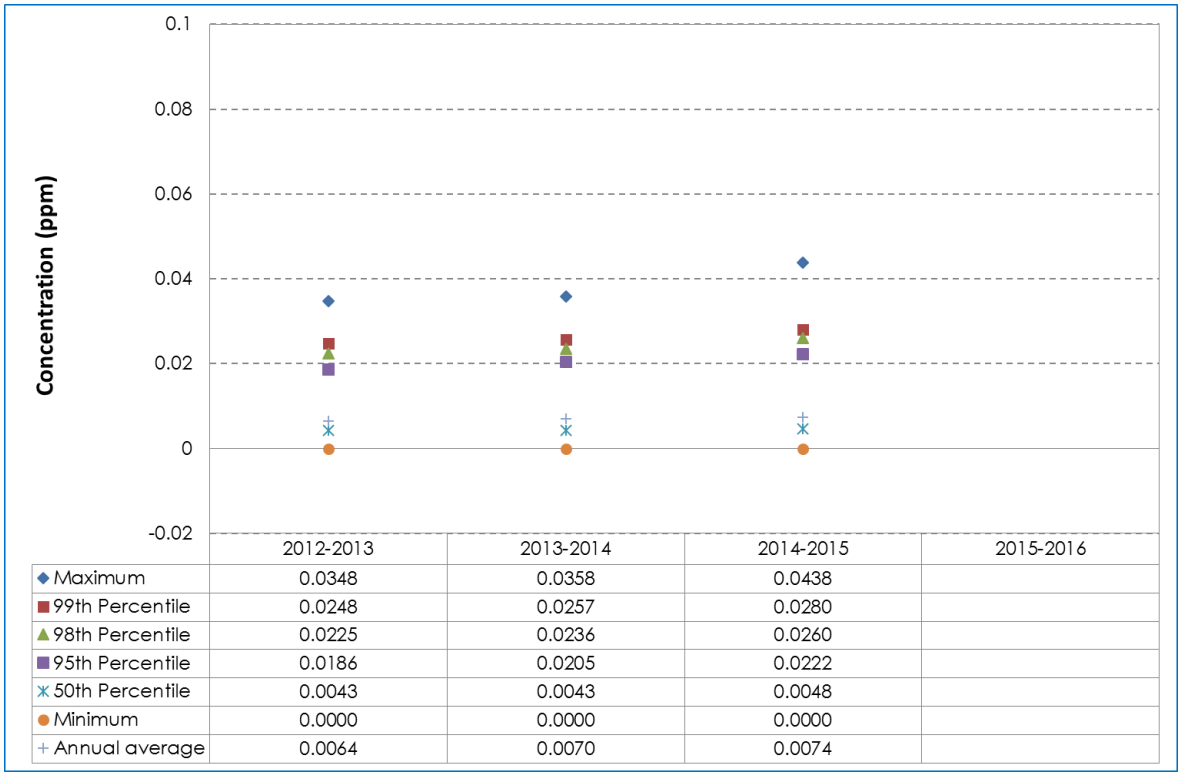
Figure C-7: 24-hour PM_{10} at Acacia Way



	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	411	176	160	
99th Percentile	250	65	87	
98th Percentile	127	53	65	
95th Percentile	58	40	50	
50th Percentile	12	14	18	
Minimum	0	2	3	

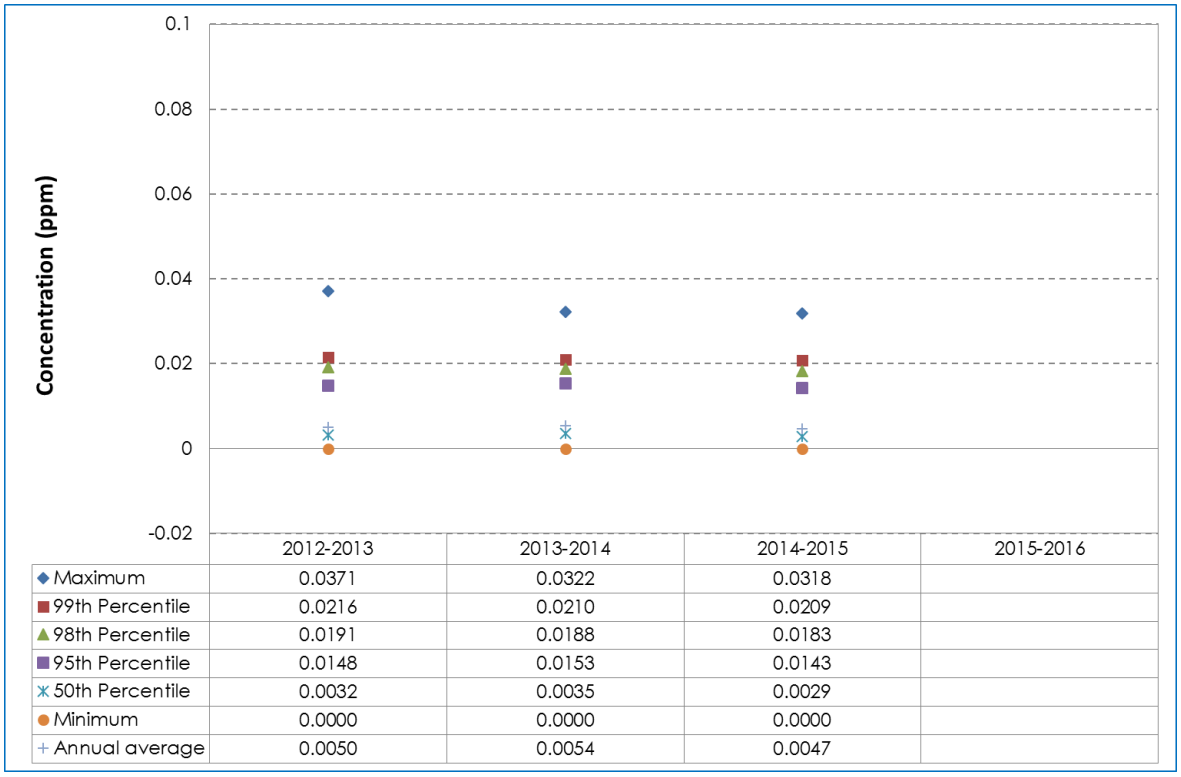
Figure C-8: 24-hour PM_{10} at Yule River

C.2 NITROGEN DIOXIDE (NO_2)



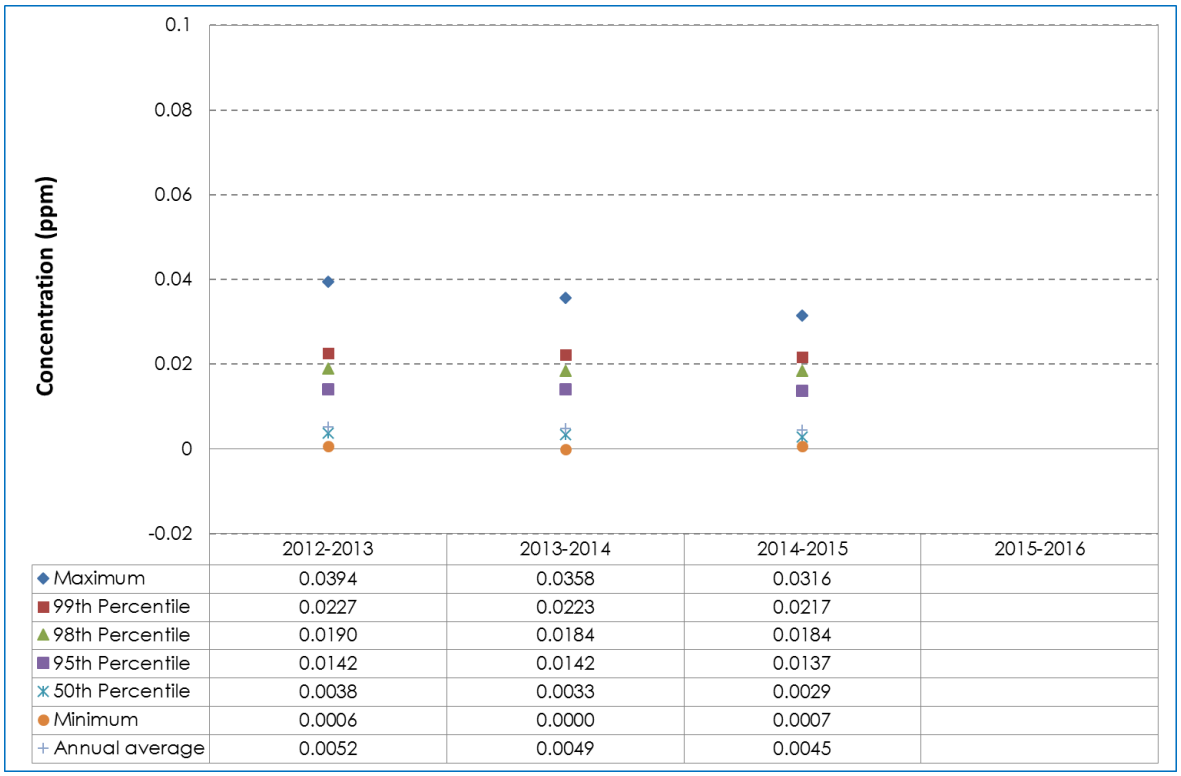
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0348	0.0358	0.0438	
99th Percentile	0.0248	0.0257	0.0280	
98th Percentile	0.0225	0.0236	0.0260	
95th Percentile	0.0186	0.0205	0.0222	
50th Percentile	0.0043	0.0043	0.0048	
Minimum	0.0000	0.0000	0.0000	
Annual average	0.0064	0.0070	0.0074	

Figure C-9: 1-hour and annual average of NO_2 at Taplin Street



	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0371	0.0322	0.0318	
99th Percentile	0.0216	0.0210	0.0209	
98th Percentile	0.0191	0.0188	0.0183	
95th Percentile	0.0148	0.0153	0.0143	
50th Percentile	0.0032	0.0035	0.0029	
Minimum	0.0000	0.0000	0.0000	
Annual average	0.0050	0.0054	0.0047	

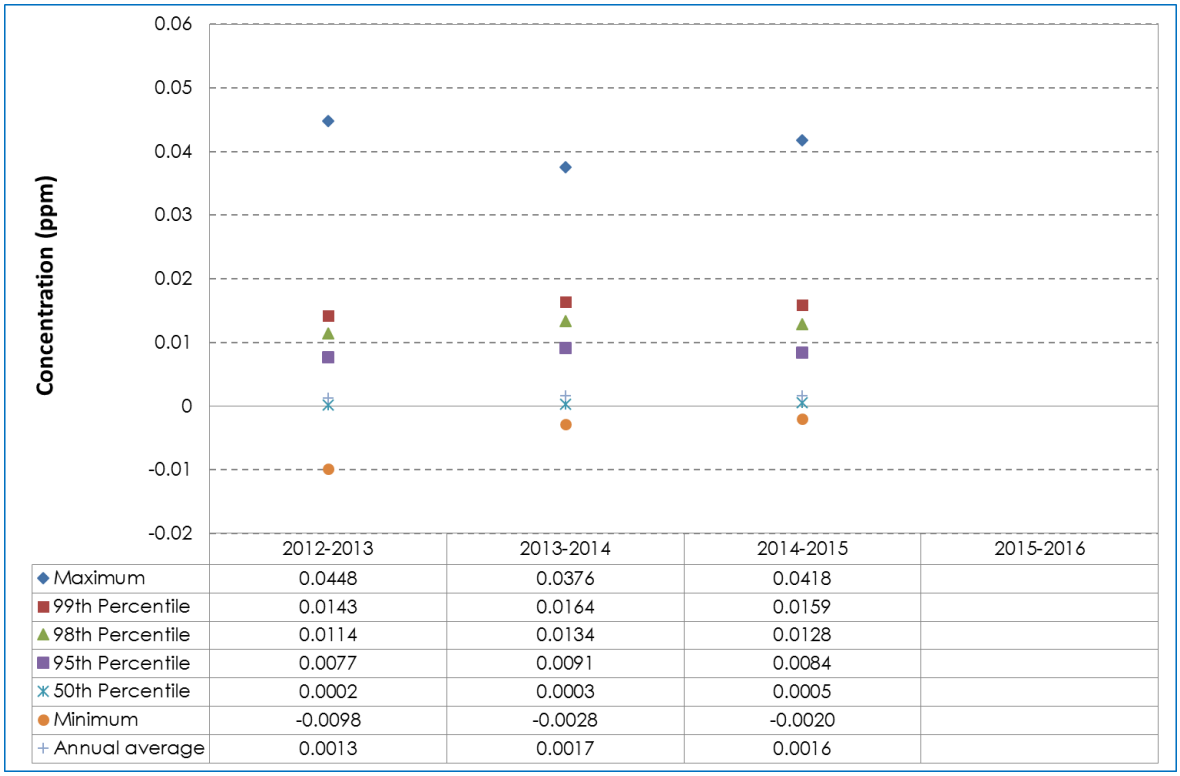
Figure C-10: 1-hour and annual average of NO_2 at Bureau of Meteorology



	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0394	0.0358	0.0316	
99th Percentile	0.0227	0.0223	0.0217	
98th Percentile	0.0190	0.0184	0.0184	
95th Percentile	0.0142	0.0142	0.0137	
50th Percentile	0.0038	0.0033	0.0029	
Minimum	0.0006	0.0000	0.0007	
Annual average	0.0052	0.0049	0.0045	

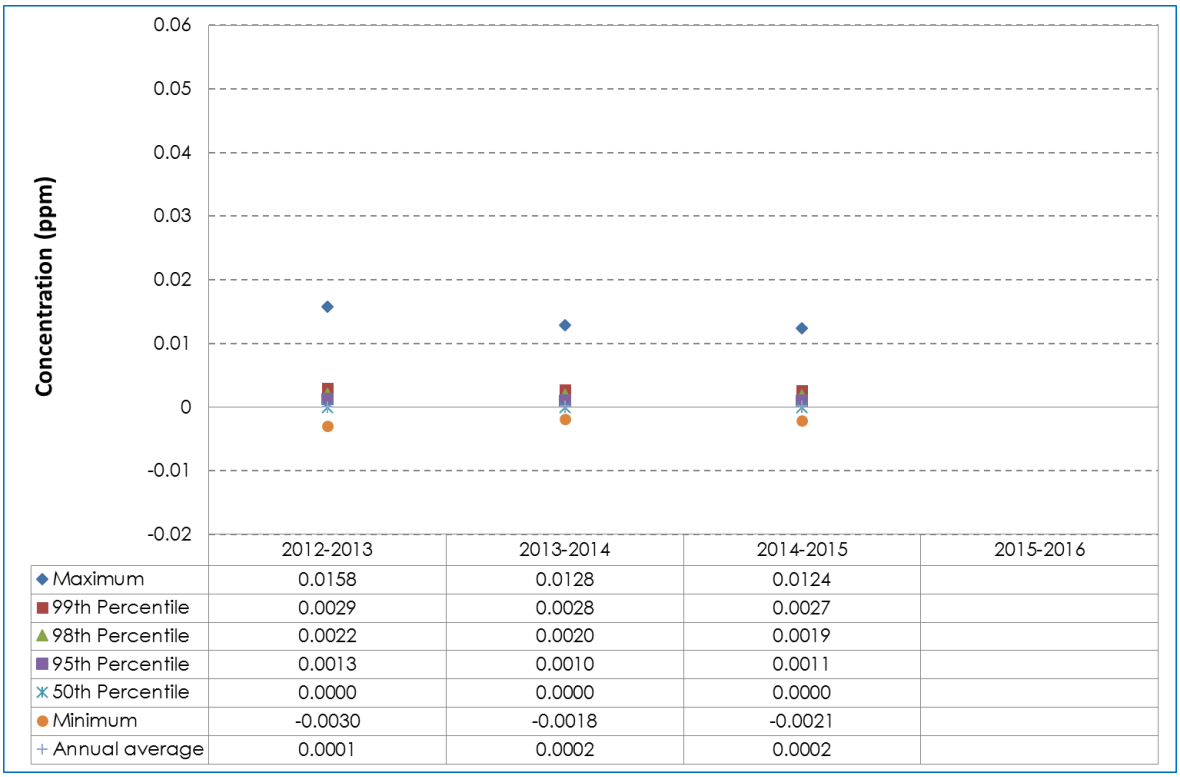
Figure C-11: 1-hour and annual average of NO_2 at Acacia Way

C.3 SULFUR DIOXIDE (SO_2)



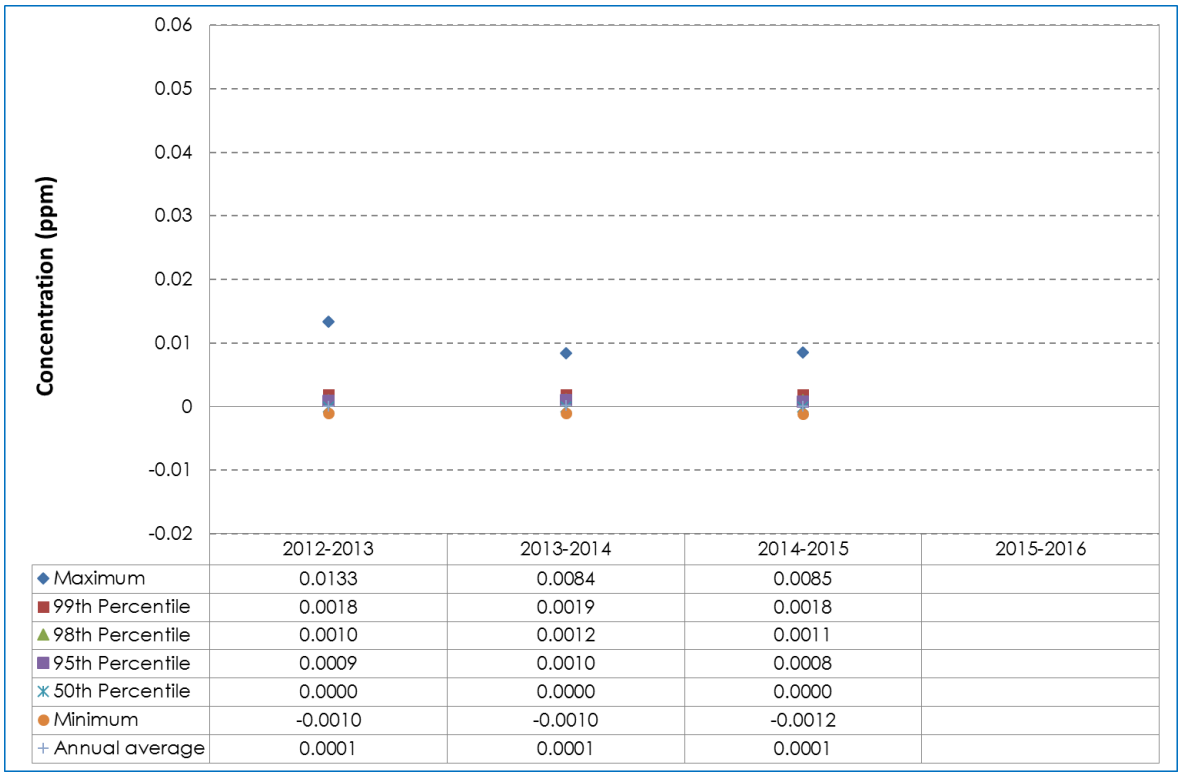
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0448	0.0376	0.0418	
99th Percentile	0.0143	0.0164	0.0159	
98th Percentile	0.0114	0.0134	0.0128	
95th Percentile	0.0077	0.0091	0.0084	
50th Percentile	0.0002	0.0003	0.0005	
Minimum	-0.0098	-0.0028	-0.0020	
Annual average	0.0013	0.0017	0.0016	

Figure C-12: 1-hour and annual average of SO_2 at Taplin Street



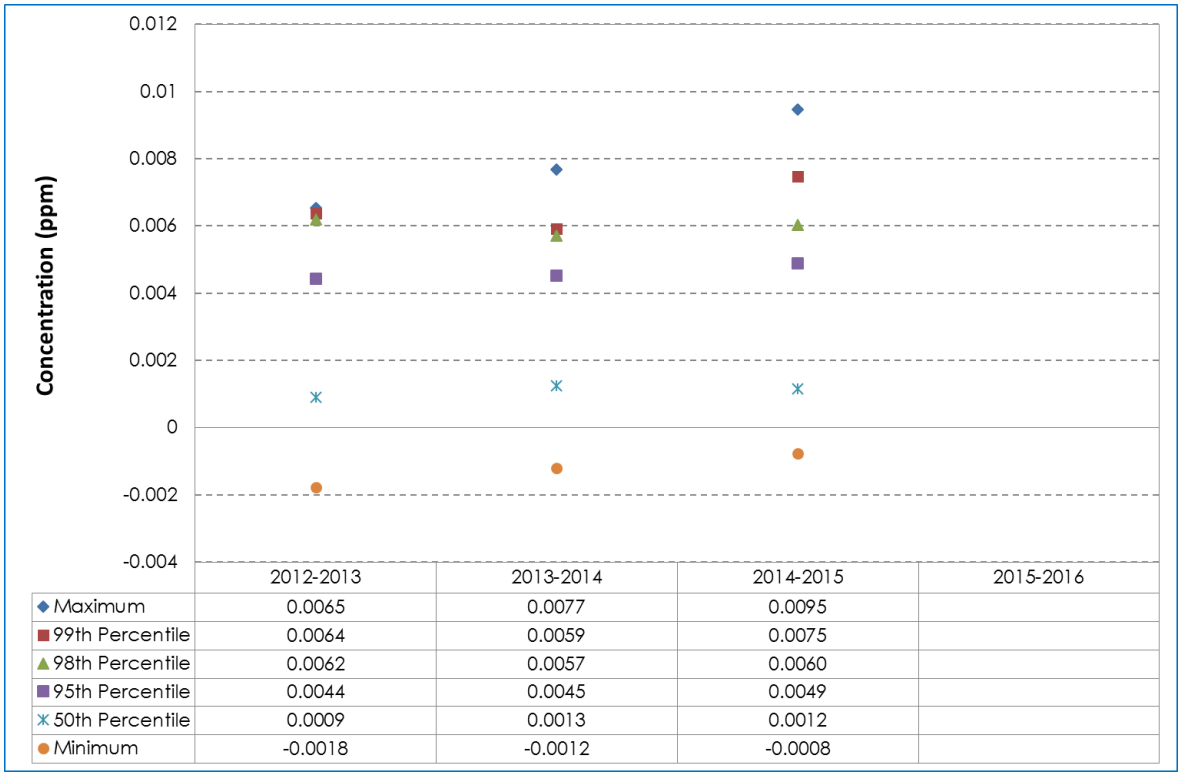
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0158	0.0128	0.0124	
99th Percentile	0.0029	0.0028	0.0027	
98th Percentile	0.0022	0.0020	0.0019	
95th Percentile	0.0013	0.0010	0.0011	
50th Percentile	0.0000	0.0000	0.0000	
Minimum	-0.0030	-0.0018	-0.0021	
Annual average	0.0001	0.0002	0.0002	

Figure C-13: 1-hour and annual average of SO_2 at Bureau of Meteorology



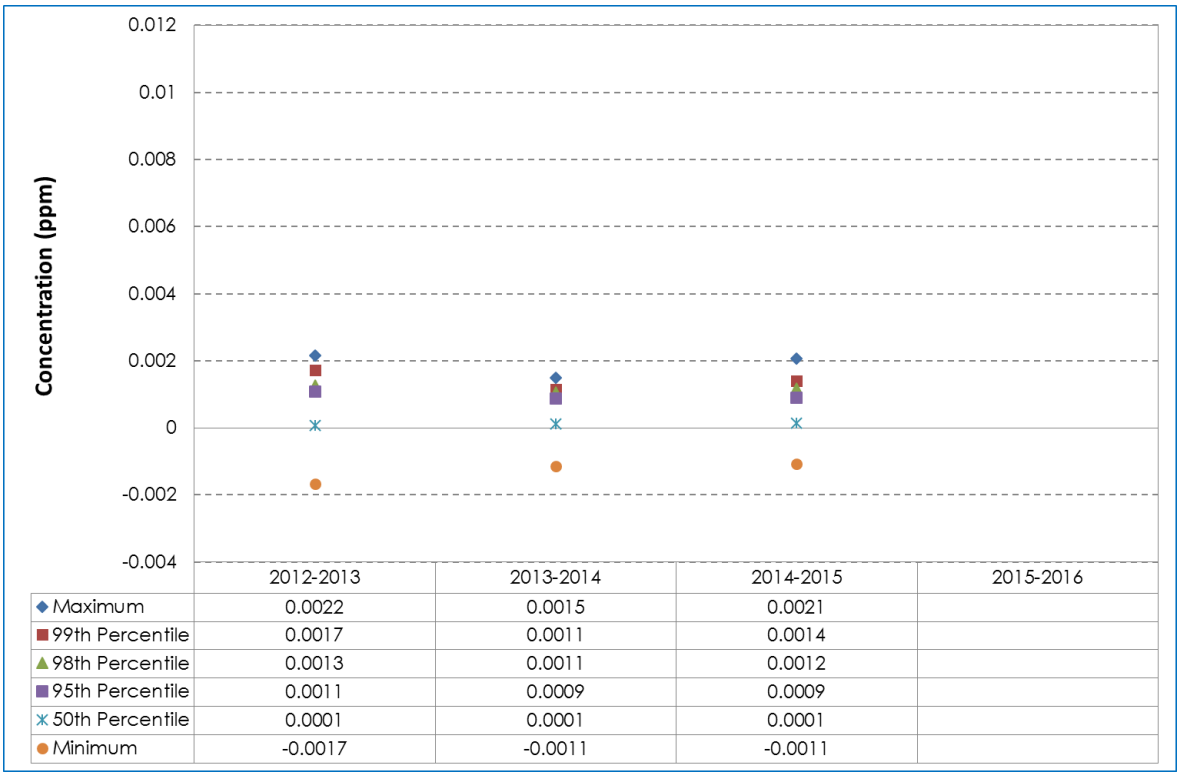
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0133	0.0084	0.0085	
99th Percentile	0.0018	0.0019	0.0018	
98th Percentile	0.0010	0.0012	0.0011	
95th Percentile	0.0009	0.0010	0.0008	
50th Percentile	0.0000	0.0000	0.0000	
Minimum	-0.0010	-0.0010	-0.0012	
Annual average	0.0001	0.0001	0.0001	

Figure C-14: 1-hour and annual average of SO_2 at Acacia Way



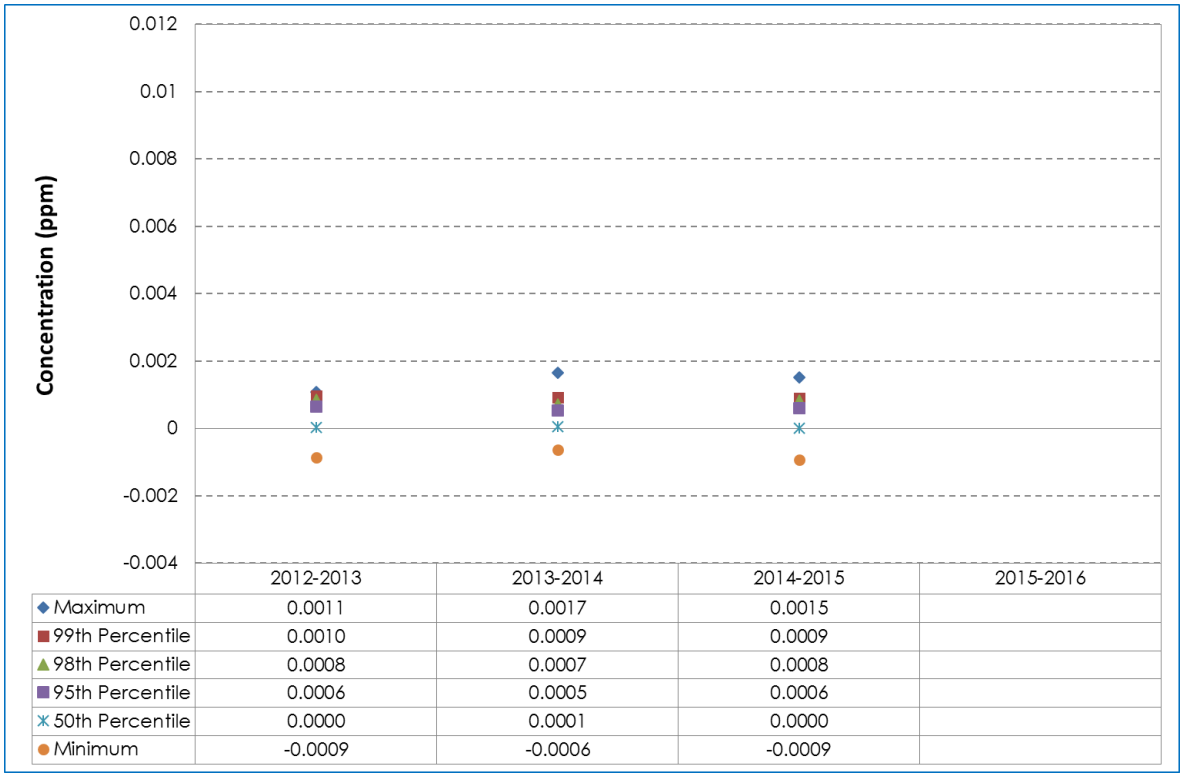
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0065	0.0077	0.0095	
99th Percentile	0.0064	0.0059	0.0075	
98th Percentile	0.0062	0.0057	0.0060	
95th Percentile	0.0044	0.0045	0.0049	
50th Percentile	0.0009	0.0013	0.0012	
Minimum	-0.0018	-0.0012	-0.0008	

Figure C-15: 24-hour SO_2 at Taplin Street



	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0022	0.0015	0.0021	
99th Percentile	0.0017	0.0011	0.0014	
98th Percentile	0.0013	0.0011	0.0012	
95th Percentile	0.0011	0.0009	0.0009	
50th Percentile	0.0001	0.0001	0.0001	
Minimum	-0.0017	-0.0011	-0.0011	

Figure C-16: 24-hour SO_2 at Bureau of Meteorology



	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0011	0.0017	0.0015	
99th Percentile	0.0010	0.0009	0.0009	
98th Percentile	0.0008	0.0007	0.0008	
95th Percentile	0.0006	0.0005	0.0006	
50th Percentile	0.0000	0.0001	0.0000	
Minimum	-0.0009	-0.0006	-0.0009	

Figure C-17: 24-hour SO_2 at Acacia Way