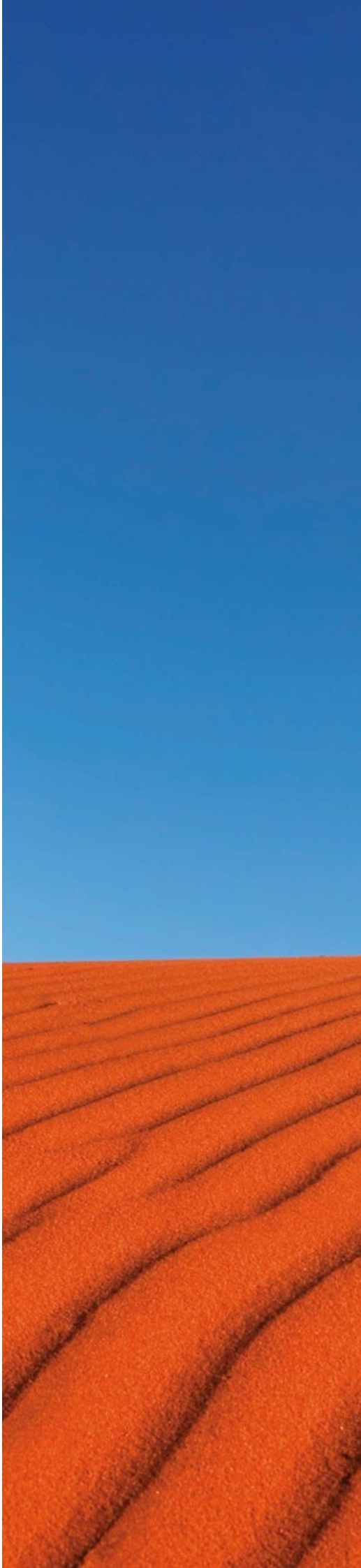
PORT HEDLAND
INDUSTRIES COUNCIL

ANNUAL REPORT

AMBIENT AIR QUALITY MONITORING REPORT TO THE PORT HEDLAND DUST MANAGEMENT TASKFORCE (2013-2014)

Port Hedland Industries Council

11 September 2014



PROJECT TITLE: Ambient air quality monitoring report to the Port Hedland Dust Management Taskforce (2013-2014)

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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).

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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 ensure that dust generated by port and industry operations does not adversely impact the Port Hedland community. The network also captures data that is used to ensure compliance with regulatory commitments and requirements for dust mitigation and management. 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 2013-2014 (FY14) 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).

ACTIVITIES IN PORT HEDLAND FY14

There are multiple large exporters within the Port Hedland air shed with continuous operations through the port of Port Hedland in FY14; for example:

- Iron ore exports from the port have risen from 280 MT in financial year (FY) 2013 to 344 MT in FY14;

In addition, Continuous earthworks have been conducted in the region, particularly in the Wedgefield Industrial Estate and at the town of Port Hedland; for instance:

- Large amount of earthworks for the Great Northern Highway realignment;
- Construction of residential building directly opposite to Taplin St monitor; and
- There were a large number of vehicle movements both on and off site, including a large number of trucks within the area transporting various products to the Utah Point loading facility.

Consequently, compared to FY13, there has been a significant increase in dust emitting sources within the Port Hedland air shed in FY14.

MONITORING NETWORK PERFORMANCE

The eight monitoring stations were independently audited in 2013. The key finding of the audit was that the monitoring station siting and the positioning of the monitoring instrumentation were generally in

accordance with the associated method and standard. The monitoring program was also found to be producing data sets that were useful for their intended purposes (PEL, 2013).

The performance of the monitoring network during the year proved to be reliable, and PHIC is pleased to report that annual data recovery of at least 75% was achieved for all monitored parameters at all monitoring stations. Data recovery of at least 75% was also achieved each quarter of the year for all parameters monitored at all monitoring stations. This year the lowest data recovery was 76% at Wedgefield (Q1 for PM_{10}) with all other monitoring stations achieving greater than 80% recovery.

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 financial year (FY13) findings, sulfur dioxide levels are shown to be lower than the specified NEPM standards (i.e. for all 1-hour, 24-hour and annual criteria).

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. There were no exceedances of the 1-hour NEPM NO_2 standard. These standards were also met for the 2012-2013 financial year.

MONITORED LEVELS OF PARTICLES (AS PM_{10})

PHIC monitored particles (PM_{10}) at all eight monitoring stations throughout the year. Monitoring at the BoM station demonstrates the relative background level of particles in the region. Monthly averages for the BoM and Taplin Street stations are shown in Figure E-1.

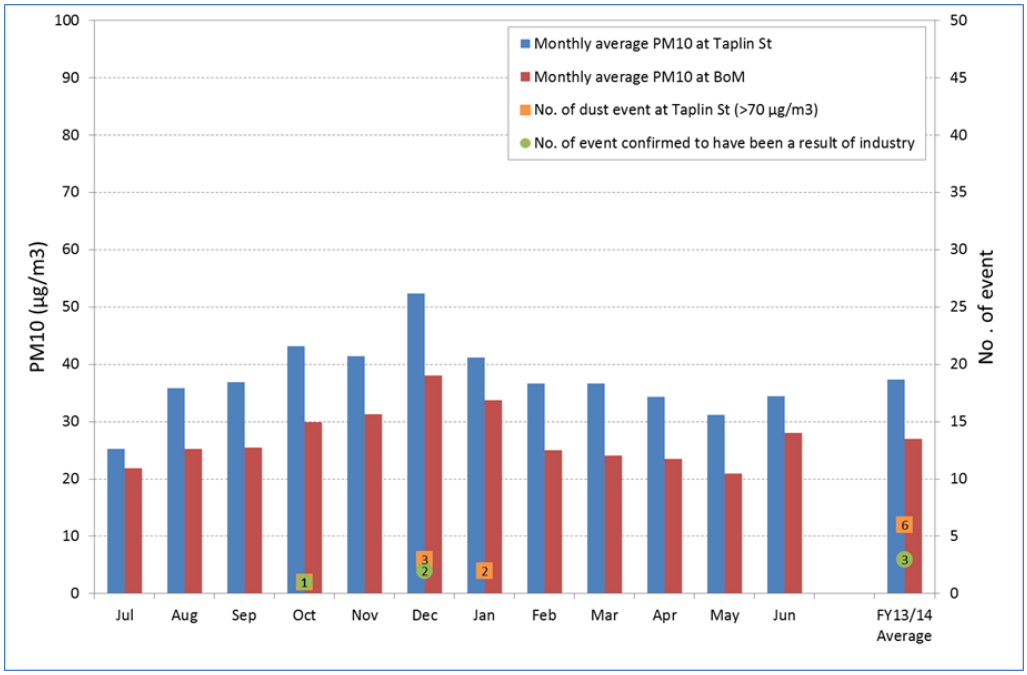


Figure E-1: Particle levels measured at Taplin Street and Bureau of Meteorology

From time to time elevated levels are recorded at each monitoring station. Dust events (i.e. 24-hour average PM_{10} level higher than 70 µg/m^3 at Taplin Street) are also shown in Table E-1, with six dust events noted for the reporting year. Comparing results for BoM and Taplin Street stations helps to understand where the relative contribution is coming from, and if the PHDMT interim guideline has been achieved. Analysis shows that three dust events for Taplin Street correspond to days with a high background event at BoM. Analysis of wind directions and wind speeds at the time shows that three dust events at Taplin Street are likely to be contributed by various factors including emissions from nearby industrial activities, wind erosion and the presence of inversion conditions.

Table E-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
4/10/2013	77	45	32	Non-background
14/12/2013	247	141	107	Background
17/12/2013	77	22	54	Non-background
22/12/2013	70	37	33	Non-background
14/01/2014	88	77	11	Background
17/01/2014	79	58	21	Background

Note: Difference = Taplin Street - BoM (µg/m^3) and all data has been rounded to the nearest whole number

As this is the second year of full reporting, long term annual trends cannot be established. In the interim, the 24-hour average PM_{10} level in the PHIC monitoring network shows a decreasing trend of peak PM_{10} levels observed from all monitoring stations. However, the number of occasions when the 24-hour average PM_{10} concentration greater than 50 µg/m^3 is increased at Kingsmill Street; while the number of occasions when 24-hour average PM_{10} concentration greater than 50 µg/m^3 in FY14 remains the same as FY13 at Taplin Street and Neptune Place (Figure E-2 and Figure E-3).

Figure E-2: PHIC Monitoring locations in Port Hedland – west end

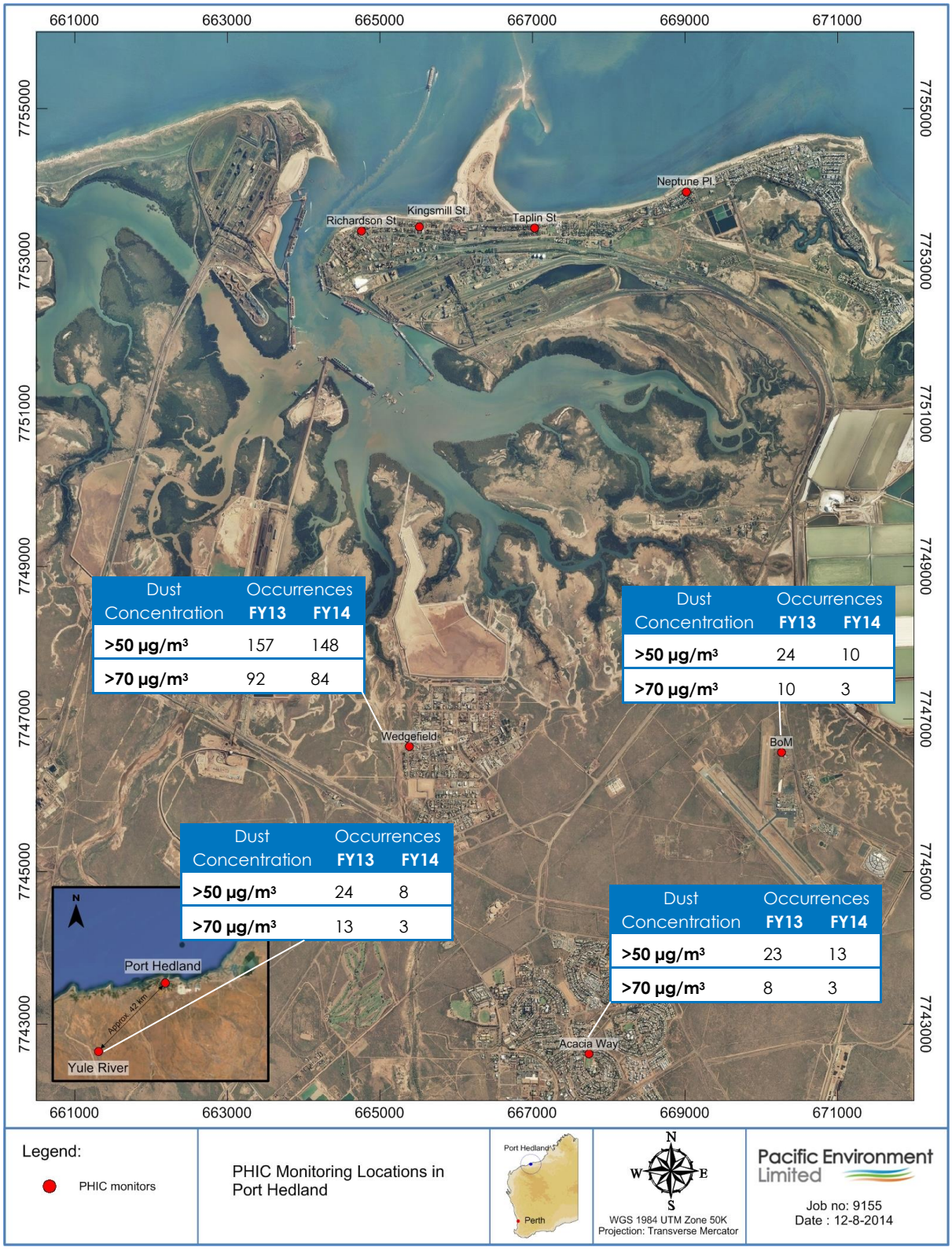


Figure E-3: PHIC Monitoring locations in Port Hedland

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

$PM_{2.5}$ was also monitored in five monitoring stations (Richardson St, Taplin St, BoM, Acacia Way and Yule River) throughout FY14. The $PM_{2.5}$ levels at all monitors have an annual average below the NEPM advisory reporting guidelines. Both the highest and lowest 24-hour averages of $PM_{2.5}$ were recorded at Taplin St. 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 (PM10) at six locations throughout the year. Metals are not monitored at Neptune Place or Kingsmill Street. From time to time metals are detected in the particles samples, with Richardson Street, Taplin Street, BoM and Acacia Way stations recording similar number of days that metals were detected (107 - 112 days), while Wedgefield and Yule River monitors recorded 45 and 56 days that metals were detected respectively. Industry is currently reviewing the toxicology of manganese ores which may lead to a review of the relevant World Health Organisation (WHO) guideline values.

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}, NO_x and SO_2 data accessible to the community via the monitoring website. PHIC will report results annually to the Taskforce, the next report being expected August 2015, presenting the monitored data for the 2014-2015 year.

CONTENTS

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 2013-2014 financial year (FY14), is the second 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 FY14; for example:

Iron ore exports from the port have raised from 280 MT in financial year (FY) 2013 to 344 MT in FY14. In addition, continuous earthworks have been conducting in the region, particularly in the Wedgefield Industrial Estate and at the town of Port Hedland; for instance:

- Large amount of earthworks for the Great Northern Highway realignment;
- Construction of residential building directly opposite to Taplin St monitor; and
- There were a large number of vehicle movements both on and off site, including a large number of trucks within the area transporting various products to the Utah Point loading facility.

Consequently, compared to FY13, there has been a significant increase in dust emitting sources within the Port Hedland air shed in FY14.

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 year. The key finding of the audit was that monitoring station siting, and the positioning of the monitoring instrumentation, was generally in accordance with the associated method and standard. The monitoring program was also found to be producing data sets that were useful for their intended purposes (PEL, 2013).

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 south-west 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

Figure 2-3: Taplin Street Monitoring Station

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} (including metals) 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'.

PM_{10} is commonly used to describe all particles less than 10 µm in aerodynamic diameter. 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 extrathoracic 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. The monthly average result for monitored PM_{10} is also shown for each monitoring station. This form of analysis assists in understanding the influence of location and seasonal variability in the monitored results.

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 can be associated with PM_{10}. Metals such as 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).

The NEPM specifies an ambient standard (based on the protection of human health) for lead only, being an annual average less than 0.50 µg/m^3.

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

2.2.3 Oxides of Nitrogen (as NO_x)

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. The concentrations in the atmosphere at any time are determined by the rate of competing reactions. Reactions that form NO_2 from NO are reversible and the net concentration of each substance is determined by competition between the forward and reverse reactions as well as the rate of other reactions that involve NO and NO_2 in the atmosphere. 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).

Net releases of NO_x in the air are a potentially significant contributor to a number of environmental effects such as acid rain, eutrophication of waterways and the formation of photochemical smog and particulate matter (DEP, 2000).

NO_x is being monitored in Port Hedland to determine the relative change in its ambient concentration over time.

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).

SO_2 is being monitored in Port Hedland to determine the relative change in its ambient concentration over time.

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
Metals	Partisol	iMET1FCICP: Metals in filters or swabs by acid digestion and ICPAES (NIOSH 7301 modification) iMET1FCEXT: Metals, water extractable on filters and ICPAES iMET2FCICP: Metals on filters as µg/m^3 calculated from ICPAES metals and/or Cr(VI) by colourimetry and client supplied air volume iMET2FCEXT: Metals, water extractable on filters as µg/m^3 calculated from ICPAES cations/metals and client supplied volume (see Appendix B.3 for limit of reporting)	Yule River

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. Therefore 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.

The monthly average result for monitored PM_{10} is also shown for each monitoring station. This form of analysis assists in understanding of influence of location and seasonal variability in the monitored results.

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.

2.5 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). Some of the key aspects include:

- All averaging periods of 8 hours or less are referenced by the end time of the averaging period;
- 8-hour averaging periods are running averages based on 1-hour averages;
- 24-hour averaging periods are referenced as midnight to midnight, and not 0900 to 0900;
- Annual averages are calculated from hourly averages;
- For valid averages, a minimum of 75% data availability for the averaging period is required, i.e. 18 hourly averages are required for a valid 24-hour average;
- For comparison to NEPM criteria, an "exceedance" means a valid pollutant level that is above the assessing criteria after rounding to the same number of significant digits;
- For comparison to NEPM criteria, "compliance" for a particular pollutant means the pollutant levels meet the criteria, including consideration of any allowable events above the criteria;

- Annual compliance statistics are based on hourly (daily for PM_{10}) data that are at least 75% complete in each calendar quarter, in addition to an annual data availability of at least 75% based on hourly (daily for PM_{10}) data;
- No correction or adjustment is made for missing data or poor data availability. Compliance and number of exceedances are based on actual measurements;
- Background concentrations (in the context of air quality or emission sources) means air quality that is reflective of natural emission sources or levels. A high background concentration is defined as 24-hour average PM_{10} higher than 60 $\mu g/m^3$ at the BoM station.
- Non-background (in the context of air quality or emission sources) means air quality or an emission source that is not considered to be background in nature or origin;
- An "event" is a monitored level that is determined to be higher than the relevant criteria used for comparison. The contributing sources to the "event" must be identified in order to determine if the "event" is also an "exceedance" of the criteria. An "event" will not be considered an "exceedance" where it can be demonstrated to be a result of elevated background concentrations.

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 0).

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. A high background event is defined as 24-hour average PM_{10} higher than 60 µg/m^3 at the BoM station.

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

- percentage of data recovered
- percentage of data usable

A summary of data recovery is provided in Table 3-1.

Table 3-1: Summary of Data Recovery for 2013-2014

Monitoring Station	Parameter	Data Availability (% of hours)				
		Q1	Q2	Q3	Q4	Annual
Richardson Street	PM_{10}	98%	97%	99%	99%	98%
Kingsmill Street	PM_{10}	100%	97%	97%	96%	97%
Taplin Street	PM_{10}	99%	97%	100%	99%	99%
	NO_x	96%	90%	95%	93%	94%
	SO_2	96%	92%	95%	95%	94%
Neptune Place	PM_{10}	96%	96%	98%	98%	97%
Bureau of Meteorology	PM_{10}	96%	88%	97%	99%	95%
	NO_x	95%	92%	95%	95%	94%
	SO_2	95%	93%	95%	94%	94%
Wedgefield	PM_{10}	76%	83%	90%	99%	87%
Acacia Way	PM_{10}	100%	92%	92%	100%	96%
	NO_x	95%	86%	90%	95%	91%
	SO_2	93%	84%	91%	95%	91%
Yule River	PM_{10}	87%	95%	92%	88%	90%

The timeframes covered by the quarterly analysis are:

- Quarter 1 (Q1) being 1/7/2013 – 30/9/2013
- Quarter 2 (Q2) being 1/10/2013 – 31/12/2013
- Quarter 3 (Q3) being 1/1/2014 – 3/31/2014
- Quarter 4 (Q4) being 1/4/2014 – 30/6/2014

3.1 Comparison by Parameter

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

Particles (PM_{10}) are presented according to the monthly averages, 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 an average for the month, and the reporting year. From time to time elevated levels are recorded at each monitoring station, and the number of dust events (i.e. days above the Taskforce criteria of 70 µg/m^3) is shown for each monitoring station, noting that achievement of the criteria is determined at Taplin Street (see Figure 3-9).

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 six dust events noted for the reporting year. Comparing results for BoM and Taplin Street stations helps to understand 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 three dust events for Taplin Street are likely to be a result of industrial activities (see Section 5).

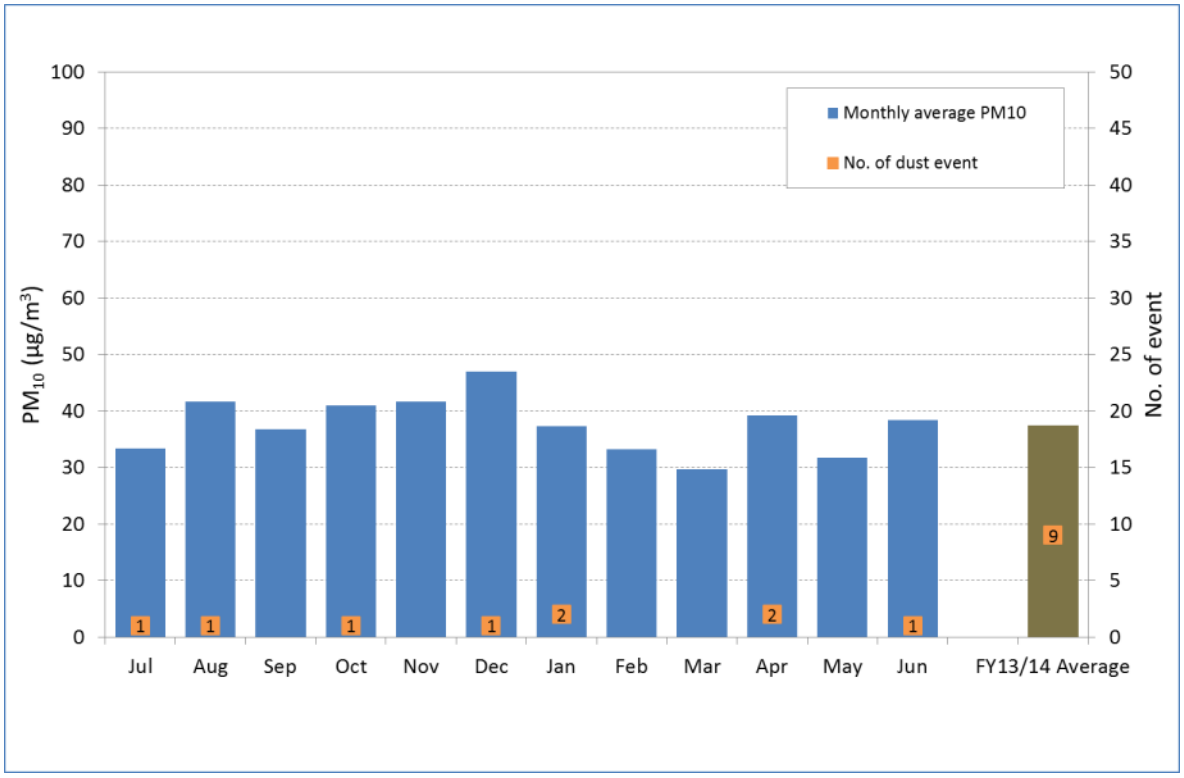


Figure 3-1: Monthly Average 24-hour PM_{10} at Richardson Street

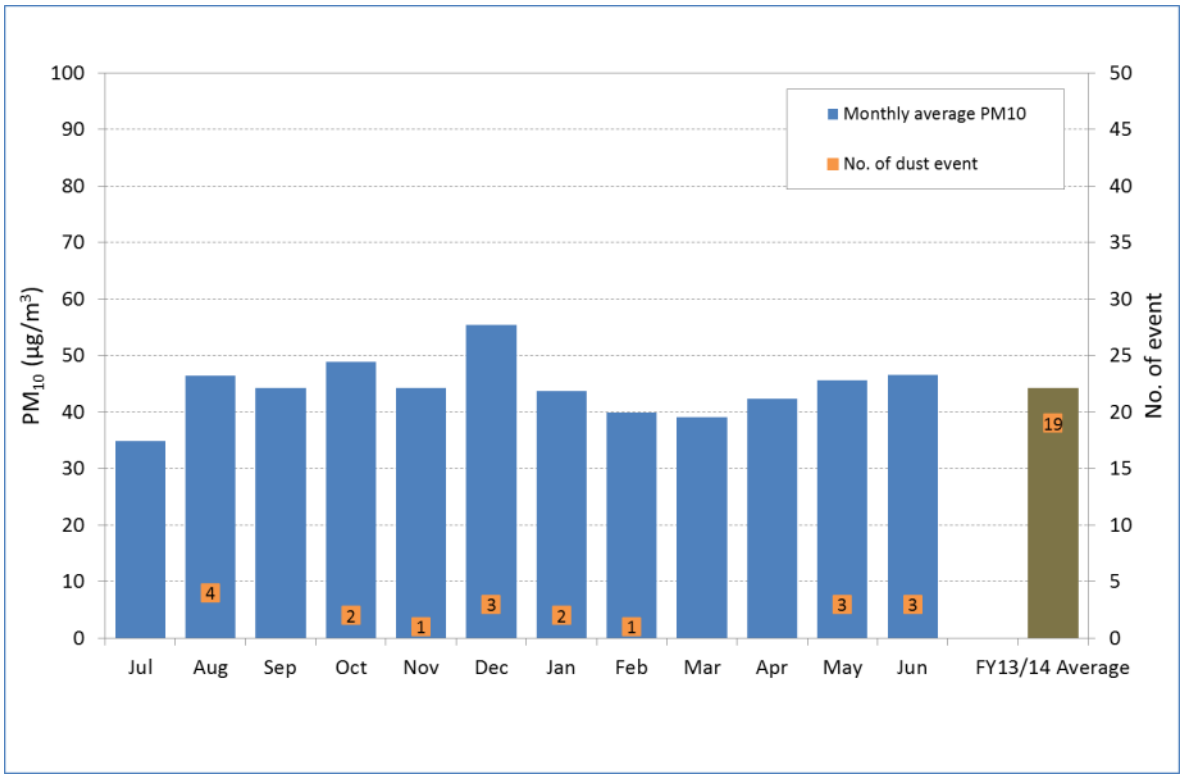


Figure 3-2: Monthly Average 24-hour PM_{10} at Kingsmill Street

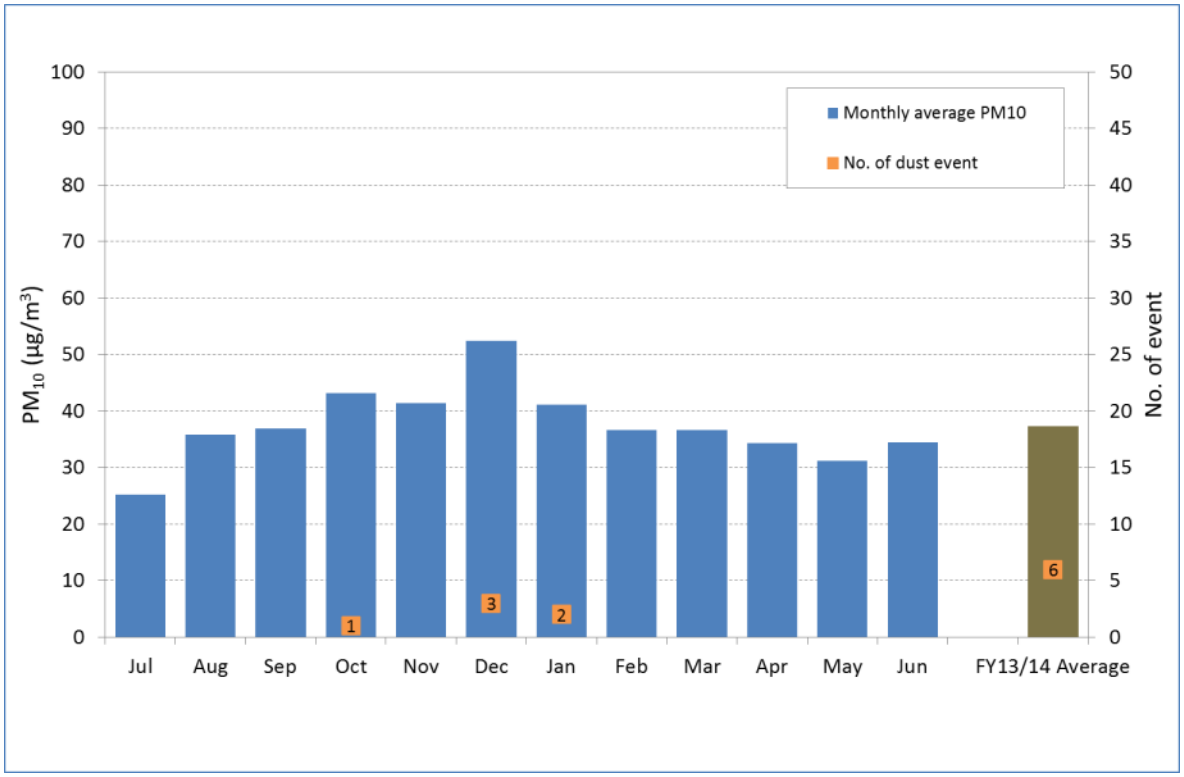


Figure 3-3: Monthly Average 24-hour PM_{10} at Taplin Street

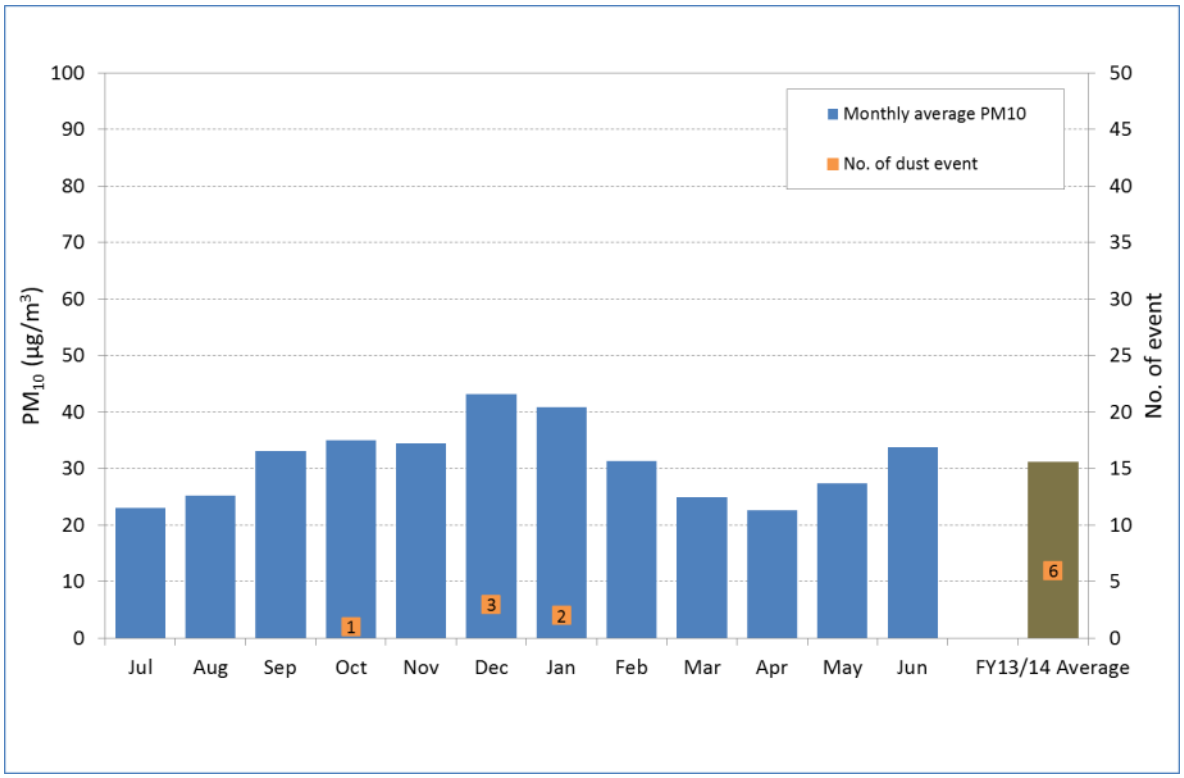


Figure 3-4: Monthly Average 24-hour PM_{10} at Neptune Place

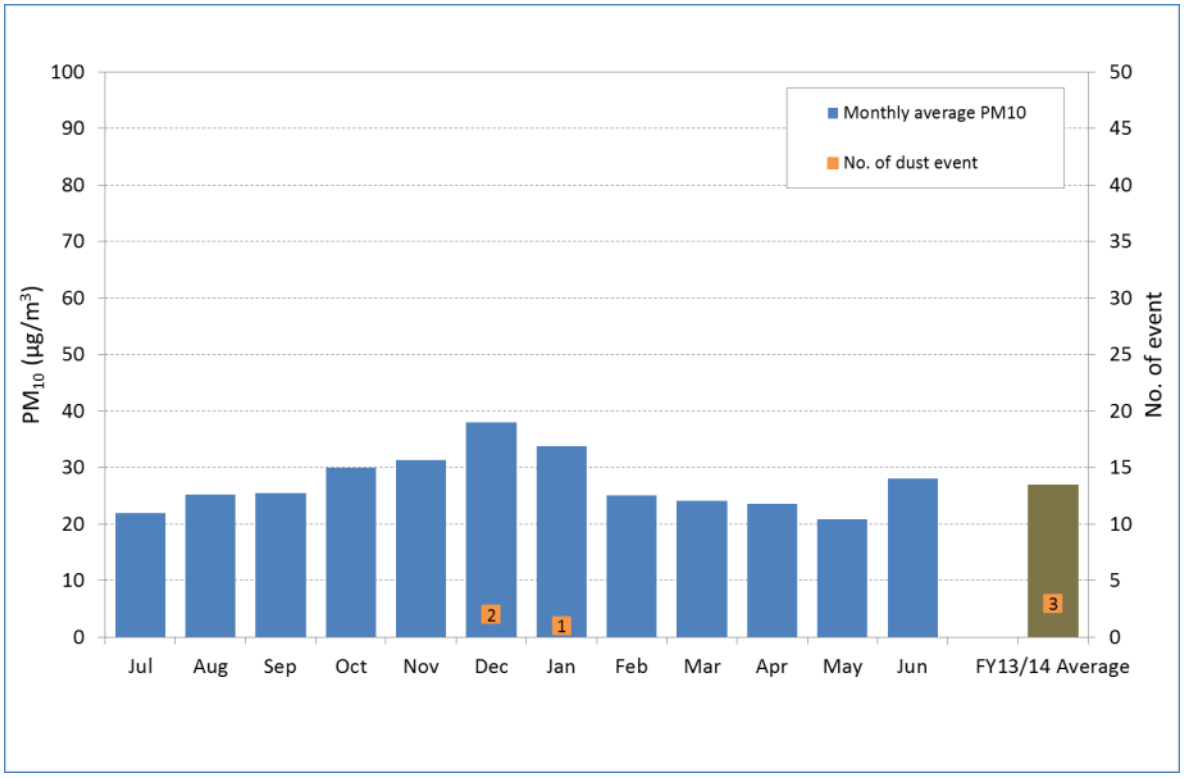


Figure 3-5: Monthly Average 24-hour PM_{10} at Bureau of Meteorology

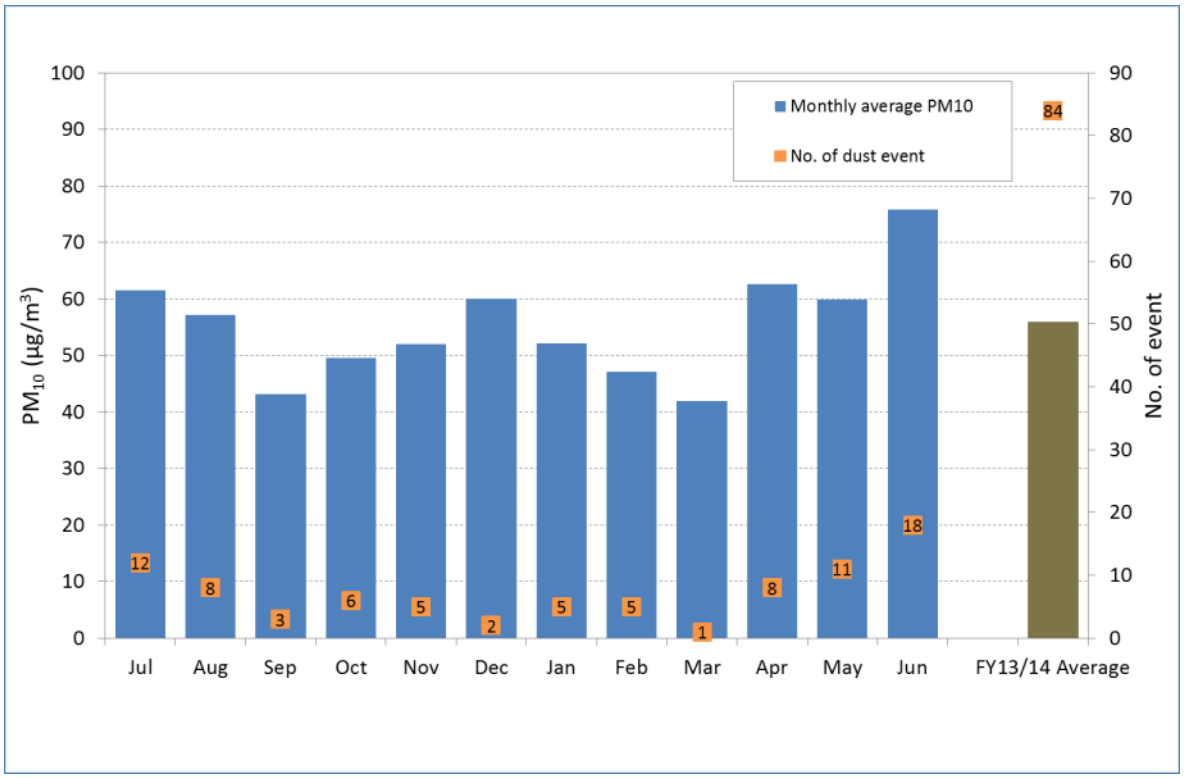


Figure 3-6: Monthly Average 24-hour PM_{10} at Wedgefield

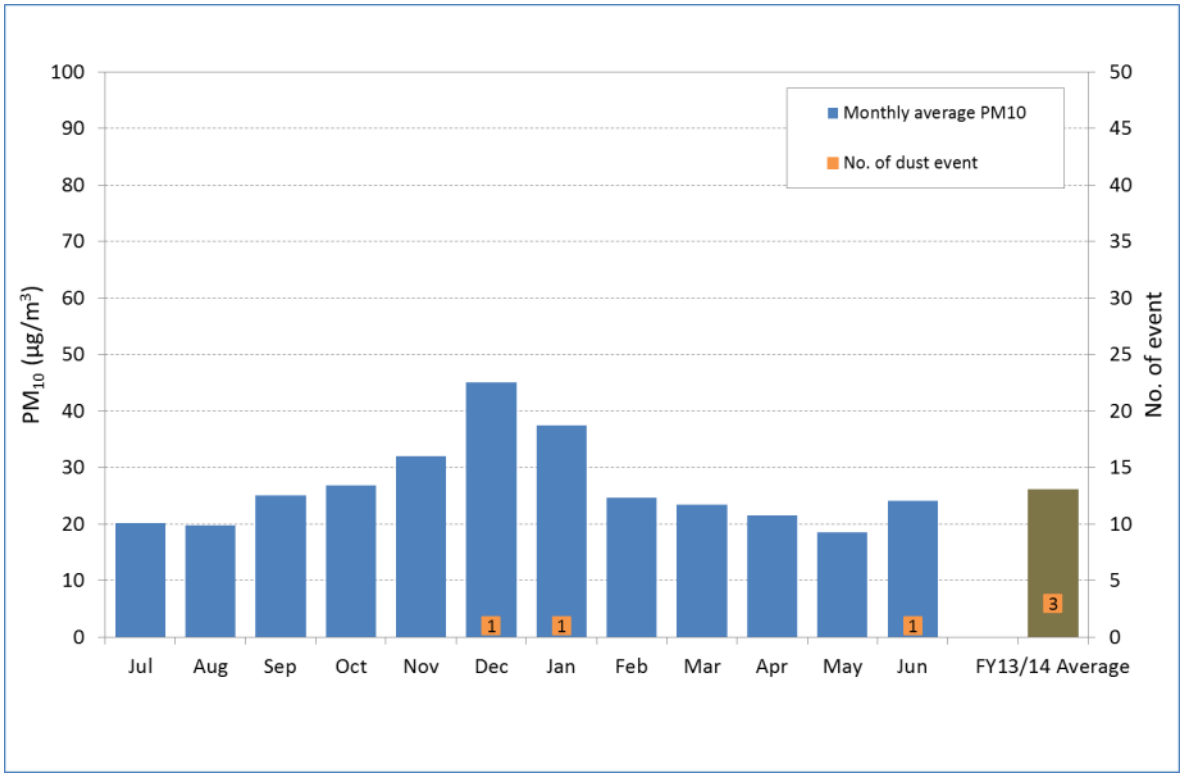


Figure 3-7: Monthly Average 24-hour PM_{10} at Acacia Way

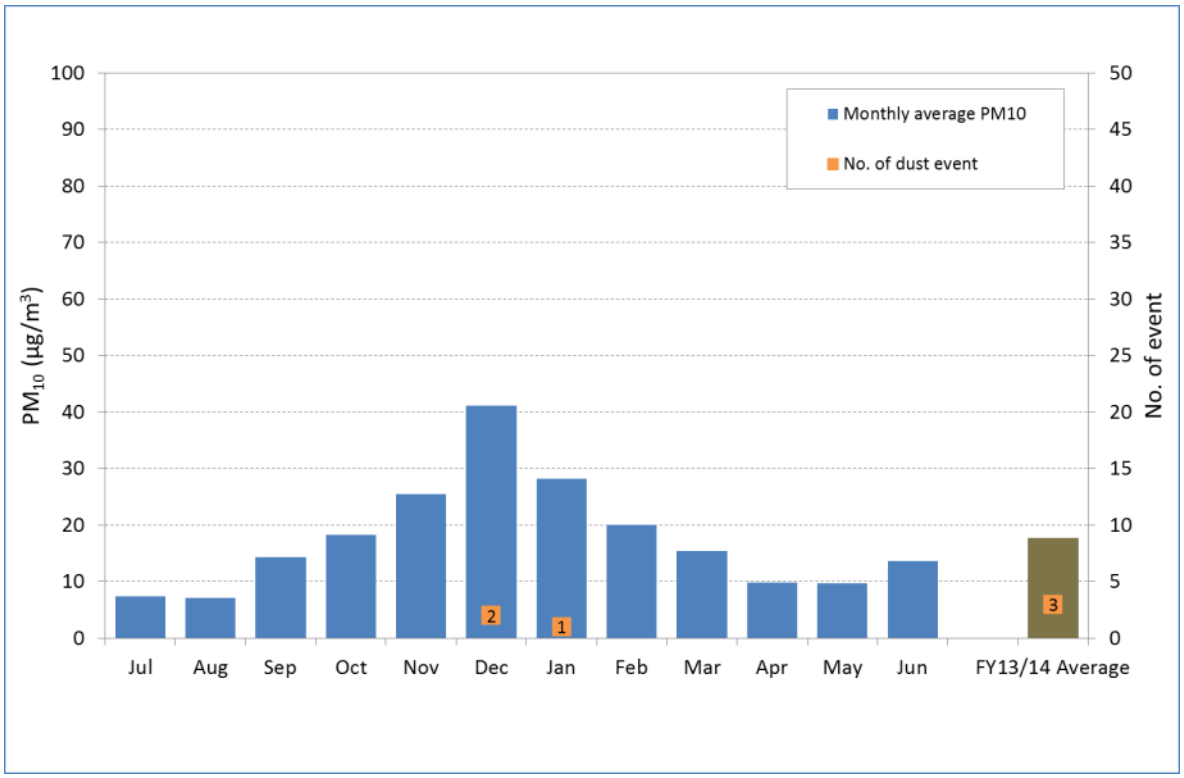


Figure 3-8: Monthly Average 24-hour PM_{10} at Yule River

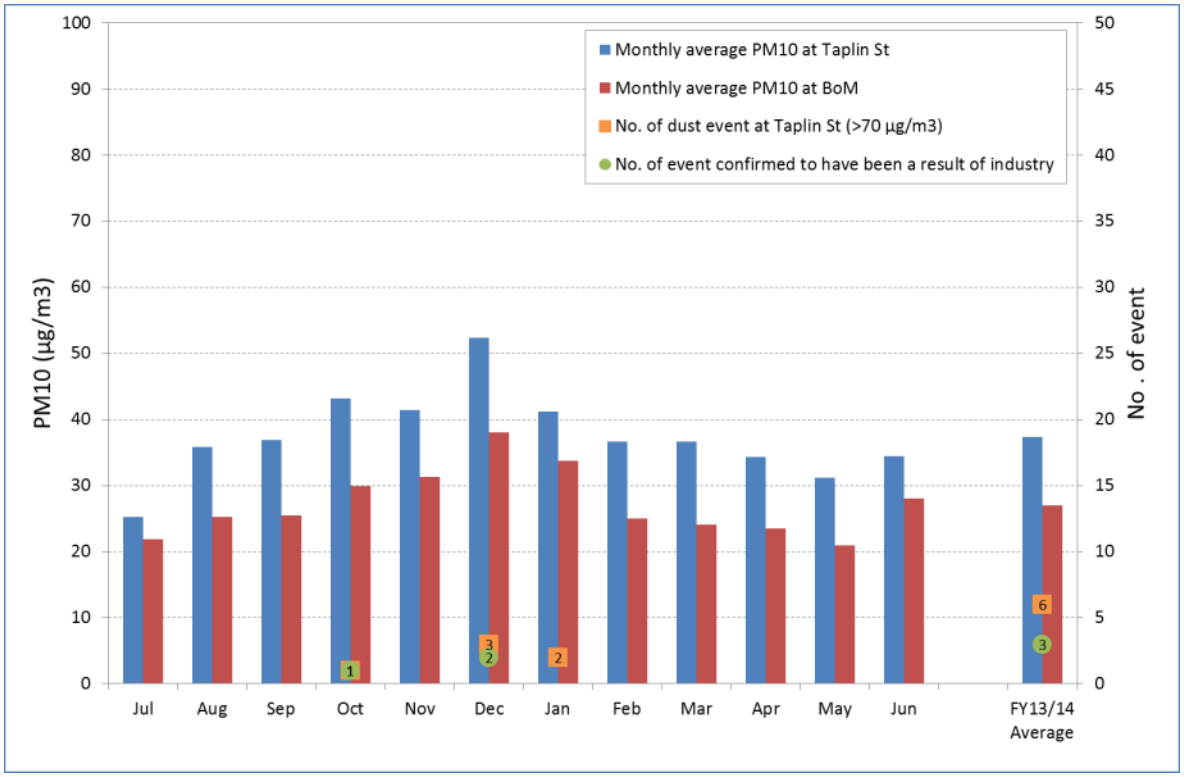


Figure 3-9: Monthly Average 24-hour PM_{10} – comparison of Taplin Street with Bureau of Meteorology

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 Taskforce criteria has 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	98%	97%	99%	99%	98%	358	50	N/A	Not met	N/A
Kingsmill Street	100%	97%	97%	96%	97%	355	98	N/A	Not met	N/A
Taplin Street	99%	97%	100%	99%	99%	360	48	6	Not met	Met
Neptune Place	96%	96%	98%	98%	97%	353	25	8	Not met	Met
Bureau of Meteorology	96%	88%	97%	99%	95%	355	10	N/A	Not met	N/A
Wedgefield	76%	83%	90%	99%	87%	317	148	N/A	Not met	N/A
Acacia Way	100%	92%	92%	100%	96%	351	13	N/A	Not met	N/A
Yule River	87%	95%	92%	88%	90%	330	8	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 at Taplin Street and Neptune Place monitor stations.

3.1.1.1 Comparison between FY14 and FY13

The 24-hour average PM_{10} for Taplin Street and BoM in FY13 and FY14 are presented in Figure 3-10 and Figure 3-11 respectively. Compared to FY13, the 24-hour averages PM_{10} at both Taplin Street and BoM monitors have less exceedances of 24-hour average PM_{10} greater than 70 µg/m³ in FY14.

In addition, the number of exceedance for 24-hour average PM_{10} greater than 50 µg/m³ and 70 µg/m³ for all stations in PHIC monitoring network are presented in Figure 3-12 and Figure 3-13. Compared to FY13, all stations recorded less number of exceedance in PM_{10} greater than 70 µg/m³. In terms of exceedances in 24-hour average PM_{10} greater than 50 µg/m³, most stations recorded less number of exceedance except Kingsmill Street; while Taplin Street and Neptune Place monitors recorded the same number of exceedance as last year.

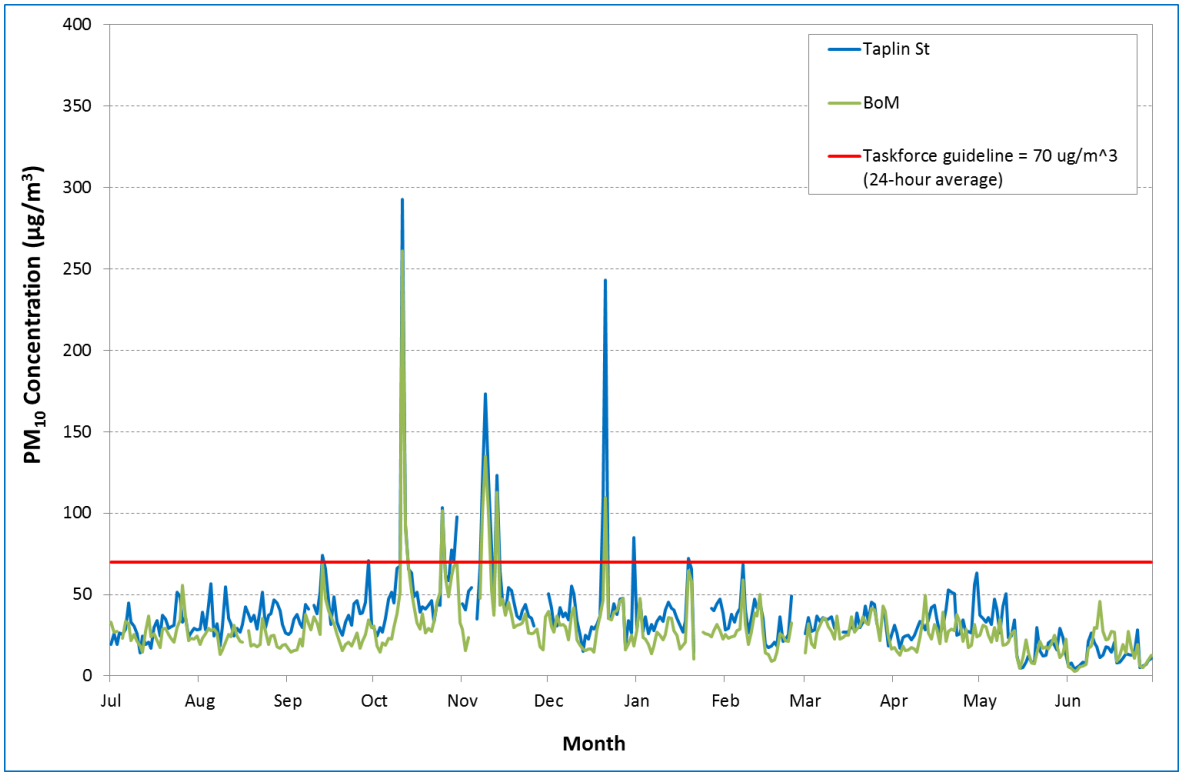


Figure 3-10: Daily Average 24-hour PM_{10} – comparison of Taplin Street with Bureau of Meteorology 2012-2013 (FY13)

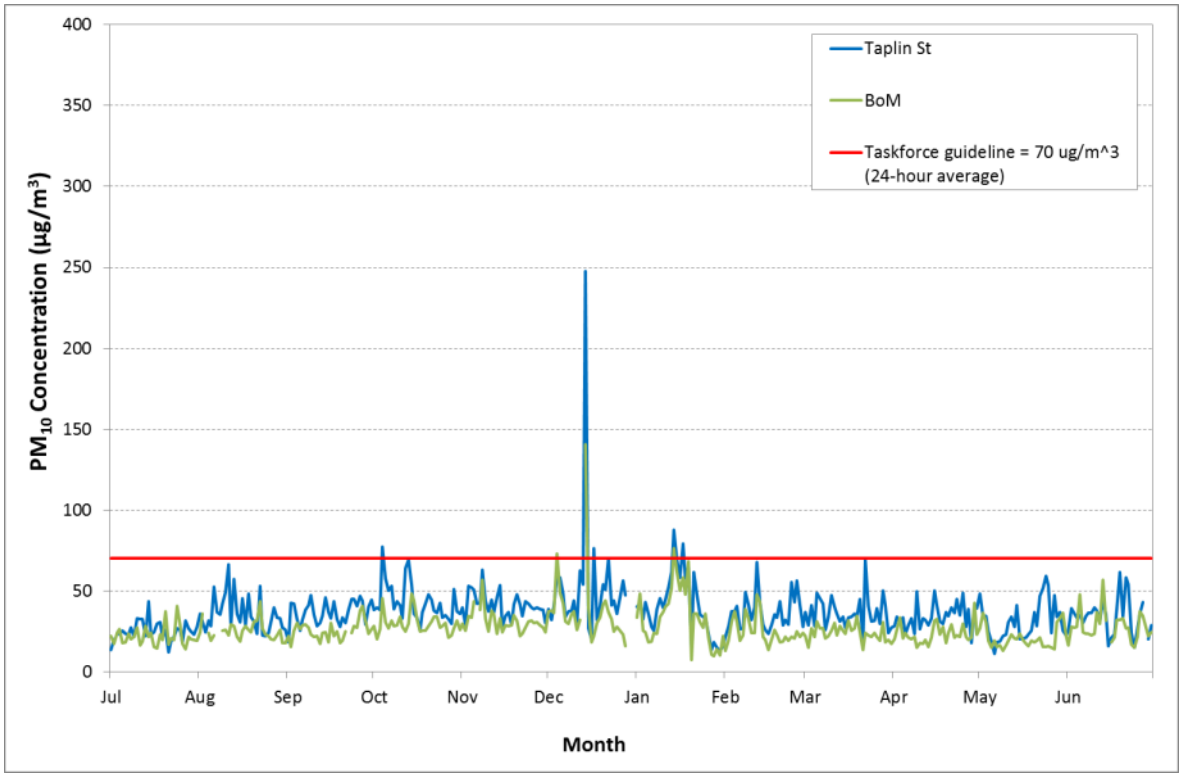


Figure 3-11: Daily Average 24-hour PM_{10} – comparison of Taplin Street with Bureau of Meteorology 2013-2014 (FY14)

Figure 3-12: PHIC Monitoring locations in Port Hedland – west end

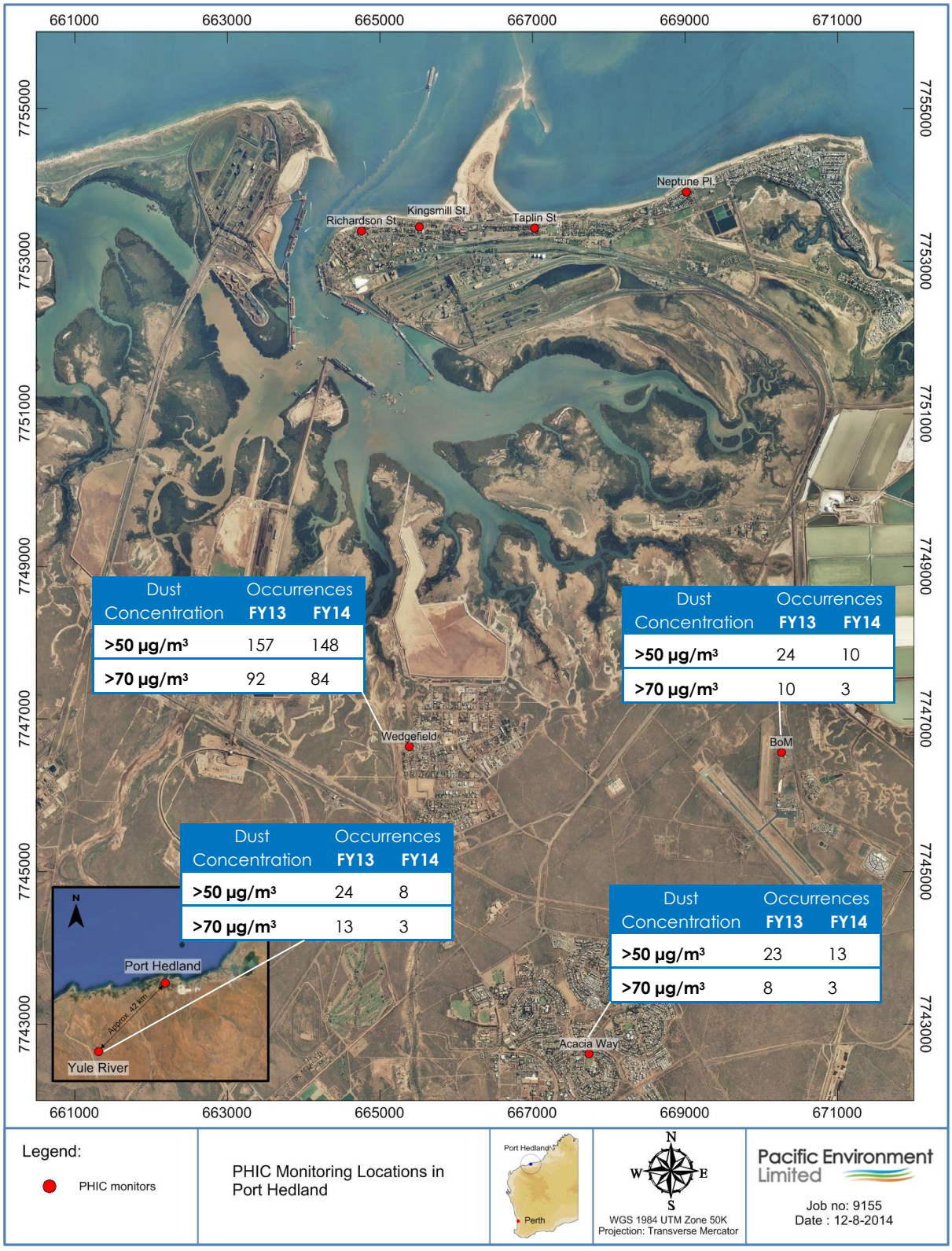


Figure 3-13: PHIC Monitoring locations in Port Hedland

3.1.2 Summary for particles as $PM_{2.5}$

The extent of $PM_{2.5}$ monitoring in the network is shown in Table 3-3. 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. 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. $PM_{2.5}$ 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.

Table 3-3: 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	98%	96%	98%	98%	97%	7.06	1	0	N/A	Met
Taplin Street	97%	96%	99%	98%	98%	6.54	1	0	N/A	Met
Bureau of Meteorology	97%	93%	97%	98%	96%	7.48	0	0	Met	Met
Acacia Way	99%	94%	94%	98%	96%	7.88	1	0	N/A	Met
Yule River	93%	93%	87%	92%	91%	7.96	1	0	N/A	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 3-4. Particles are measured at six of the eight monitoring stations. The number of occasions when metals were detected in the monitoring is reported here for each station. Statistical summaries and limit of reporting for metals are presented in Appendix B.3.

Table 3-4: Summary for Metals in PM_{10}

Monitoring Station	Total number of monitoring days
Richardson Street	112
Taplin Street	112
Bureau of Meteorology	107
Wedgefield	56
Acacia Way	112
Yule River	45

3.1.4 Summary for Oxides of Nitrogen

The extent of NO_x monitoring in the network is shown in Table 3-5. 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 3-5: 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	96%	90%	95%	93%	94%	0.007	0	Met	Met
Bureau of Meteorology	95%	92%	95%	95%	94%	0.005	0	Met	Met
Acacia Way	95%	86%	90%	95%	91%	0.005	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 3-6. 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 3-6: 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	96%	92%	95%	95%	94%	0.0017	0	Met	Met	Met
Bureau of Meteorology	95%	93%	95%	94%	94%	0.0002	0	Met	Met	Met
Acacia Way	93%	84%	91%	95%	91%	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 3-7.

Table 3-7: 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	50	Not met
	70 µg/m³	24-hour average[a]	9	N/A
$PM_{2.5}$	25 µg/m³	24-hour average[b]	1	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.

3.2.2 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 3-8.

Table 3-8: 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	98	Not met
	70 µg/m³	24-hour average[a]	19	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 3-9.

Table 3-9: 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	48	Not met
	70 µg/m³	24-hour average	6	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]	1	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. The comparison of the Neptune Place monitoring results to the relevant criteria is shown in Table 3-10.

Table 3-10: 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	25	Not met
	70 µg/m³	24-hour average	8	Met

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 3-11.

Table 3-11: 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	10	Not met
	70 µg/m³	24-hour average[a]	3	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 provides site-worker accommodation. 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 3-12. The Wedgefield site recorded the highest number of PM10 events in the year.

3-12: Summary for Wedgefield

Monitoring Station / Parameter	Criteria	Timeframe	Number of Occurrences above criteria	Performance against criteria
PM_{10}	50 µg/m³	24-hour average	148	Not met
	70 µg/m³	24-hour average[a]	84	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 3-13.

Table 3-13: 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	13	Not met
	70 µg/m³	24-hour average[a]	3	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]	1	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.

3.2.8 Yule River

The Yule River monitoring location is relatively distant to industrial and related activities, and populations, and acts as a background monitoring location 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 3-14.

Table 3-14: 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	8	Not met
	70 µg/m³	24-hour average[a]	3	N/A
$PM_{2.5}$	25 µg/m³	24-hour average[b]	1	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.

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). 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 second year of full reporting, long term annual trends cannot be established for the monitoring network. In the interim, by comparing the 24-hour average PM_{10} concentration in FY14 to the values in FY13, the maximum to 95th percentile in FY14 amongst all monitoring stations are lower than those in FY13.

Comparing the 1-hour average NO_2 concentration in FY14 to the values in FY13, no obvious trend can be observed. Also, no obvious trend can be observed between the 1-hour as well as 24-hour average SO_2 concentrations in FY14 and the values in FY13.

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).

5.1 Number of PM_{10} "Events"

As defined in Section 2.5, a PM_{10} "event" is a monitored level that is higher than the relevant criteria used for comparison. The contributing sources to the "event" must be identified in order to determine if the "event" is also an "exceedance" of the criteria. An "event" will not be considered an "exceedance" where it can be demonstrated to be 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/m^3. There are a total of six PM_{10} events recorded at Taplin Street.

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). Further analysis of the Taplin Street data was undertaken to identify the likely contributing cause of the events. 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.

Table 5-1 shows there to be 6 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). To determine if the event is attributable to industry activity or not, background dust levels are also taken into account for comparison. 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
4/10/2013	77	45	32	Non-background
14/12/2013	**247**	**141**	**107**	**Background**
17/12/2013	77	22	54	Non-background
22/12/2013	70	37	33	Non-background
14/01/2014	**88**	**77**	**11**	**Background**
17/01/2014	**79**	**58**	**21**	**To be investigated**

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 17/1/2014, the difference between the 24 hour average PM_{10} levels at Taplin Street and BoM is less than 25 µg/m^3. The relatively high background dust levels present at BoM (58 µg/m^3) on this occasion leaves a relatively small buffer before criterion is exceeded. This indicates high regional background dust levels potentially contributed to this dust event.

Further investigations were conducted to identify the potential sources contributing to the inferred non-background dust. This analysis is demonstrated in Section 5.2.

5.2 "Event" analysis to confirm an "Exceedance"

A dust "event" is defined as a 24-hour average PM_{10} level higher than 70 µg/m^3 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.

5.2.1 04/10/2013 (Non-background event)

The hourly average PM_{10} concentration, wind direction and wind speed recorded at Taplin Street on 04/10/2013 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^o to 290^o from Taplin St, is considered to be the arc of influence by industrial activities in the Port Hedland region which is 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 midnight up to 9am. It was noted that the wind speed was relatively low during these periods which prevented the dispersion of the accumulated dust in the atmosphere. It is also worth noting that the PM_{10} data at BoM are missing from 9 am to 4 pm. Nevertheless, the analysis suggests 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.

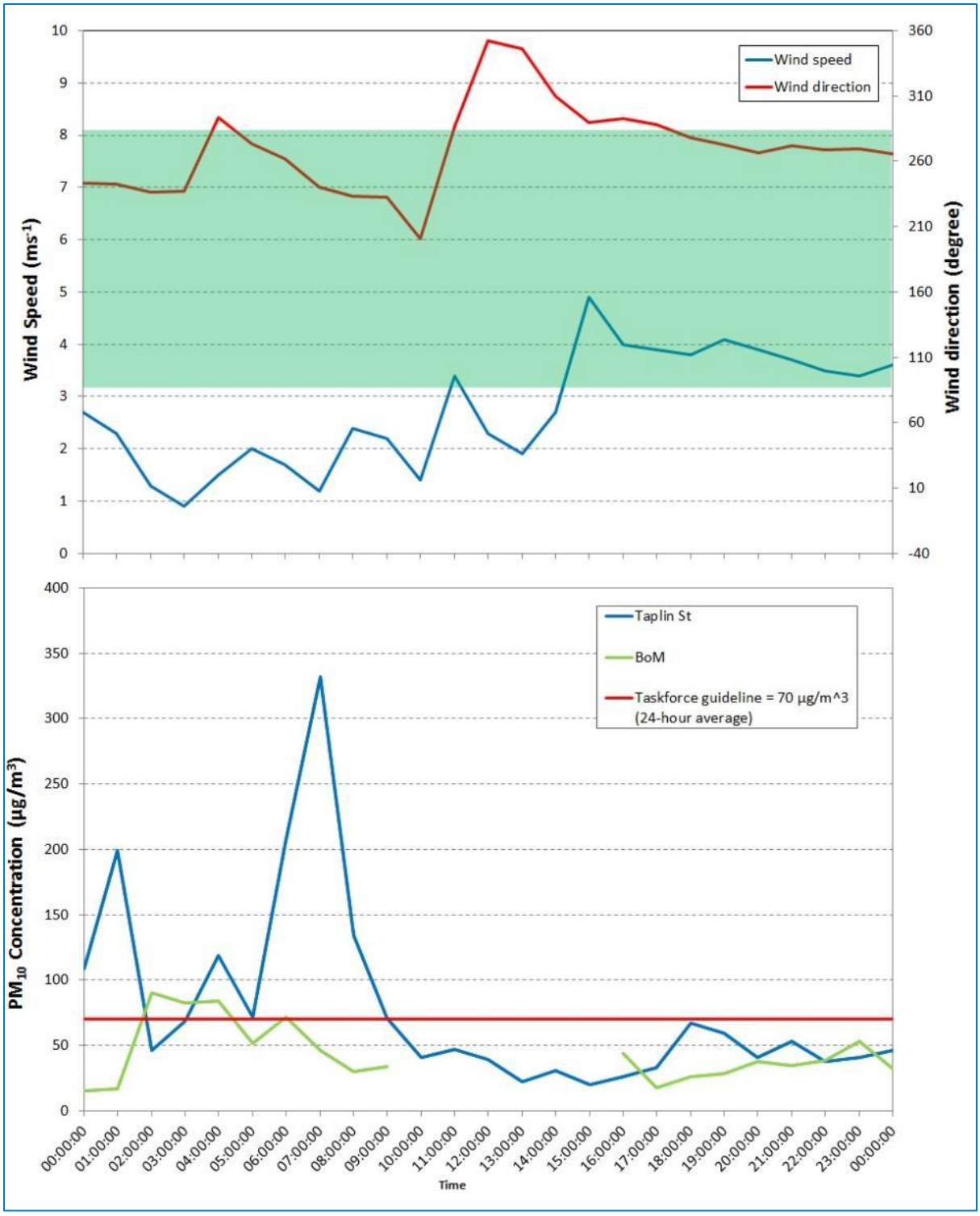


Figure 5-2: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 04/10/2013.

5.2.2 17/12/2013 (Non-background 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 17/12/2013 are shown in Figure 5-3. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-3.

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 am to 10 am. The wind speed was relatively low during this period. It is highly likely that this dust event is attributable to industrial activities in the Port Hedland region.

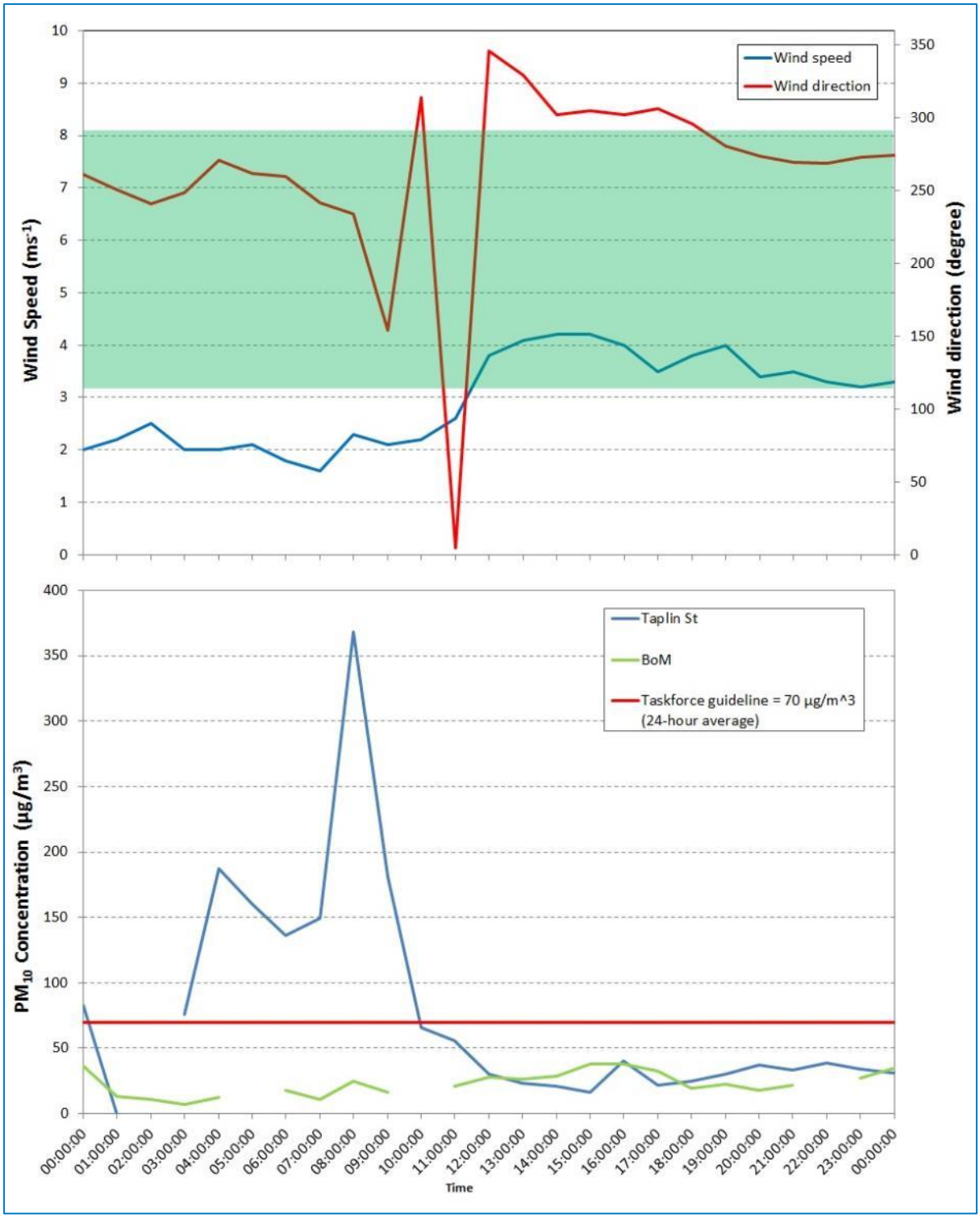


Figure 5-3: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 17/12/2013.

5.2.3 22/12/2013 (Non-background 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 22/12/2013 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 PM_{10} concentration started to increase when the wind direction swung towards the arc of influence and reached above 70 µg/m^3 between 4 to 12 pm. This suggests the dust event is potentially caused by nearby industrial activities.

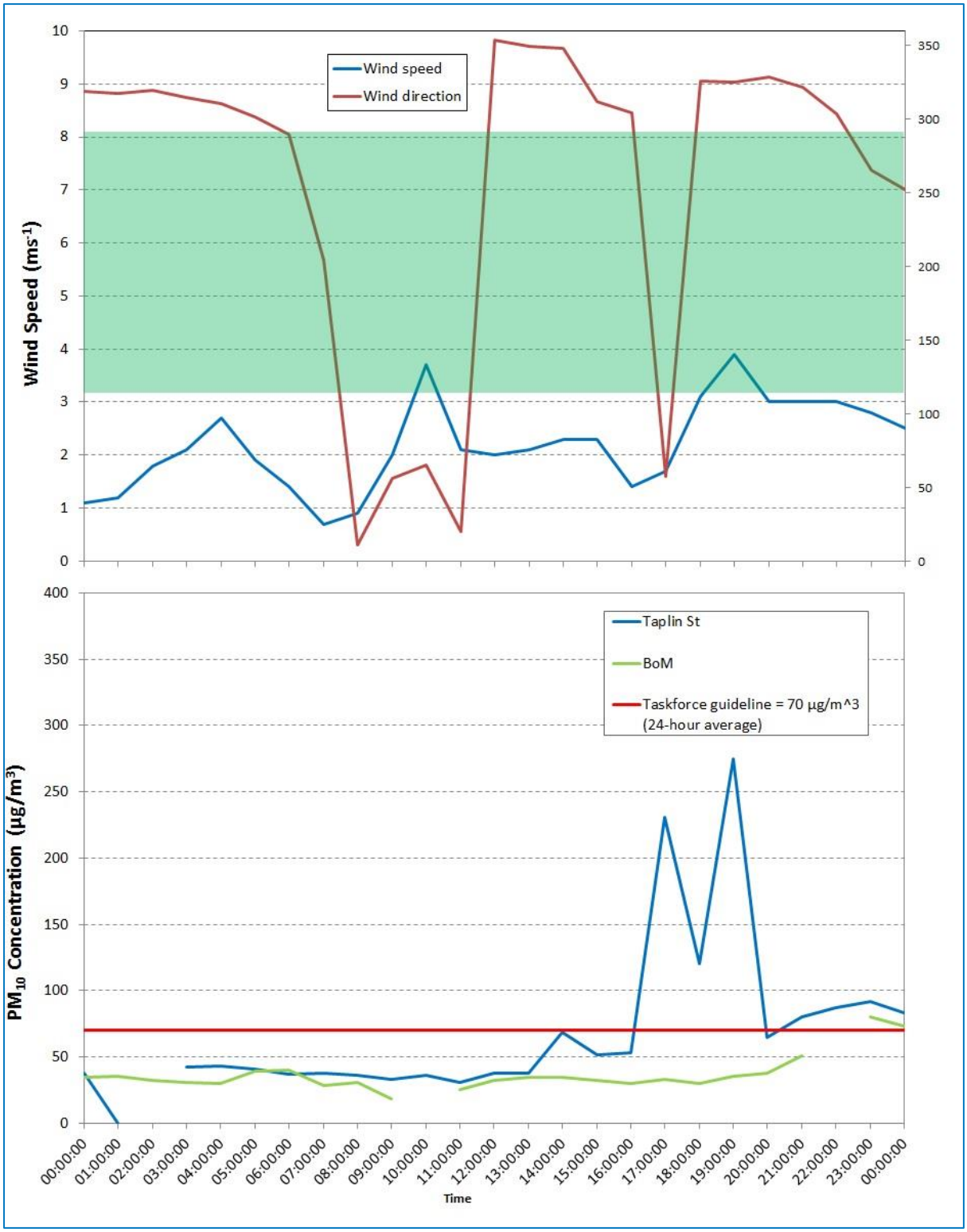


Figure 5-4: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 22/12/2013.

5.2.4 17/01/2014 (Background 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 17/01/2014 are shown in Figure 5-5. The arc of influence by the industrial activities from Port Hedland is shaded as light green on Figure 5-5.

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. The trend indicates that the dust event is highly likely to be caused by elevated background dust levels.

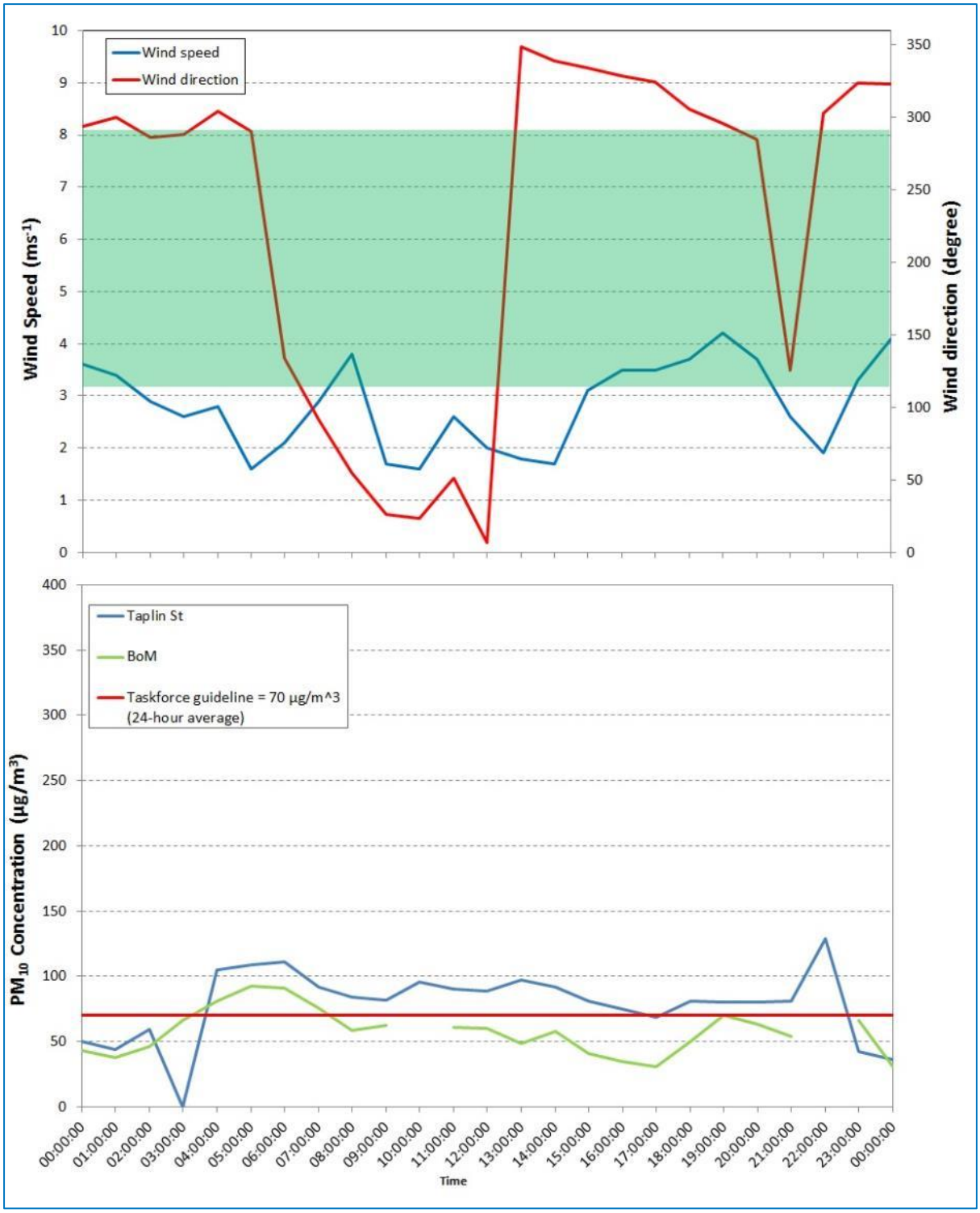


Figure 5-5: Time series PM_{10} concentration, wind speed and wind direction at Taplin Street monitor and corresponding PM_{10} concentration at BoM monitor on 17/01/2014.

6 SUMMARY OF RESULTS

6.1 Monitoring Network Performance

The performance of the monitoring network during the year proved to be reliable, and annual data recovery of at least 75% was achieved for all monitored parameters at all monitoring stations. Data recovery of at least 75% was also achieved each quarter of the year for all parameters monitored at all monitoring stations. This is an improvement from the 2012-2013 financial year where quarterly data recovery failed to meet the 75% requirement at several monitoring stations. This year the lowest data recovery was 76% at Wedgefield (Q1 for PM_{10}) with all other monitoring stations achieving greater than 80% recovery.

6.2 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 financial year findings, sulfur dioxide levels are shown to be lower than the specified NEPM standards (i.e. for all 1-hour, 24-hour and annual criteria).

6.3 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 was also lower than the 1-hour NEPM NO_2 standard. These standards were also met for the 2012-2013 financial year.

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 Yule River, and the highest number of events was recorded at Wedgefield. Particle levels higher that the 24-hour NEPM criteria were recorded for eight occasions at Yule River and 148 occasions at Wedgefield. Last year PM_{10} recordings at Yule River exceeded the 24-hour NEPM criteria on 24 occasions and at Wedgefield on 157 occasions.

As this is the second year of full reporting, long term annual trends cannot be established. In the interim, compared to last year, all stations recorded less number of occasions in PM_{10} greater than 70 $\mu g/m^3$. In terms of exceedances in 24-hour average PM_{10} greater than 50 $\mu g/m^3$, most stations recorded less number of occasions except Kingsmill Street; while Taplin Street and Neptune Place recorded the same number as last year.

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 six days when particle levels recorded at the Taplin Street monitoring station were above the Taskforce criterion in contrast to 17 days last year. The occasions of 24-hour average PM_{10} concentration over 70 $\mu g/m^3$ were reduced by more than a half. Analysis of the data shows that half of the events were attributable to the elevated background dust levels. The non-background events (4 October 2013, 17 December 2013 and 2 December 2013) 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 five monitoring stations (Richardson St, Taplin St, BoM, Acacia Way and Yule River) throughout FY14. The $PM_{2.5}$ levels at all monitors have an annual average below the NEPM advisory reporting guidelines. Both the highest and lowest 24-hour averages of $PM_{2.5}$ were recorded at Taplin St. 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 six 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. Industry is currently reviewing the toxicology of manganese ores in relation to WHO guideline values.

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}, NO_x and SO_2 data accessible to the community via the monitoring website. PHIC will report results annually to the Taskforce, the next report being expected August 2015, presenting the monitored data for the 2014-2015 year.

7 REFERENCES

DEC (2012) Environmental Protection Act 1986, *Licence: L4432/1989/13. EAR*, Port Hedland Port Authority. Department of Environment and Conservation, Government of Western Australia.

DEP (2000) Perth Air Quality Management Plan – State of Knowledge. Department of Environmental Protection, Government of Western Australia, Perth, July 2000.

DSD (2010) Port Hedland Air Quality and Noise Management Plan. Department of State Development, Government of Western Australia.

EA (2002) Review of data on heavy metals in ambient air in Australia: Technical Report No. 3, Environment Australia, Canberra.

NEPC (1998) Ambient Air National Environment Protection Measure for Ambient Air Quality. National Environment Protection Council, Canberra.

PEL (2013) Audit of Ambient Air Quality Monitoring Stations – Port Hedland. Report prepared by Pacific Environment Limited for Port Hedland Industries Council, June 2013.

PRC (2001) National Environment Protection (Ambient Air Quality) Measure. Technical Paper No. 5 – Data Collection and Handling. Report prepared by the Peer Review Committee for NEPC.

PRC (2002) National Environment Protection (Ambient Air Quality) Measure. Technical Paper No. 8 – Annual Reports. Report prepared by the Peer Review Committee for NEPC.

SKM (2011) *Design of a Boundary Monitoring Network for BHPBIO Port Hedland*. Report prepared by Sinclair Knight Merz for BHP Billiton Iron Ore.

USEPA (2006) *Federal Register*, Vol. 71, No. 200, Rules and Regulations.

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/m³)
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).

Table A-5: Data from Taplin Street monitoring station

Time	PM_{10} (µg/m³)	Hourly average PM_{10} (µg/m³)
1/07/2012 0:10	41	
1/07/2012 0:20	41	
1/07/2012 0:30	41	
1/07/2012 0:40	41	
1/07/2012 0:50	61	
1/07/2012 1:00	61	47.7

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.

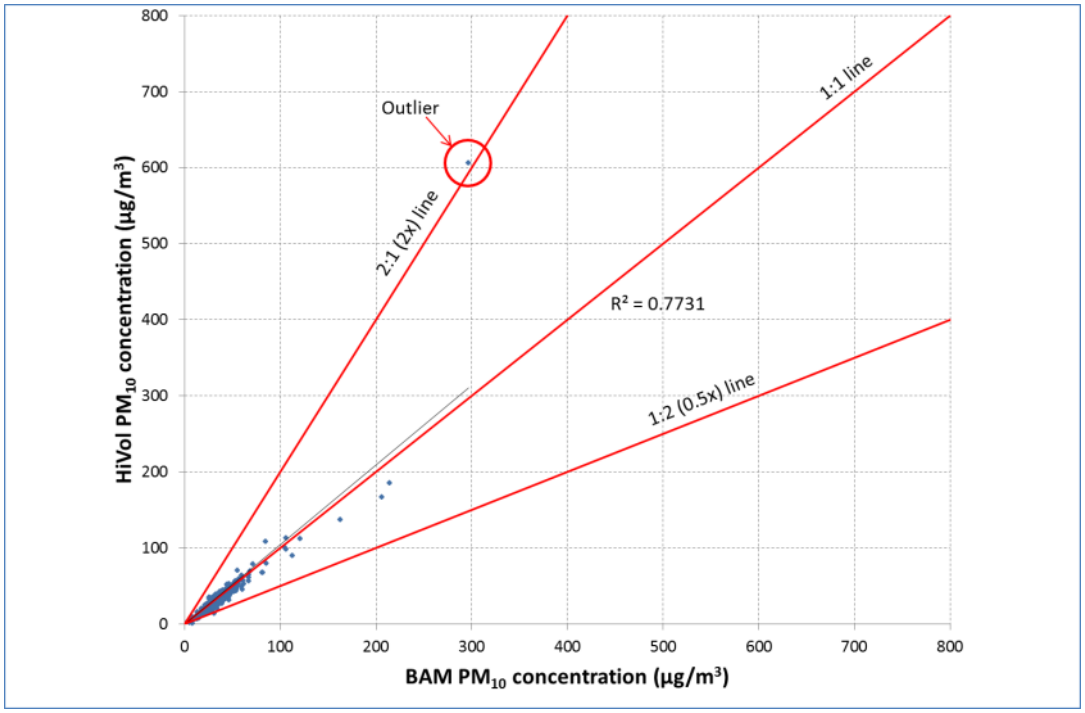


Figure A-1: Correlation of HiVol PM10 data to BAM PM10 at Taplin Street monitoring station (2012/2013)

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

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
Max	227	272	247	222	141	254	183	176
99th Percentile	72	88	77	87	65	137	67	65
98th Percentile	70	80	69	73	56	129	55	53
95th Percentile	58	70	59	56	44	104	47	40
50th Percentile	35	42	35	28	25	48	23	14
Minimum	10	7	11	2	7	15	10	2
>50	50	98	48	25	10	148	13	8
>70	9	19	6	8	3	84	3	3
Count	358	355	360	353	355	317	351	330
Recovery	98%	97%	99%	97%	97%	87%	96%	90%

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

	Taplin Street	BoM	Acacia Way
Max	0.0358	0.0322	0.0358
99th Percentile	0.0257	0.0210	0.0223
98th Percentile	0.0236	0.0188	0.0184
95th Percentile	0.0205	0.0153	0.0142
50th Percentile	0.0043	0.0035	0.0033
Minimum	0.0000	0.0000	0.0000
Annual Average	0.0070	0.0054	0.0049
>0.12	0	0	0
Count	8203	8248	8012
Recovery	94%	94%	91%

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

	Taplin Street	BoM	Acacia Way
Max	0.0376	0.0128	0.0084
99th Percentile	0.0164	0.0028	0.0019
98th Percentile	0.0134	0.0020	0.0012
95th Percentile	0.0091	0.0010	0.0010
50th Percentile	0.0003	0.0000	0.0000
Minimum	-0.0028	-0.0018	-0.0010
Annual Average	0.0017	0.0002	0.0001
>0.12	0	0	0
Count	8272	8265	7945
Recovery	94%	94%	91%

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

	Taplin Street	BoM	Acacia Way
Max	0.0077	0.0015	0.0017
99th Percentile	0.0059	0.0011	0.0009
98th Percentile	0.0057	0.0011	0.0007
95th Percentile	0.0045	0.0009	0.0005
50th Percentile	0.0013	0.0001	0.0001
Minimum	-0.0012	-0.0011	-0.0006
>0.08	0	0	0
Count	360	359	337
Recovery	98%	98%	92%

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-5: 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
1/07/2013	19	9	14	12	22	73	12	6
2/07/2013		15	20		18	85	18	6
3/07/2013	19	28			24	95	15	4
4/07/2013	42	63	23	23	27	77	21	4
13/07/2013	31	22	22		28	75	24	7
15/07/2013	27	29	23	20	24	73	23	10
19/07/2013	38	30	22	30	20	73	12	
22/07/2013	23	17	19	15	21	106	44	
23/07/2013	29	27	22	20	20	85	27	
24/07/2013	35	40	27	23	41	123	27	
25/07/2013	32	46	26	20	29	97	17	
26/07/2013	34	37	18	18	18	72	41	
29/07/2013	71	39	25	26	20		18	7
2/08/2013	50	70	31	31	36	123	28	8
3/08/2013	47	48	24	18		85	22	9
4/08/2013	57	74	32	15	24	57	17	10
5/08/2013	32	41	28	17	20	72	21	8
6/08/2013	56	88	53	22	23	40	16	3
10/08/2013	63	70	50	30	26	34	18	5
11/08/2013	64	86	67	31	23	27	16	7
17/08/2013	37	27	29	22	28	79	21	6
19/08/2013	36	38	34	28	25	86	21	3
20/08/2013	50	42	31	18	31	93	25	8
22/08/2013	72	45	53	31	44	196	25	9
23/08/2013	38	42	23	23	27	73	19	7
18/09/2013	34	30	33	25	25	82	26	13
26/09/2013	53	68	47	41	38	76	32	22
27/09/2013	46	56	44	43	41	78	32	21
4/10/2013	70	78	77	38	46	71	26	18
5/10/2013	48	70	58	37	31	51	28	22
13/10/2013	55	65	69	47	30	71	31	24
14/10/2013	52	52	54	42	48	93	35	27
15/10/2013	30	29	36	27	44	103	30	23
22/10/2013	33	39	38	26	34	71		20

24/10/2013	43	48	42	28	27	71	27	18
3/11/2013	63	79	53	36	35	40	22	17
8/11/2013	52	59	63	51	57	74	41	45
9/11/2013	33	45	44	26	33	82	35	28
10/11/2013	25	34	38	22	25	82	29	16
11/11/2013	47	56	45	25	38	82	28	19
12/11/2013	30	34	37	29	36	104	35	21
4/12/2013	52	57	59	56	73		68	47
12/12/2013	55	80	63	47	32	52	37	35
14/12/2013	227	272	248	222	141	254	183	170
15/12/2013	32	37	27	22	40	103	45	60
17/12/2013	32	69	77	35	22	37	24	15
22/12/2013	35	49	70	45	37	61	42	42
27/12/2013	57	72	56	33	23	38	27	22
29/12/2013								176
13/01/2014	56	70	62	62	52	72	59	47
14/01/2014	72	90	88	97	77	90	88	85
15/01/2014	55	69	70	74	62	80	67	67
17/01/2014	71	79	79	73	58	90		45
19/01/2014	51	66	65	57	69	82	46	
21/01/2014	47	66	62	94	36	48	47	
22/01/2014	43	57	48	78	36	47	40	
4/02/2014	42	47	37	55	37	71	47	28
9/02/2014	36	46	42	36	33	70	26	29
12/02/2014	53	72	68	93	48	66	55	53
19/02/2014	33	35	34	23	23	85	26	16
22/02/2014	30	40	32	20	22	84	22	15
28/02/2014	40	34	28	20	24	75	21	12
20/03/2014	30	40	45	19	25	81	30	15
11/04/2014	94	34	33	23	17	40	15	10
12/04/2014	33		32	15	20	128	21	9
14/04/2014	46	54	33	29	21	126	21	13
15/04/2014	46	54	50	18	32	126	29	10
16/04/2014	33	48	41	16	33	129	22	14
18/04/2014	33	41	30	16	28	84	23	10
24/04/2014	44	45	35	25	22	71	26	9
28/04/2014	87	27	18	17	21	36	17	7
29/04/2014	52	49	40	49	43	138	42	19
30/04/2014	33	36	39	21	23	98	22	12
1/05/2014	34	49	48	29	27	83	20	11
2/05/2014	47	32	34	24	36	167	39	15

3/05/2014	21	19	34	15	31	132	20	
4/05/2014	22	26	25	16	19	76	19	
10/05/2014	26	37	23	24	16	73	21	
12/05/2014	29	46	34	27	23	105	20	
14/05/2014	52	79	41	30	21	73	25	11
15/05/2014	26	36	20	26	24	70	21	14
24/05/2014		81	59	30	15	34	14	8
28/05/2014	42	57	34	27	31	80	23	15
29/05/2014	52	75	37	28	33	93	28	8
30/05/2014	37	34	25	24	37	87	23	10
2/06/2014	44	57	39	44	28	71	36	8
3/06/2014	29	47	36	30	28	74	22	11
4/06/2014	38	45	34	29	28	97	27	15
5/06/2014	58	45	35	28	48	96	28	12
6/06/2014	38	50	30	24	25	78	22	13
7/06/2014	33	36	35	33	24	90	23	15
8/06/2014	29	39	36	33	23	91	22	20
9/06/2014	23	32	37	28	23	87	22	20
10/06/2014	24	34	40	34	24	88	23	21
12/06/2014	52	52	32	59	30	110	25	21
13/06/2014	66	45	44	81	57	130	97	17
14/06/2014	55	41	35	59	32	93	28	22
16/06/2014	26	22	21	23	19	71	17	11
17/06/2014	18	27	23	25	21	73	18	13
19/06/2014	42	77	62	50	32	76	23	13
21/06/2014	56	87	58	45	27	64	25	11
22/06/2014	73	97	54	35	27	56	24	13
25/06/2014	38	65	27	26	22	109	22	11
28/06/2014	41	32		29	28	75	18	16
30/06/2014	28	28	29	21	25	75	20	12

B.3 STATISTICS OF METALS CONCENTRATION

The following series of tables 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.

Table B-12: Statistics of metal concentrations detected at Richardson Street (µg/m³)

Method	Chromium(III) iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP	Magnesium iMET2HVEXT	Magnesium iMET2HVICP	Sodium iMET2HVICP
Max			0.290	9.90	0.750	1.20	1.40	10.00
99th Percentile			0.085	9.18	0.697	1.10	1.19	9.45
98th Percentile	Below limit of reporting	Below limit of reporting	0.067	8.98	0.426	1.08	1.07	7.38
95th Percentile			0.055	7.46	0.249	0.78	0.82	6.14
50th Percentile			0.007	3.25	0.043	0.25	0.31	1.80
Average			0.017	3.58	0.080	0.33	0.38	2.48
Minimum			0.002	0.5	0.008	0.04	0.11	0.2
Limit of Reporting	0.01	0.01	0.002	0.1	0.001	0.02	0.01	0.1
Number of days metals detected	0	0	96	112	112	112	112	112
Total number of monitoring days	112							

Table B-13: Statistics of metal concentrations detected at Taplin St (µg/m³)

Method	Chromium(III) iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP	Magnesium iMET2HVEXT	Magnesium iMET2HVICP	Sodium iMET2HVICP
Max	Below limit of reporting	0.01	0.016	7.90	0.210	1.00	1.20	8.40
99th Percentile		0.01	0.014	6.05	0.163	0.98	1.10	8.19
98th Percentile		0.01	0.014	5.49	0.106	0.94	1.05	7.08
95th Percentile		0.01	0.011	4.95	0.077	0.70	0.76	5.70
50th Percentile		0.01	0.004	1.40	0.025	0.22	0.27	1.70
Average		0.01	0.005	1.84	0.033	0.29	0.33	2.24
Minimum		0.01	0.002	0.3	0.004	0.04	0.08	0.2
Limit of reporting	0.01	0.01	0.002	0.1	0.001	0.02	0.01	0.1
Number of days metals detected	0	1	82	112	112	112	112	112
Total number of monitoring days	112							

Table B-14: Statistics of metal concentrations detected at BoM (µg/m³)

Method	Chromium(III) iMET2HVICP	Chromium iMET2HVICP	Copper iMET2HVICP	Iron iMET2HVICP	Manganese iMET2HVICP	Magnesium iMET2HVEXT	Magnesium iMET2HVICP	Sodium iMET2HVICP
Max	Below limit of reporting	Below limit of reporting	0.039	3.20	0.200	0.93	1.20	7.90
99th Percentile			0.037	2.89	0.197	0.89	1.09	7.19
98th Percentile			0.036	2.68	0.150	0.86	0.88	6.88
95th Percentile			0.023	2.30	0.134	0.64	0.70	5.30
50th Percentile			0.005	1.20	0.041	0.16	0.25	1.20
Average			0.008	1.26	0.052	0.24	0.31	1.86
Minimum			0.002	0.2	0.006	0.04	0.05	0.2
Limit of reporting	0.01	0.01	0.002	0.1	0.001	0.02	0.01	0.1
Number of days metals detected	0	0	77	107	107	107	107	107
Total number of monitoring days	107							

Table B-15: Statistics of metal concentrations detected at Wedgefield (µg/m³)

	Chromium(III)	Chromium	Copper	Iron	Manganese	Magnesium	Sodium
Method	**iMET2HVICP**	**Cr_iMET2HVICP**	**Cu_iMET2HVICP**	**iMET2HVICP**	**iMET2HVICP**	**iMET2HVICP**	**iMET2HVICP**
Max	0.03	0.03	0.042	16.00	0.480	3.50	8.40
99th Percentile	0.03	0.03	0.035	10.78	0.365	2.29	7.52
98th Percentile	0.03	0.03	0.029	6.49	0.262	1.28	6.68
95th Percentile	0.03	0.03	0.018	5.95	0.190	1.10	5.53
50th Percentile	0.03	0.01	0.008	2.55	0.075	0.49	1.35
Average	0.03	0.02	0.009	3.00	0.094	0.58	1.95
Minimum	0.03	0.01	0.002	0.6	0.014	0.14	0.3
Limit of reporting	0.01	0.01	0.002	0.1	0.001	0.01	0.1
Number of days metals detected	1	3	49	56	56	56	56
Total number of monitoring days				56			

Table B-16: Statistics of metal concentrations detected at Acacia Way (µg/m³)

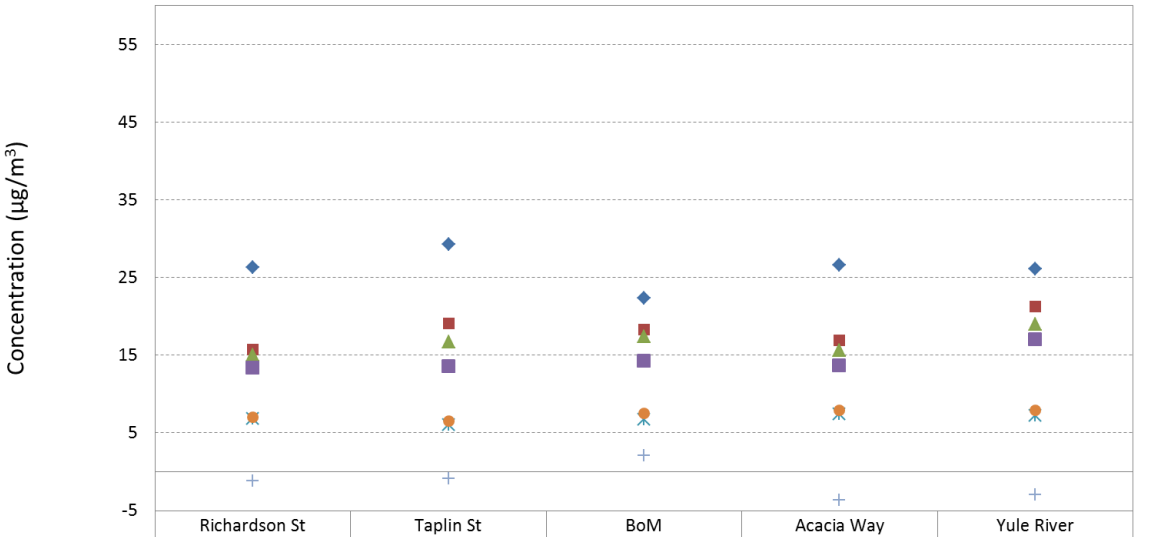
Method	Chromium(III)	Chromium	Copper	Iron	Manganese	Magnesium	Magnesium	Sodium
	iMET2HVICP	**iMET2HVICP**	**iMET2HVICP**	**iMET2HVICP**	**iMET2HVICP**	**iMET2HVEXT**	**iMET2HVICP**	**iMET2HVICP**
Max	Below limit of reporting	Below limit of reporting	0.036	2.60	0.051	0.85	1.40	6.70
99th Percentile			0.024	2.41	0.043	0.85	0.93	6.68
98th Percentile			0.011	1.68	0.038	0.84	0.88	6.32
95th Percentile			0.004	1.45	0.031	0.64	0.72	4.99
50th Percentile			0.003	0.70	0.015	0.16	0.21	1.10
Average			0.004	0.80	0.016	0.23	0.28	1.70
Minimum			0.002	0.2	0.004	0.03	0.05	0.1
Limit of reporting	0.01	0.01	0.002	0.1	0.001	0.02	0.01	0.1
Number of days metals detected	0	0	41	112	112	111	112	112
Total number of monitoring days	112							

Table B-17: Statistics of metal concentrations detected at Yule River (µg/m³)

Analysis Method	Chromium iMET2FCICP	Copper iMET2FCICP	Iron iMET2FCICP	Manganese iMET2FCICP	Magnesium iMET2FCEXT	Magnesium iMET2FCICP	Sodium iMET2FCICP	Sodium iMET2FCEXT
Max	2.200	0.064	0.88	0.012	Below limit of reporting	0.34	4.00	3.10
99th Percentile	2.074	0.064	0.87	0.012		0.34	3.87	3.04
98th Percentile	1.948	0.064	0.86	0.012		0.34	3.74	2.97
95th Percentile	1.570	0.064	0.68	0.012		0.32	2.94	2.78
50th Percentile	0.039	0.060	0.32	0.011		0.17	1.40	1.55
Average	0.421	0.060	0.35	0.011		0.19	1.53	1.63
Minimum	0.010	0.055	0.05	0.010		0.10	0.11	0.90
Limit of reporting	0.005	0.005	0.02	0.005	0.2	0.05	0.05	0.2
Number of days metals detected	19	2	44	5	0	25	45	22
Total number of monitoring days	45							

B.4 STATISTICS OF $PM_{2.5}$ CONCENTRATION

The following table shows the $PM_{2.5}$ concentration statistics recorded at the respective monitoring stations.



	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

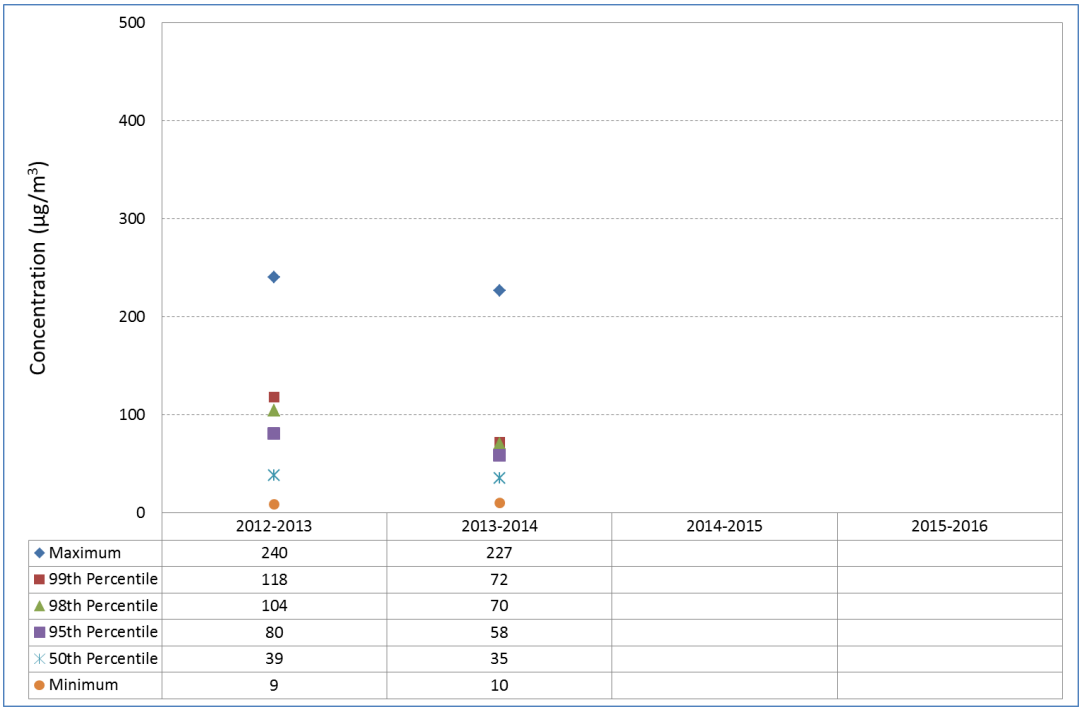
Appendix C ANALYSIS OF AIR QUALITY MONITORING GRAPHS

Appendix C 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:

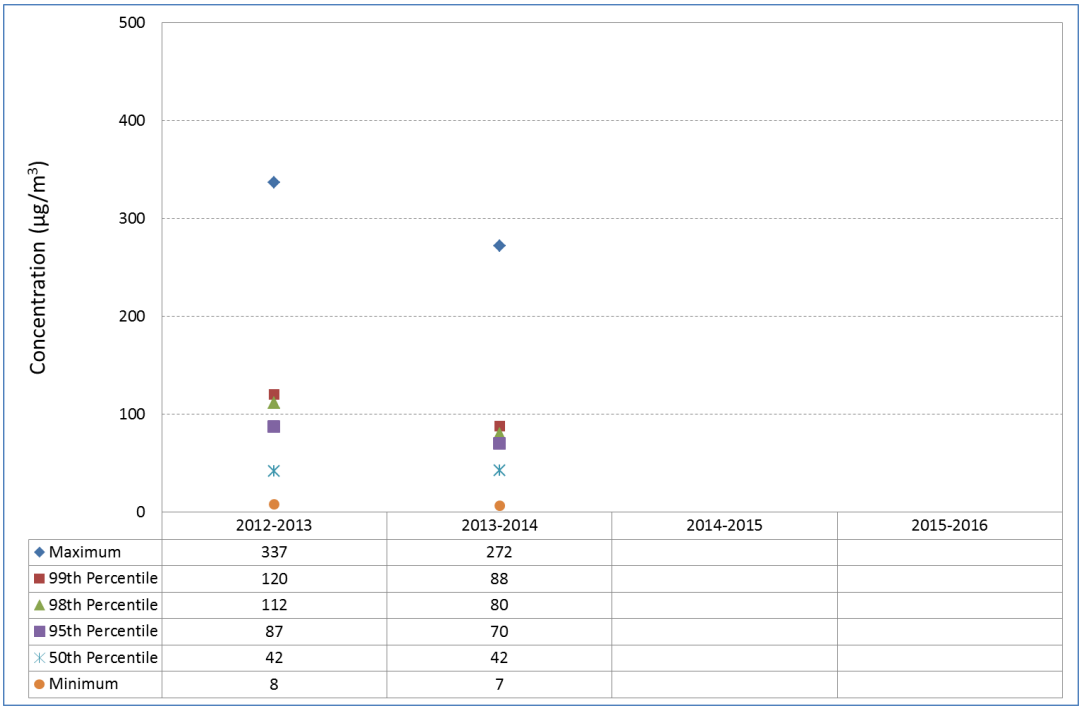
- maximum
- 99th percentile
- 98th percentile
- 95th percentile
- 90th percentile
- 50th percentile
- minimum

C.1 PARTICLES (AS PM_{10})



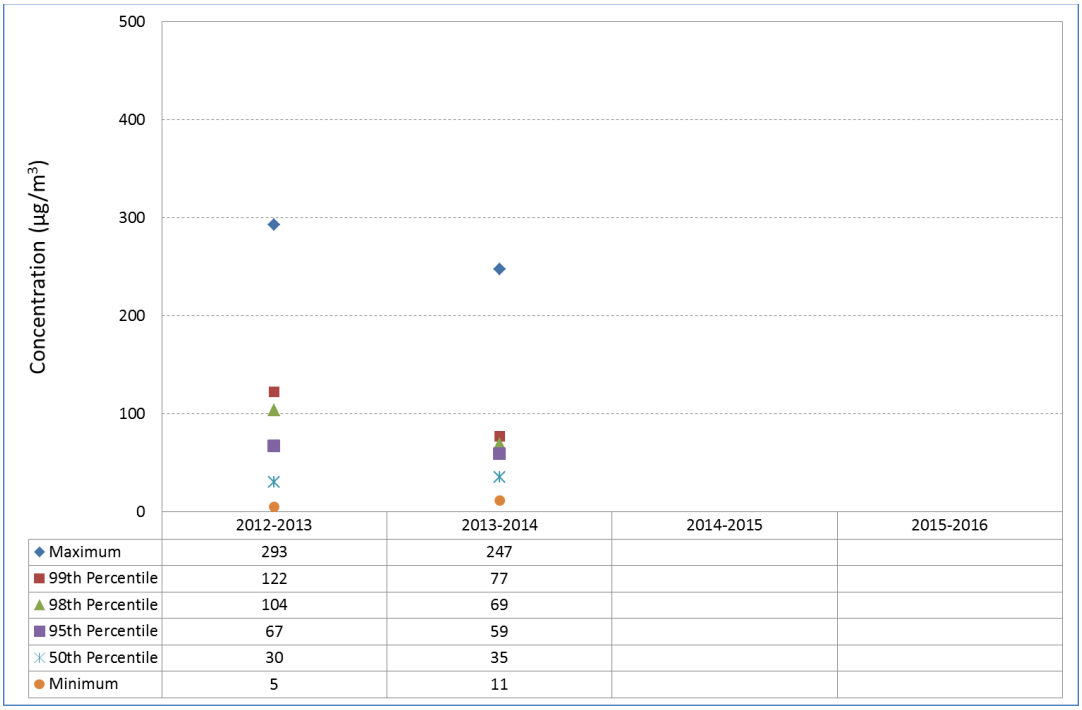
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	240	227		
99th Percentile	118	72		
98th Percentile	104	70		
95th Percentile	80	58		
50th Percentile	39	35		
Minimum	9	10		

Figure 4-1: 24-hour PM_{10} at Richardson Street



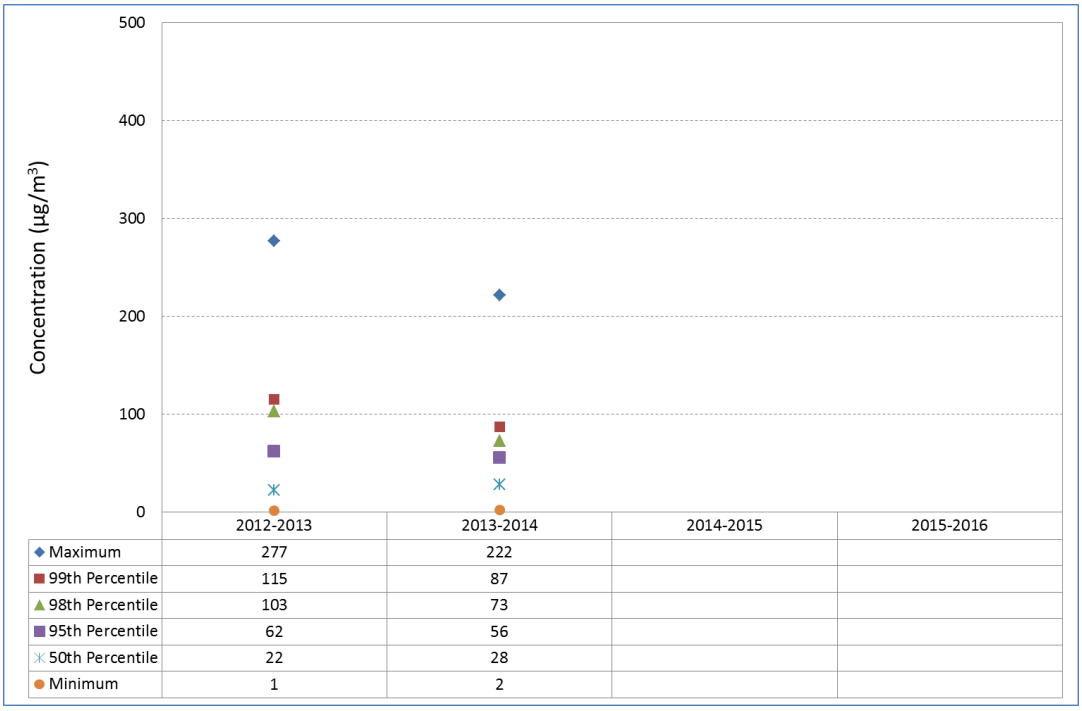
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	337	272		
99th Percentile	120	88		
98th Percentile	112	80		
95th Percentile	87	70		
50th Percentile	42	42		
Minimum	8	7		

Figure 4-2: 24-hour PM_{10} at Kingsmill Street



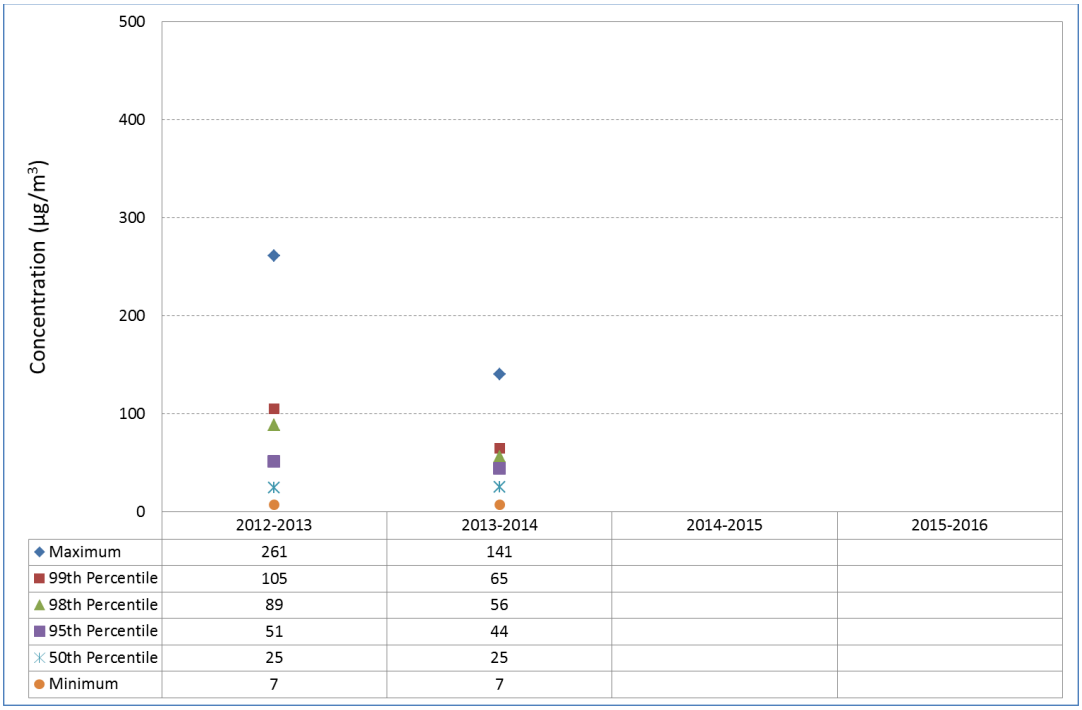
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	293	247		
99th Percentile	122	77		
98th Percentile	104	69		
95th Percentile	67	59		
50th Percentile	30	35		
Minimum	5	11		

Figure 4-3: 24-hour PM_{10} at Taplin Street



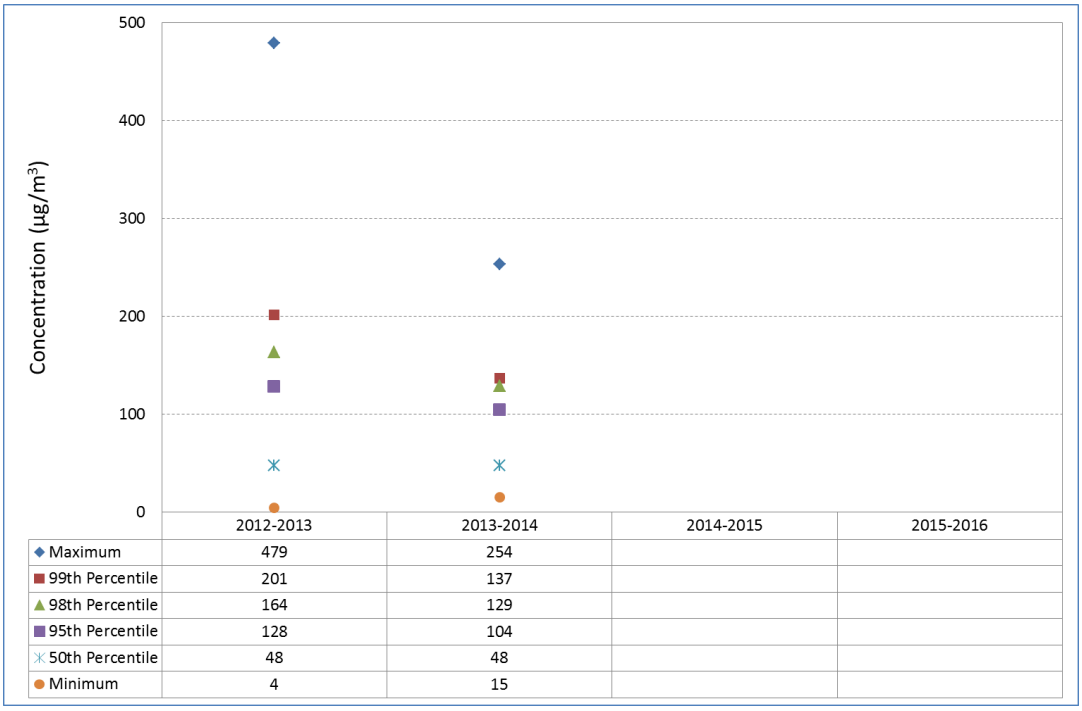
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	277	222		
99th Percentile	115	87		
98th Percentile	103	73		
95th Percentile	62	56		
50th Percentile	22	28		
Minimum	1	2		

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



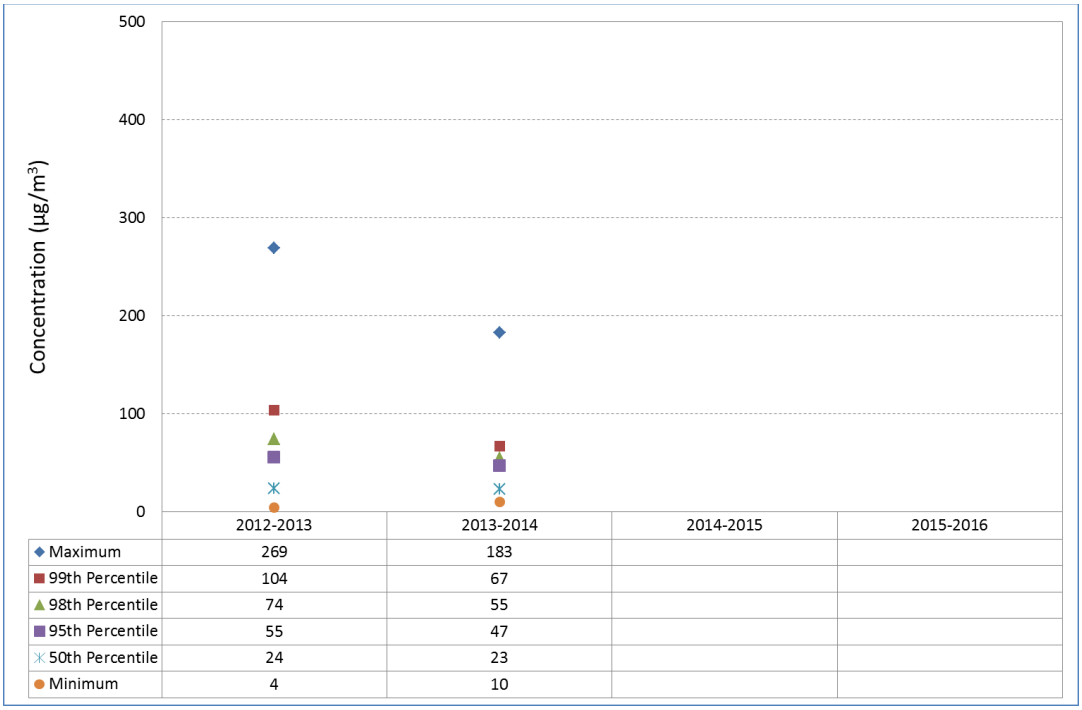
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	261	141		
99th Percentile	105	65		
98th Percentile	89	56		
95th Percentile	51	44		
50th Percentile	25	25		
Minimum	7	7		

Figure 4-5: 24-hour PM_{10} at Bureau of Meteorology



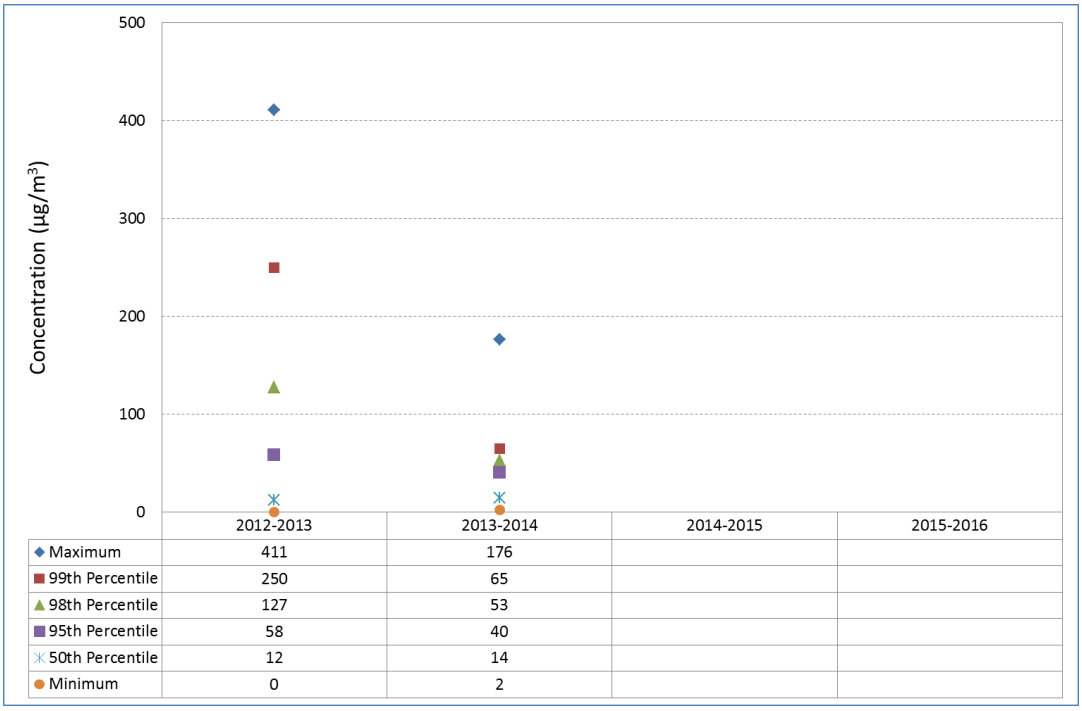
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	479	254		
99th Percentile	201	137		
98th Percentile	164	129		
95th Percentile	128	104		
50th Percentile	48	48		
Minimum	4	15		

Figure 4-6: 24-hour PM_{10} at Wedgefield



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

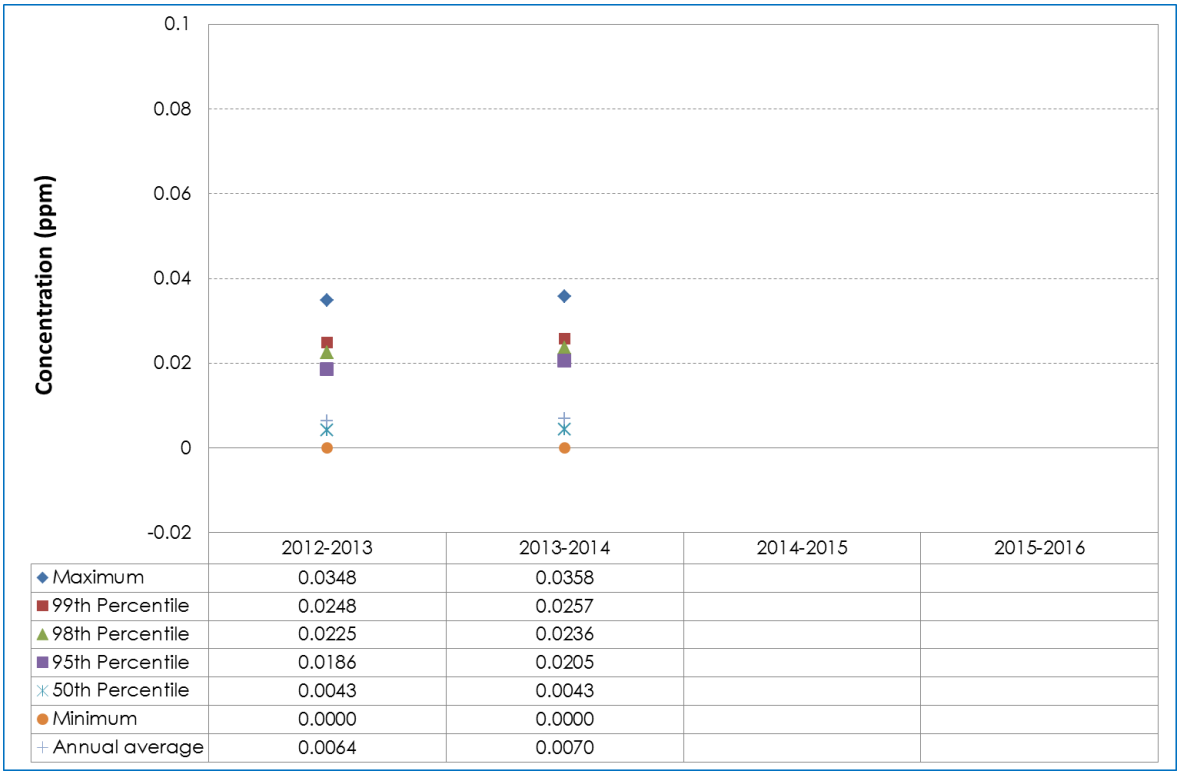
Figure 4-7: 24-hour PM_{10} at Acacia Way



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

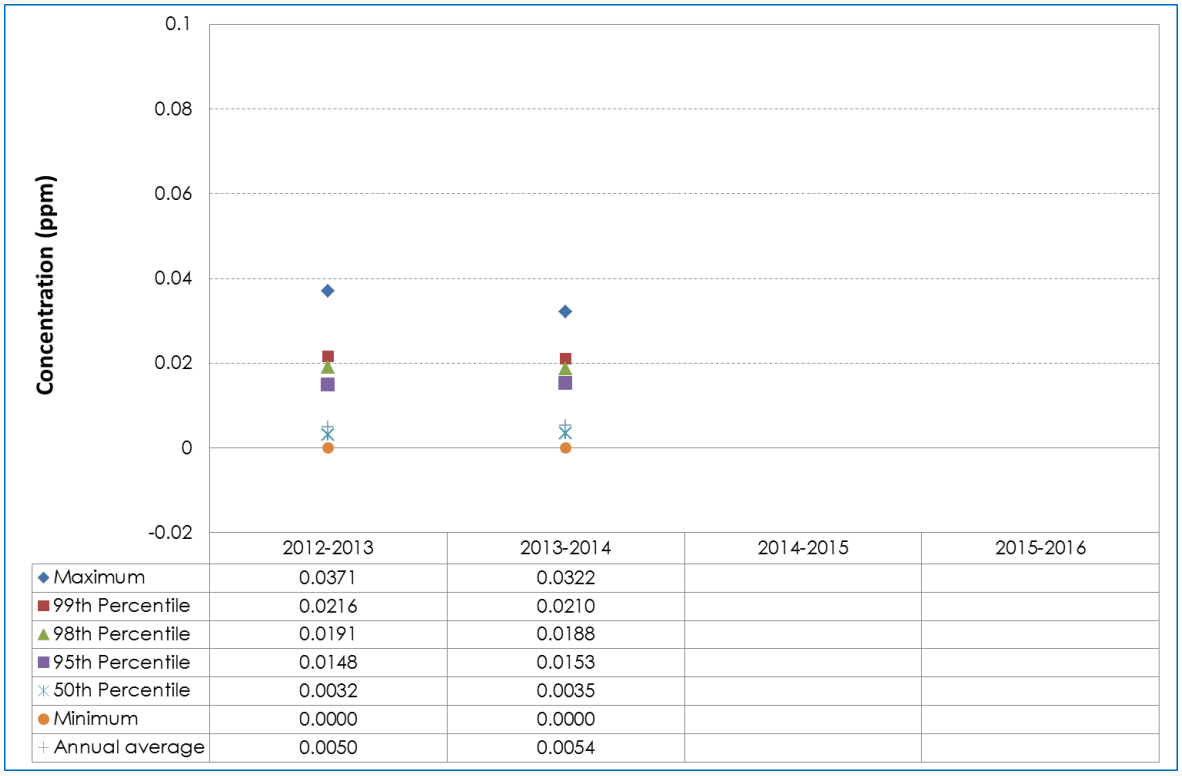
Figure 4-8: 24-hour PM_{10} at Yule River

C.2 NITROGEN DIOXIDE (NO_2)



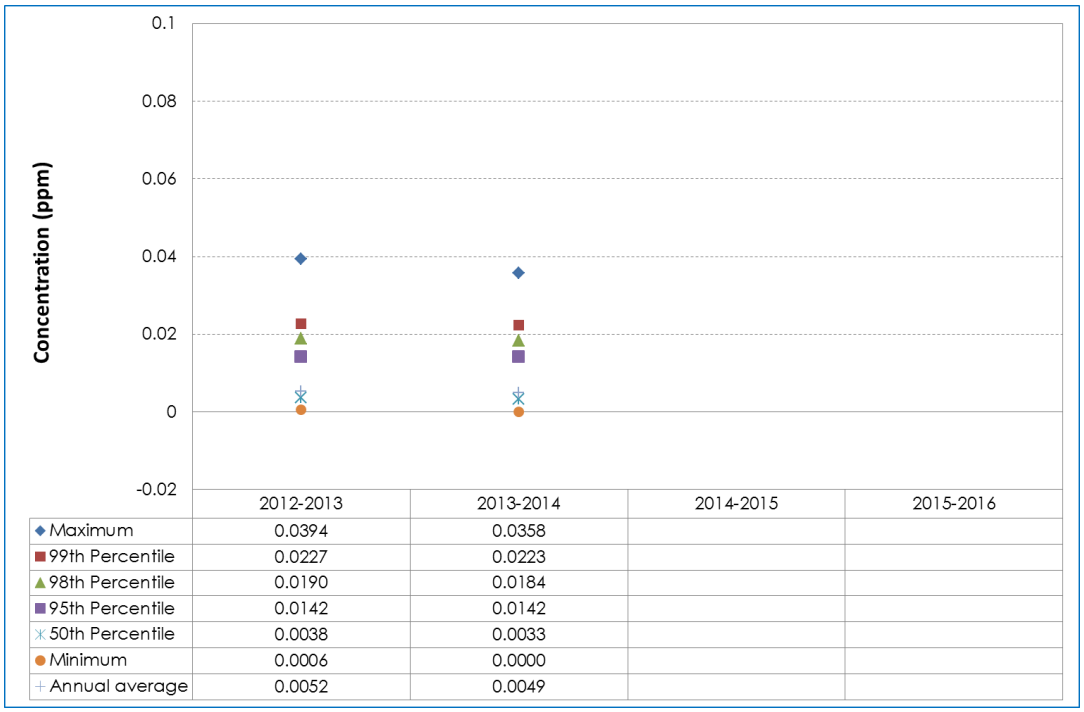
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0348	0.0358		
99th Percentile	0.0248	0.0257		
98th Percentile	0.0225	0.0236		
95th Percentile	0.0186	0.0205		
50th Percentile	0.0043	0.0043		
Minimum	0.0000	0.0000		
Annual average	0.0064	0.0070		

Figure 4-9: 1-hour and annual average of NO_2 at Taplin Street



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

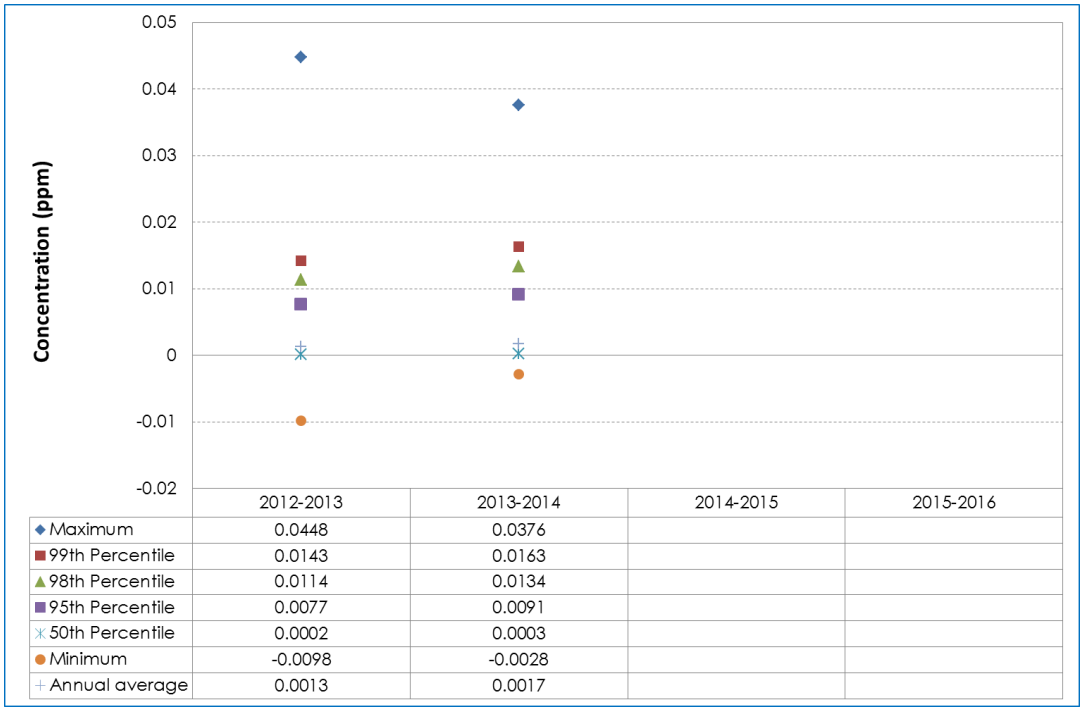
Figure 4-10: 1-hour and annual average of NO_2 at Bureau of Meteorology



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

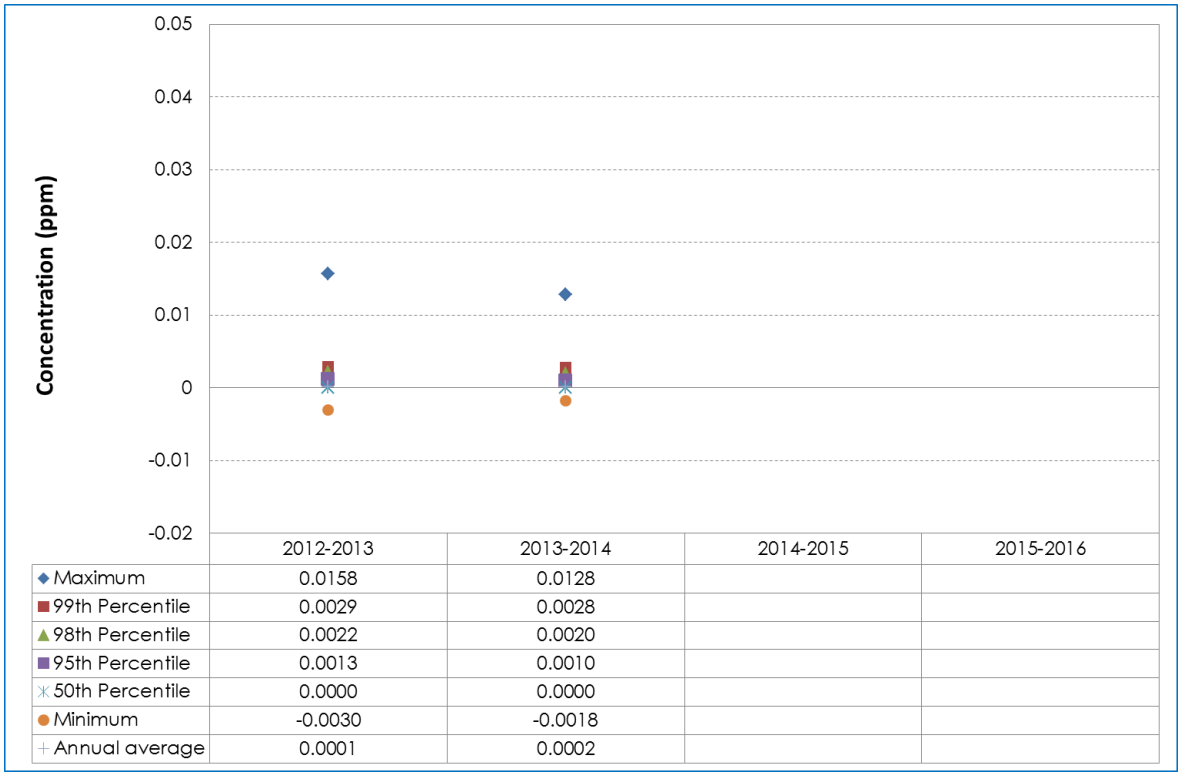
Figure 4-11: 1-hour and annual average of NO_2 at Acacia Way

C.3 SULFUR DIOXIDE (SO_2)



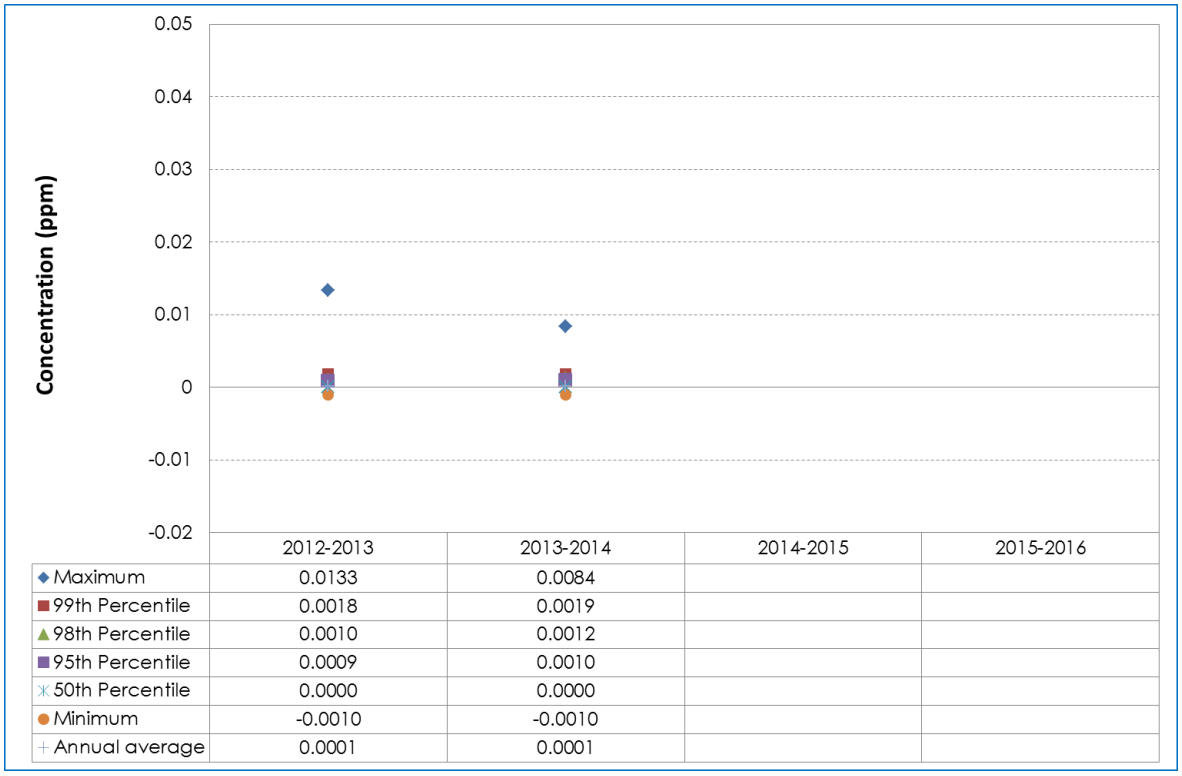
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0448	0.0376		
99th Percentile	0.0143	0.0163		
98th Percentile	0.0114	0.0134		
95th Percentile	0.0077	0.0091		
50th Percentile	0.0002	0.0003		
Minimum	-0.0098	-0.0028		
Annual average	0.0013	0.0017		

Figure 4-12: 1-hour and annual average of SO_2 at Taplin Street



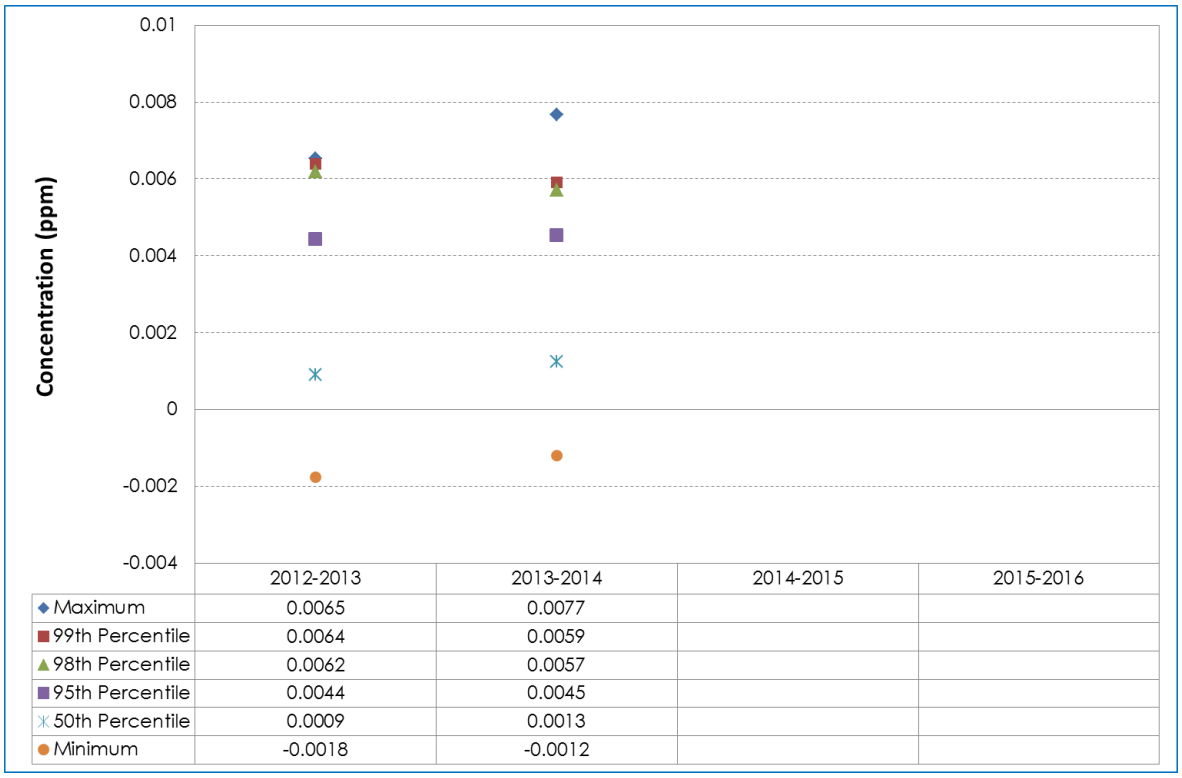
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0158	0.0128		
99th Percentile	0.0029	0.0028		
98th Percentile	0.0022	0.0020		
95th Percentile	0.0013	0.0010		
50th Percentile	0.0000	0.0000		
Minimum	-0.0030	-0.0018		
Annual average	0.0001	0.0002		

Figure 4-13: 1-hour and annual average of SO_2 at Bureau of Meteorology



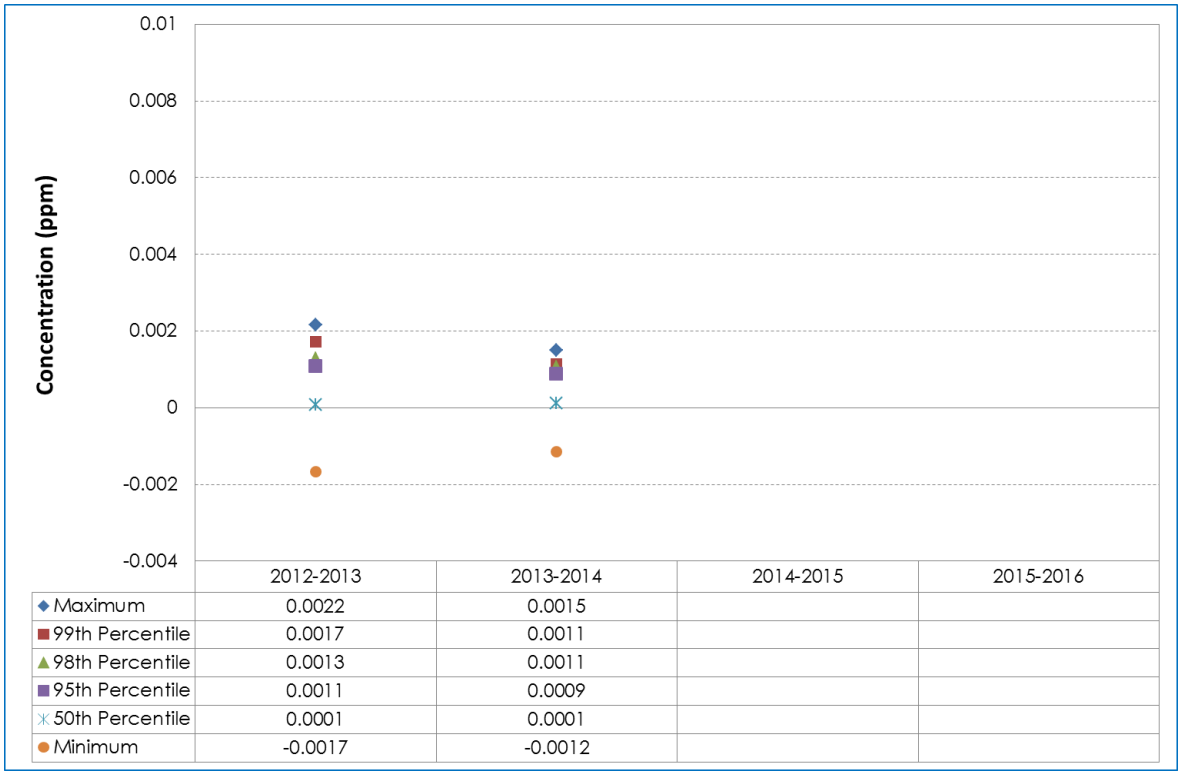
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0133	0.0084		
99th Percentile	0.0018	0.0019		
98th Percentile	0.0010	0.0012		
95th Percentile	0.0009	0.0010		
50th Percentile	0.0000	0.0000		
Minimum	-0.0010	-0.0010		
Annual average	0.0001	0.0001		

Figure 4-14: 1-hour and annual average of SO_2 at Acacia Way



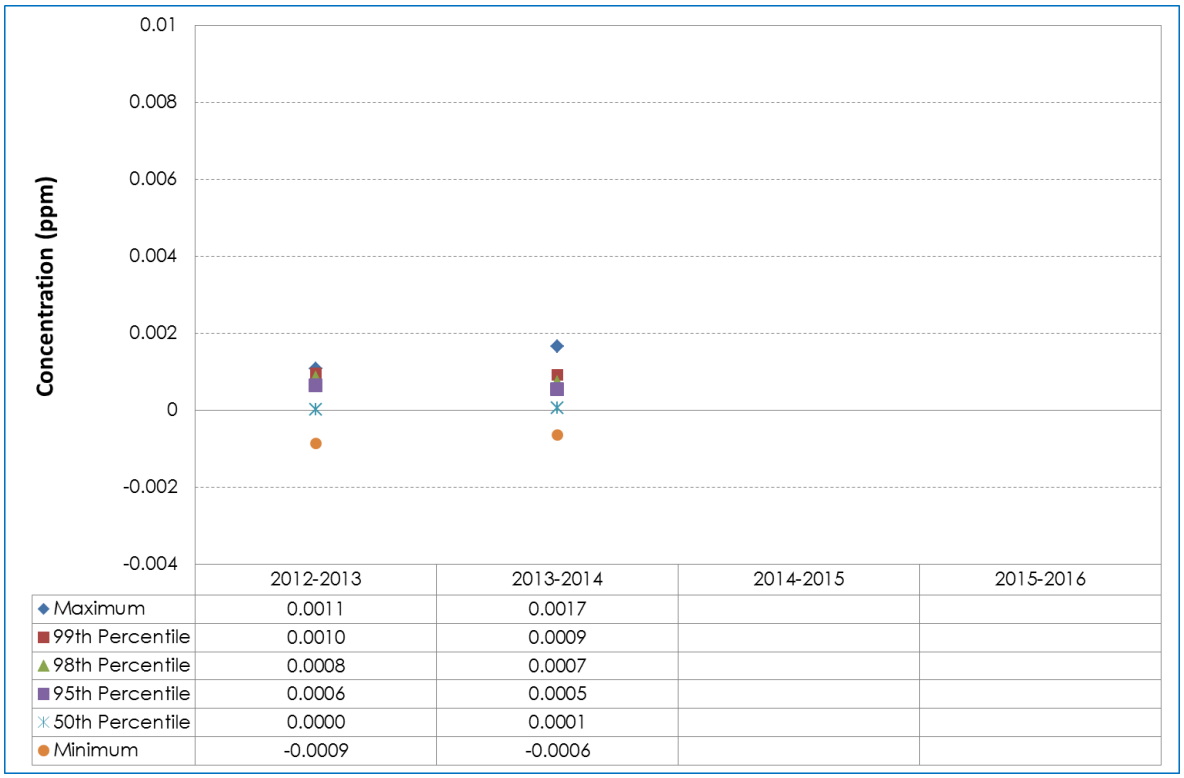
	2012-2013	2013-2014	2014-2015	2015-2016
Maximum	0.0065	0.0077		
99th Percentile	0.0064	0.0059		
98th Percentile	0.0062	0.0057		
95th Percentile	0.0044	0.0045		
50th Percentile	0.0009	0.0013		
Minimum	-0.0018	-0.0012		

Figure 4-15: 24-hour SO_2 at Taplin Street



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

Figure 4-16: 24-hour SO_2 at Bureau of Meteorology



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

Figure 4-17: 24-hour SO_2 at Acacia Way