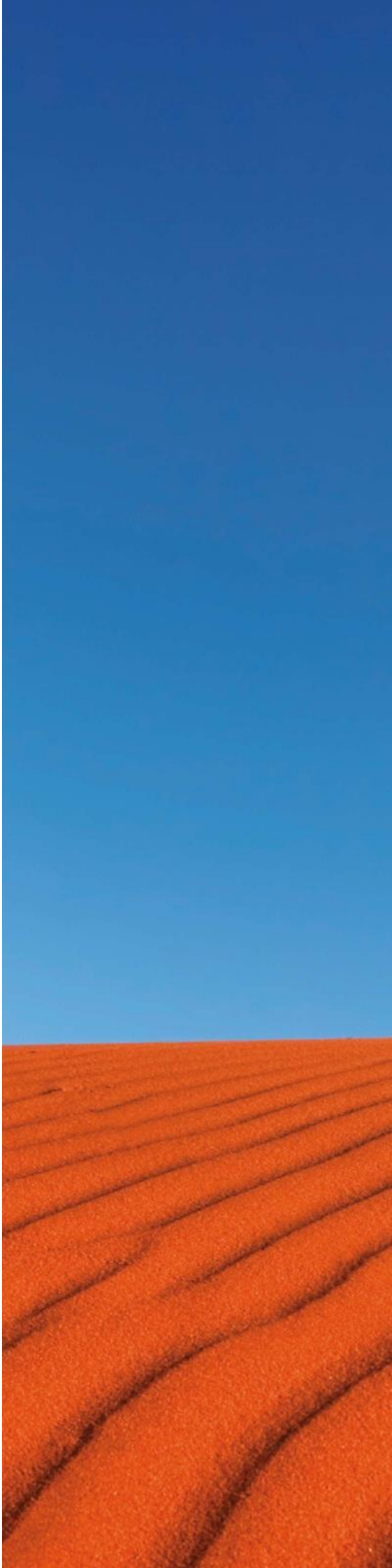
PORT HEDLAND
INDUSTRIES COUNCIL

FY2021/22 Port Hedland Ambient Air Quality Monitoring Program - July/December 2021 Progress Report

FINAL

Port Hedland Industries Council

May 2022



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EXECUTIVE SUMMARY

Port Hedland, a regional town in Western Australia, is home to the world's largest iron ore export port. Air quality, and specifically dust, has been recognised as a significant environmental issue for Port Hedland by the Western Australia Government. Dust can be generated from natural sources (such as the arid landscape of the Pilbara region) and anthropogenic sources (such as urban and industrial development, including the handling and stockpiling of bulk commodities). Dust generation is also influenced by Port Hedland's arid and subtropical climate. The town experiences year-round warm to hot temperatures and low, irregular rainfall.

The Port Hedland Industries Council (PHIC) was founded in 2009 to provide an integrated and coordinated approach to establishing and operating an ambient air quality monitoring network in the Port Hedland region. The PHIC ambient air quality monitoring network was established and operated by PHIC until January 2022, when operational control was passed to the Department of Water and Environmental Regulation (DWER). A memorandum of understanding was developed between PHIC and DWER, where industry will continue to fund the network now that it is operated by DWER. PHIC will continue to support the Port Hedland community through its work as a liaison between industry, regulatory bodies, and the community.

The PHIC ambient air quality monitoring network consists of eight (8) stations distributed across the region. The eight stations measure a combination of PM_{10}, $PM_{2.5}$, meteorological conditions (wind speed, wind direction and temperature) and oxides of nitrogen (reported as NO_2). Data from each station is uploaded to a public website for viewing in real-time (http://www.phic-hedland.com.au/index.php/our-environment/live-monitoring/). This monitoring network was developed by PHIC and data was made available in real-time up to the point of transfer to DWER.

PHIC commissioned Katestone Environmental Pty Ltd (Katestone) to prepare this six-monthly performance report on the Port Hedland ambient air quality monitoring network for FY 2021/22 covering the July to December 2021 period.

A summary of the PHIC ambient air quality monitoring network in FY 2021/22 is provided in the table below.

Monitoring Station	Type	Parameters Measured			
		PM_{10}	$PM_{2.5}$	NO_x	Meteorology [A]
BoM	Background	✓	✓		✓
Kingsmill	Residential	✓			✓
Neptune	Residential	✓			✓
Richardson	Residential	✓	✓		✓
South Hedland	Residential	✓			✓
Taplin	Residential	✓	✓	✓	✓ [B]
Wedgefield	Industrial	✓			✓
Yule	Background	✓	✓		✓

Table Note:

[A] Sites measure wind speed and wind direction unless otherwise specified

[B] Site measures wind speed, wind direction, temperature and relative humidity

This six-monthly progress report presents a summary of the Port Hedland ambient air quality monitoring network performance for the July to December 2021 period. Performance of the monitoring network has been assessed through the following:

- Pollutant concentrations at each monitoring station compared with relevant air quality guidelines and standards, namely:
    - Port Hedland Dust Management Taskforce Dust Management Plan and Department of Water and Environmental Regulation Port Hedland Regulatory Strategy – Air Guideline Value (AGV)

for PM_{10} of 70 µg/m³ (24-hour average) with ten allowable exceedances at Taplin, excluding natural events.

- *National Environmental Protection (Ambient Air Quality) Measure (AAQ NEPM)* standards for PM_{10}, $PM_{2.5}$ and NO_2.

- Data capture for each parameter at each station compared with the PHIC criterion of at least 75% capture on a quarterly and six-monthly basis, in accordance with the AAQ NEPM protocol.

PM_{10}

Analysis of the PM_{10} data found the following:

- The Taplin monitoring station recorded five days above the 24-hour average AGV for PM_{10} of 70 µg/m³ (15 August, 23 October, 28 November, 6 December, and 26 December).
- Detailed analysis of the monitoring data during each exceedance day showed the following:
  - The exceedance at the Taplin site on 15 August 2021 is believed to have likely been the result of local industry and non-industry sources
  - The exceedance events at the Taplin site on 23 October 2021 and 26 December 2021 are believed to have likely been the result of a local industry source
  - The exceedance at the Taplin site on 28 November 2021 is believed to have likely been the result of a regional event as well as a local non-industry source
  - The exceedance at the Taplin site on 6 December 2021 is believed to have likely been the result of local industry and non-industry sources as well as a contribution from a regional event.
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites during the July to December 2021 period. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 1 day at Yule to 76 days at Richardson.
- The number of days above the PM_{10} AAQ NEPM standard at each monitoring station for the six-month July to December 2021 period and for each year since FY 2012/13 have been presented; however, the trend to FY 2021/22 will be more apparent when the full twelve months of data is available for this financial year.
- The six-month average concentrations of PM_{10} for the July to December 2021 period at each site has been presented in this summary report and an assessment to track levels against the annual AAQ NEPM criteria has been carried out using monitoring data from the previous FY 2020/21 period.

$PM_{2.5}$

Analysis of the $PM_{2.5}$ data found the following:

- The 24-hour average concentrations of $PM_{2.5}$ were below the AAQ NEPM standard of 25 µg/m³ at all monitoring stations during the July to December 2021 period.
- The six-month average concentrations of $PM_{2.5}$ for the July to December 2021 period at each site has been presented in this summary report and an assessment to track levels against the annual AAQ NEPM criteria has been carried out using monitoring data from the previous FY 2020/21 period.

NO_2

Analysis of the NO_2 data found that, for the period of available data, the concentrations of NO_2 measured at Taplin during the July to December 2021 period were well below the AAQ NEPM standards. Concentrations were consistent with the NO_2 concentrations measured in previous years.

The six-month average concentrations of NO_2 for the July to December 2021 period at each site has been presented in this summary report and an assessment to track levels against the annual AAQ NEPM criteria has been carried out using monitoring data from the previous FY 2020/21 period.

Data Capture

The Taplin monitoring station achieved a lower data capture rate for NO_X of 72% for the six-month July to December 2021 period which is below the PHIC criterion of 75% data capture. The Taplin site achieved a capture rate of 95% for the October to December quarter; however, ongoing instrument faults and non-scheduled maintenance lowered the capture during the July to September quarter to 48%, below the criterion.

The quarterly and six-monthly data capture criterion of 75% was met for all other pollutants at all monitoring stations during the six-month July to December 2021 period.

1. INTRODUCTION

1.1 Overview

Port Hedland, a regional town in Western Australia, is home to the world's largest iron ore export port. Air quality, and specifically dust, has been recognised as a significant environmental issue in Port Hedland by the Western Australian Government. Dust can be generated by natural sources (such as the arid landscape of the Pilbara region) and anthropogenic sources (such as urban and industrial development, including the handling and stockpiling of bulk commodities by Port users). Dust generation is also influenced by Port Hedland's arid and subtropical climate.

In 2009, at the direction of the WA Premier, the Port Hedland Dust Management Taskforce (the Taskforce) was established to plan for and provide effective air quality (and noise) management strategies in Port Hedland. In parallel with the Taskforce, the Port Hedland Industries Council (PHIC) was formed to provide industry cooperation and a more coordinated approach in considering and addressing environment issues from users of the Port.

In 2010, the Taskforce introduced the *Port Hedland Air Quality and Noise Management Plan (*DSD 2010). Amongst other things, it required PHIC to establish and operate an ambient air quality monitoring network in Port Hedland that included real-time data access for the public and preparation of an annual performance report for review by the Taskforce.

In 2017, the Taskforce released a second report to Government on its recommendations for addressing dust management in Port Hedland, including recommendations for the air quality monitoring network. In 2018, the Government issued a response that included the support of the proposed transfer of full responsibility for operating and maintaining the Port Hedland air quality monitoring network to the Department of Water and Environmental Regulation (DWER). This transfer occurred on 1 January, 2022, thus this is the final report of monitoring network performance under PHIC's operation of the network.

DWER is committed to its responsibility under the State Government-endorsed recommendations of the Taskforce, including developing and implementing a Dust Management Guideline for bulk-handling port premises, and taking over control of the operation and maintenance of the Port Hedland ambient air quality monitoring network. The department's regulatory approach remains the regulation of dust emissions from port operations that are licenced under Part V of the *Environmental Protection Act 1986* (EP Act), while recognising that the air guideline value is applicable to all residential areas in Port Hedland.

In May 2021 the DWER released the *Port Hedland Regulatory Strategy*. This document outlines the approach to addressing the regulatory requirements, including the establishment of the Port Hedlands Dust Program, with short-term (2019-2023) and medium-term (2024-2029) regulatory strategies. A key department recommendation that was adopted by the State Government in October 2018 is the use of an Air Guideline Value (AGV) of 24-hour PM_{10} of 70 µg/m³ with 10 exceedances per year, to be met east of Taplin Street. This AGV applies at locations where people live on a permanent basis and excludes natural events. The 10 exceedances are granted on the grounds that the population of the Port Hedland peninsula not exceed 17,000 people, the modelled population in the Health Risk Assessment. The AGV is applied in the same manner as the National Environmental Protection (Ambient Air Quality) Measure, providing guidance on monitoring population exposure to air pollution through the application of nationally consistent monitoring methods. Exceedances of the measure result in an appropriate and proportionate regulatory response aimed at returning air quality to an acceptable level.

1.2 Scope of Works

PHIC routinely reports on the outcome and performance of the Port Hedland ambient air quality network on a bimonthly and annual basis, consistent with the format approved by the Taskforce. This six-monthly performance report for the July to December 2021 period includes the following information:

- Overview of ambient air quality monitoring network and assessment methods (**Section 2**)
- Summary of Port Hedland meteorology (**Section 3**)
- Ambient air quality monitoring data summary by pollutant (**Section 4**)
- Ambient air quality monitoring data summary by monitoring station (**Section 5**)
- Summary of PM10 trends and progress towards annual performance criteria (**Section 6**)

- Investigation of PM_{10} events (**Section 7**)
- Six-month progress report conclusions (**Section 8**).

2. AMBIENT AIR QUALITY MONITORING NETWORK OVERVIEW AND ASSESSMENT METHODS

2.1 Background

The Port Hedland Air Quality and Noise Management Plan (DSD, 2010) identified the need to establish an 'independent, comprehensive air quality monitoring regime' in Port Hedland. The Taskforce intended that the monitoring regime would provide a basis to measure the performance of industry against relevant targets, and the data would inform and guide future industry and community planning. In 2009 PHIC established an ambient air quality monitoring network in Port Hedland.

The Port Hedland ambient air quality monitoring network locations were independently audited in 2013 (PEL, 2013), in 2016 (PEL, 2016) and again in 2018 (Environmental Technologies and Analytics, 2018) to ensure compliance against the Australian Standard for siting air quality monitoring equipment. The audit of the siting of the equipment found the requirements of the Standard were generally being met.

2.2 Monitoring Network Summary

The Port Hedland ambient air quality monitoring network is comprised of eight (8) stations at strategic locations in the Port Hedland region that measure a combination of PM_{10}, $PM_{2.5}$, oxides of nitrogen (NO_x), and meteorological conditions (wind speed and wind direction).

The Kingsmill Street (Kingsmill), Neptune Place (Neptune), Richardson Street (Richardson) and Taplin Street (Taplin) monitoring stations are sited within residential areas of Port Hedland. The South Hedland monitoring station serves as a generally representative site for the South Hedland township. The Taplin monitoring station has served as a benchmark site for residential areas since the interim standard was first introduced in 2010, thus it forms a key focus of the analysis presented in this report. It should be noted that the Taplin station also monitors temperature and relative humidity in addition to wind speed and wind direction.

The Wedgefield monitoring station is within a light industrial area located between the South Hedland and Port Hedland townships that is classed as either General Industry of Light Industry under the Town of Port Hedland Local Planning Scheme 7. Accommodation in Wedgefield is limited to explicitly permitted caretaker's dwellings only. Consequently, the AGV is not applicable at this monitor.

The Bureau of Meteorology (BoM) station in Port Hedland is relatively distant from the bulk of port related industrial activities and residential populations and serves as a general Port Hedland background monitoring location. The Yule River (Yule) monitoring station is well removed from any industry and populations being some 40 km from Port Hedland and serves as a rural background location. The AGV is also not applicable at the BoM and Yule monitors.

Real time data from each station is made available via a public website (http://www.phic-hedland.com.au/index.php/our-environment/live-monitoring/). Real-time data was made available by PHIC until 1 January 2022; this data is now available from DWER.

A summary and a map of the Port Hedland ambient air quality monitoring network is provided in Table 2-1 and Figure 2-1.

Table 2-1: Summary of Port Hedland ambient air quality monitoring network

Monitoring Station	Latitude	Longitude	Type	Parameter			
				PM_{10}	$PM_{2.5}$	NO_x	Meteorology [B]
BoM	-20.371508°	118.631353	Port Hedland Background	✓	✓		✓
Kingsmill	-20.309717°	118.585187	Residential	✓			✓
Neptune	-20.303910°	118.622836	Residential	✓			✓
Richardson	-20.310221°	118.578037	Residential	✓	✓		✓
South Hedland	-20.407376°	118.607549	Residential	✓			✓
Taplin	-20.309746°	118.599700	Residential	✓	✓	✓	✓ [A]
Wedgefield	-20.370454°	118.584820	Industrial	✓			✓
Yule	-20.595167°	118.296311	Rural Background	✓	✓		✓

Table Note:

[A] Site measures wind speed, wind direction, temperature, and relative humidity

[B] Sites measure wind speed and wind direction unless otherwise specified

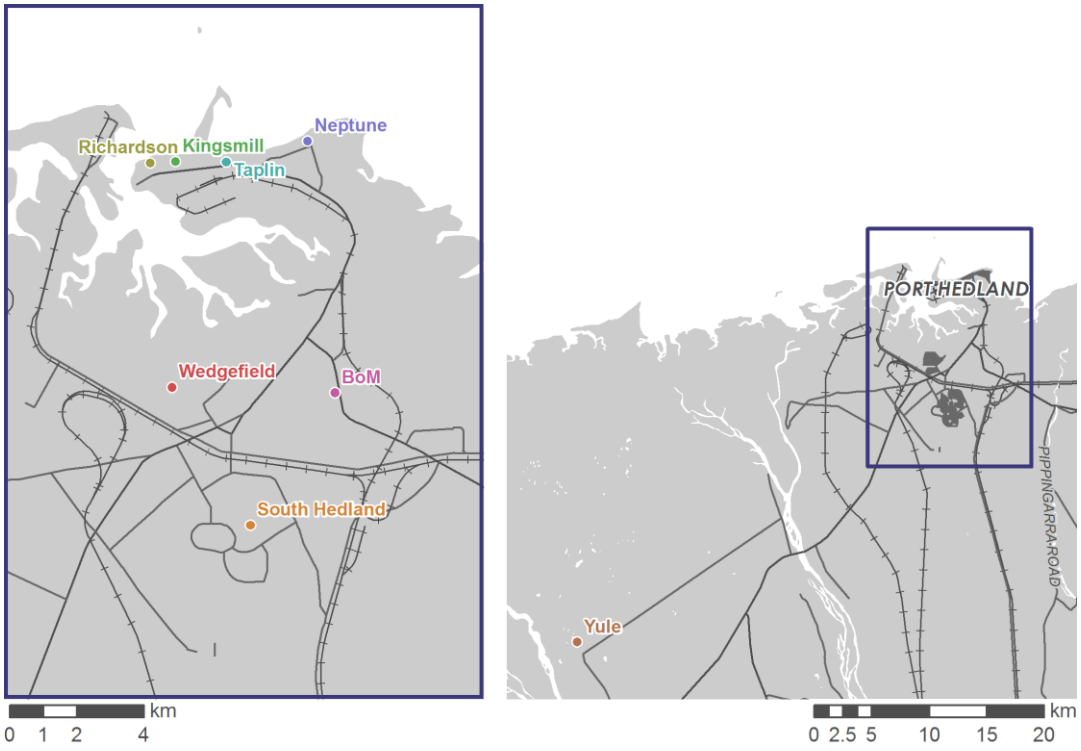

Figure 2-1: Port Hedland Ambient Air Quality Monitoring Network

2.3 Monitoring Methods

The Port Hedland ambient air quality monitoring network is operated and maintained by Ecotech Pty Ltd (Ecotech), an independent third-party contractor. A description of the monitoring methods used at each site to measure PM_{10}, $PM_{2.5}$ and NO_x is provided in Table 2-2.

It should be noted that the Port Hedland BAM1020 monitors are operated in accordance with two monitoring methods. The BAM1020 has both the Australian Standard (AS) accredited beta attenuation method (BAM) for 1-hour average measurement and a real-time module (light scattering method) that measures concentrations of PM_{10}

and $PM_{2.5}$ at sub hourly intervals (used for display on the public website). Ecotech provided both the real-time data and BAM accredited data as 5-minute or 10-minute averages.

To produce the BAM data as 5-minute or 10-minute averages, the monitoring system repeats the 1-hour average BAM measurements across each of the 5-minute or 10-minute time intervals that make up each 1-hour average. For example, if the 1-hour average measured by the BAM was 27 µg/m³, the system would record six 10-minute averages of 27 µg/m³ and assign timestamps to each that span the period represented by the 1-hour average. If a BAM 1-hour average measurement is not obtained or is invalidated, then "-99" is repeated across each of the 5-minute or 10-minute time intervals that make up the relevant 1-hour average.

The investigation of PM_{10} exceedance events (Section 7) was carried out using the raw 10-minute average real-time data. This provided the best resolution to determine the source contribution to each event.

All meteorological parameters including wind speed, wind direction, temperature and relative humidity are recorded and analysed as 10-minute data.

Table 2-2: Port Hedland ambient air quality monitoring network monitoring methods

Parameter	Equipment	Monitoring Method (Australian and New Zealand Standard AS/NZS)	Monitoring Station							
			BoM	Kingsmill	Neptune	Richardson	South Hedland	Taplin	Wedgefield	Yule
PM_{10}	BAM1020	AS/NZS 3580.9.11:2008 & 2016	✓	✓	✓	✓	✓	✓	✓	✓
$PM_{2.5}$	BAM1020	AS/NZS 3580.9.12:2013	✓			✓		✓		✓
NO_x	Ecotech ML9841	AS/NZS 3580.5.1:2011						✓		

2.4 July to December 2021 Activities

The Port Hedland ambient air quality monitoring network activities for the July to December 2021 period are detailed in Table 2-3. The BoM, Kingsmill, Neptune, Richardson, South Hedland, and Yule monitoring stations all achieved monthly capture rates that satisfied the PHIC criterion of 75%. The Taplin site also achieved monthly capture rates for meteorological parameters and particulate matter that satisfied the PHIC criterion of 75%, while the capture rate for NO_X was below the criterion during August and September 2021.

Data capture for NO_X at Taplin was below the PHIC criterion of 75% during August (40%) and September (5%) 2021 due to the following:

- A faulty sampling manifold fan resulted in unrealistic data between 13 August and 10 September that was subsequently removed from the dataset prior to analysis, and non-scheduled maintenance to repair the faulty sampling manifold fan on 10 September
- Non-scheduled maintenance with the NO_X analyser calibrated on 1 September
- Instrument fault with possible leaking in the NO_X analyser between 10 and 29 September, and non-scheduled maintenance to calibrate (27 September) and then replace (29 September) the NO_X analyser.

Data capture for PM_{10} at Wedgefield was below the PHIC criterion of 75% during December 2021 (64%) due to the following:

- Intermittent instrument tape fault between 4 and 15 December, non-scheduled maintenance on 5, 7 and 15 December to have the tape replaced, and non-scheduled maintenance to replace photo sensor on 16 December
- Power interruption followed by instrument stabilisation on 8 and 9 December

- Instrument fault with noisy RTM between 13 and 20 December and non-scheduled maintenance with replacement of RTM unit on 21 December
- Intermittent instrument fault with BAM flow fault between 24 and 30 December.

Table 2-3: FY 2020/21 Port Hedland ambient air quality monitoring network activities

Station	Parameter	Averaging time [A]	Q1			Q2		
			July 21	August 21	September 21	October 21	November 21	December 21
BoM	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓
Kingsmill	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓
Neptune	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓
Richardson	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓
South Hedland	PM_{10}	5-min / 1-hr	✓	✓	✓	✓	✓	✓
	Meteorology	5-min	✓	✓	✓	✓	✓	✓
Taplin	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓
	NO_x	5-min	✓	✓ [B]	✓ [C]	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓
Wedgefield	PM_{10}	5-min / 1-hr	✓	✓	✓	✓	✓	✓ [D]
	Meteorology	10-min	✓	✓	✓	✓	✓	✓
Yule	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓

Table Note:

✓ Shaded and ticked cells indicate a complete month of data for the stated parameter (i.e. greater than 75% PHIC criterion). Unshaded ticked cells indicate a partially complete month for that parameter. The table note indicates the extent to which data is missing. Unticked, unshaded cells indicate that no data was collected in the month.

[A] All Port Hedland BAM1020 monitors for PM_{10} and $PM_{2.5}$ are equipped with a real-time module. Therefore, averaging periods for these monitors are 1-hour (AS/NZS method) and 10-minute or 5-minute (real time module)

[B] Data capture for NO_x at Taplin was 39.9% during August as a result of a faulty sampling manifold fan between 13 August and 10 September.

[C] Data capture for NO_x at Taplin was 4.7% during September as a result of the faulty sampling manifold fan between 13 August and 10 September, non-scheduled maintenance to repair the manifold fan on 10 September, instrument fault with the NO_x analyser between 10 and 29 September, and non scheduled maintenance to calibrate and replace the NO_x analyser on 27 and 29 September

[D] Data capture for PM_{10} at Wedgefield was 64% during December as a result of intermittent instrument faults, power interruption and non-scheduled maintenance

2.5 Data Processing

The July to December 2021 Port Hedland ambient air quality monitoring network data was processed and analysed in accordance with the following procedures and documents:

- PHIC data handling procedure (approved by DER[a]).
- National Environment Protection (Ambient Air Quality) Measure Technical Paper No.5. Data Collection and Handling, Peer Review Committee (PRC, 2001).
- National Environment Protection (Ambient Air Quality) Measure. Technical Paper No.8. Annual Reports, PRC 2002 Peer Review Committee (PRC, 2002).

The process for data quality assurance and analysis was as follows:

- Quality assured Port Hedland monitoring data was supplied by Ecotech for each site, as either 5-minute or 10-minute averaged data, depending on the site/parameter (see Table 2-3).
- For the stations using a BAM1020, two sets of data were provided: one set being the raw real-time data that was displayed on the public website and the second set (beta data) being the BAM1020 measurements reported as 5-minute or 10-minute averages (see Section 2.3). Unless specifically stated, only the beta data is considered in this report as it is in accordance with the AS method.
- Further quality assurance was performed by Katestone that included:
    - ensuring data fell within acceptable ranges (e.g. wind directions between 0° and 360°)
    - checking for outliers and inconsistencies
    - checking for abnormal patterns
    - checking that the BAM1020 and light scattering datasets (real-time and beta data) showed good correlation.
- The quality assurance checks conducted by Katestone found that all July to December 2021 data was acceptable for final processing.

Final processing included the following steps:

- All 1-hour average data were combined into a single file.
- The light scattering data were separated from the 1-hour data and not analysed unless required to investigate elevated events.
- Data capture rates from all stations and air pollutants was calculated from the 1-hour average dataset and compared with the data capture performance criterion (see Section 3.2.1).
- A 24-hour average dataset (midnight to midnight) was created from the 1-hour average dataset under the PRC protocol requirement of a minimum 75% data capture, that is eighteen (18) 1-hour readings per day are required for a valid 24-hour average.
- Statistical analysis on the valid 1-hour and 24-hour average datasets was conducted and produced the following:
    - Maximum values
    - Mean value
    - Percentiles
    - Number of exceedances of relevant air pollutant standards and guidelines
    - Time series graphs
    - Wind roses
    - Pollution polar plots.

If, in any calendar day, the concentration of PM_{10} is found to be above the AGV of 70 µg/m³ at the Taplin monitoring station, the event is investigated further through the examination of wind roses, PM_{10} polar plots and time series plots. There were five days during the July to December 2021 period when the Taplin monitoring station recorded a 24-hour average concentration of PM_{10} above the AGV of 70 µg/m³. Further analysis of these event days are provided in Section 7.

[a] Known as Department of Environment Regulation (DER) at the time of approval.

The standard routine bimonthly analysis of the air quality monitoring network data includes an investigation of event days at the Kingsmill, Richardson, and Neptune monitoring stations. The methodology that was developed for Taplin is applied to the investigation of event days where the AGV of 70 µg/m^3 is exceeded, to monitor site performance at these sites. Event days at Kingsmill, Richardson and Neptune are discussed in Section 7.

Data visualisations that were used to analyse and present PHIC data were produced using the statistical software: R (R Core Team, 2016) and the R-packages Openair (Carslaw and Ropkins, 2012 and Carslaw, 2015), GGPlot2 (Wickham, 2009) and Cowplot (Wilke, 2016).

2.6 Network Performance

Network performance (Section 4) is recorded against the data capture rate and air quality guidelines and standards as:

- Met
- Not met
- Not demonstrated (as a result of inadequate data recovery or data quality).

2.7 Data Capture Rate

The network performance for data capture rate for each air pollutant is based on the PRC protocol requiring at least 75% data capture in each calendar quarter in addition to an annual data availability of at least 75%. Performance criteria is based on 1-hour average data.

2.8 Air Quality Guidelines and Standards

Air quality guidelines and standards for the pollutants measured by the Port Hedland ambient air quality network (PM_{10}, $PM_{2.5}$ and NO_x) that have been used to determine performance of the July to December 2021 monitoring data have been selected from local and federal legislation.

In 2010, the Taskforce specified a 24-hour average interim guideline for PM_{10} in its Port Hedland Air Quality and Noise Management Plan (DSD, 2010). In May 2021, the State Government released the Port Hedland Regulatory Strategy. The guideline for PM_{10}, adopted by the state government as an AGV in 2018, is defined as follows:

- Maximum concentration of 70 µg/m^3 for a 24-hour average
- Ten exceedance events per calendar year due to industry as measured at Taplin Street, on the understanding that the overall population for the Port Hedland peninsula does not exceed 17,000 (the modelled population in the Health Risk Assessment)
- Applies to residential areas where people live on a permanent basis in Port Hedland
- Appropriate action is to be caried out to understand the cause of exceedance events.
- No limit on exceedances solely as a result of natural events as per the application of the National Environmental Protection (Ambient Air Quality) Measure, with natural events defined as bushfires, jurisdiction authorised hazard reduction burning, or continental-scale windblown dust.
- Exceedances of the measure are to result in an appropriate and proportionate regulatory response aimed at returning air quality to an acceptable level, with an appropriate and proportionate response including ensuring that licensed premises ensure compliance with licence conditions relating to dust management.

At the federal level, the National Environment Protection Council (NEPC) set air quality standards under the AAQ NEPM for criteria pollutants, which includes PM_{10}, $PM_{2.5}$ and NO_2. These standards were updated and adopted on 18 May 2021. These are defined as follows:

- Maximum concentration of 50 µg/m^3 for 24-hour average concentration of PM_{10}
- Maximum concentration of 25 µg/m^3 for annual average concentration of PM_{10}
- Maximum concentration of 25 µg/m^3 for 24-hour average concentration of $PM_{2.5}$
- Maximum concentration of 8 µg/m^3 for annual average concentration of $PM_{2.5}$
- Maximum concentration of 164 µg/m^3 for 1-hour average concentration of NO_2
- Maximum concentration of 31 µg/m^3 for annual average concentration of NO_2.

The NEPM requires that all measured data must be reported including data associated with an exceptional event. An exceptional event is defined as being "directly related to bushfire, jurisdiction authorised hazard reduction burning, or continental scale windblown dust. However, data associated with exceptional events is to be excluded when determining compliance.

Relevant air quality standards and guidelines used to determine network performance are detailed in Table 2-4.

Table 2-4: FY 2020/21 Port Hedland ambient air quality monitoring network activities

Pollutant	Averaging Period	Standard / Guideline (µg/m³)	Source
PM_{10}	24-hour	70 [A, B]	AGV DWER 2021
	24-hour	50	AAQ NEPM 2021
	Annual	25	
$PM_{2.5}$	24-hour	25	AAQ NEPM 2021
	Annual	8	
NO_2	1-hour	164 [C]	AAQ NEPM 2021
	Annual	31 [C]	

Table note:
[A] Ten exceedance days allowed per year due to industry as measured at Taplin, excluding natural events
[B] Applies to residential areas (Richardson, Kingsmill, South Headland, Taplin, and Neptune)
[C] Calculated at 25 ºC

3. SUMMARY OF JULY-DECEMBER 2021 METEOROLOGICAL CONDITIONS

The focus of this six-monthly report is the analysis of air pollutants measured by the Port Hedland ambient air quality monitoring network. However, meteorological conditions play an important role in the dispersion (and emission generation in the case of dust) of air pollutants in the Port Hedland region.

Exposed dust sources (be it from industry sources, other anthropogenic sources or natural sources) will have higher dust emissions during dry conditions and strong winds. The dust emissions will also have a greater radius of impact during periods of stronger wind speeds due to dust remaining suspended in the air for longer periods and therefore being carried further distances. The variability in the wind speed and wind direction in Port Hedland will result in variation of dust emissions and in the areas potentially affected by dust.

A graphical summary (in the form of wind roses) of the 10-minute average meteorological data collected at BoM, Taplin and Yule during the July to December 2021 period are provided in Figure 3-1, Figure 3-2 and Figure 3-3, respectively. A wind rose is a tool used to illustrate the frequency and intensity of a given wind speed and its direction. Wind speeds (metres per second) are grouped based on the data range (for each site) and wind directions are grouped into sixteen 22.5-degree sectors that represent all possible wind directions.

The wind roses at BoM, Taplin and Yule indicate the following:

- The distribution of winds shown in Figure 3-1, Figure 3-2 and Figure 3-3 are typical of the Port Hedland region and its location on the WA coastline.
- The predominant wind directions at all three sites during the July to December 2021 period are the northwest (west to northwest) and southeast (east-southeast to south) quadrants.
- Winds from the southwest quadrant are less common but do occur on occasion at all sites, while minimal winds occurred from the northeast quadrant during the July to December period.
- Wind speeds measured at all three monitoring stations are relatively strong (important for dust generation and dispersion) with six-month average wind speeds of 5.0 m/s, 3.0 m/s and 2.8 m/s at BoM, Taplin, and Yule, respectively.
- Wind speeds are highest at BoM due to the exposed nature of the BoM monitoring station near Port Hedland Airport.

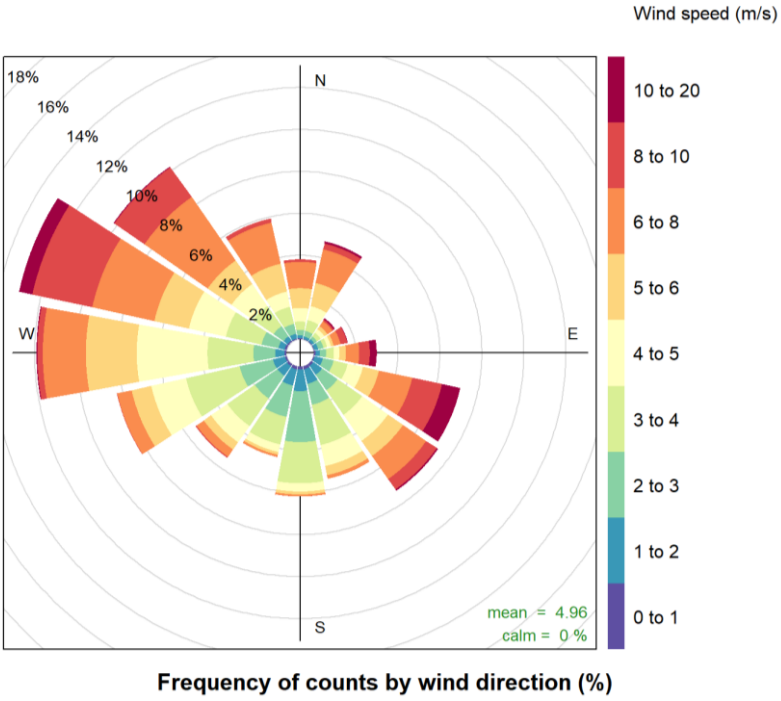

Figure 3-1: July to December 2021 six-month wind rose for BOM

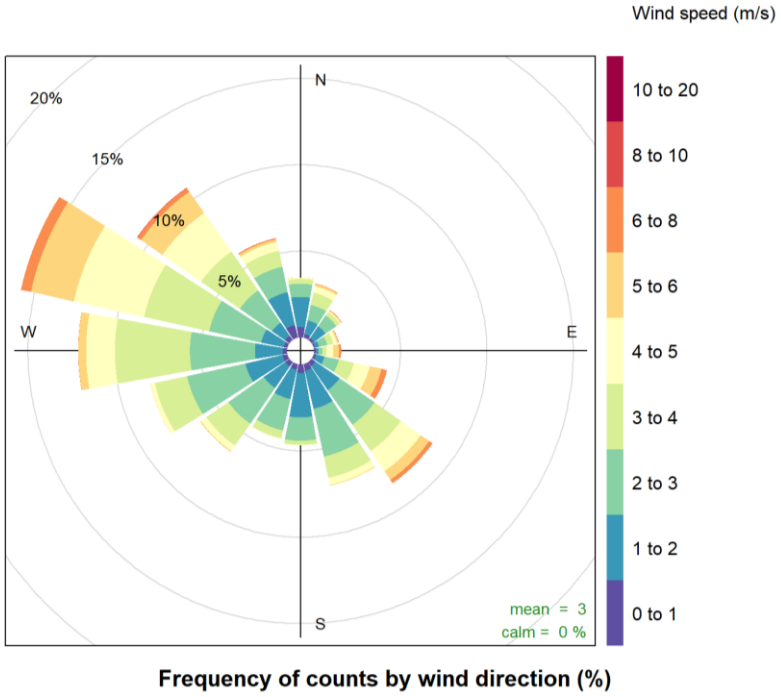

Figure 3-2: July to December 2021 six-month wind rose for Taplin

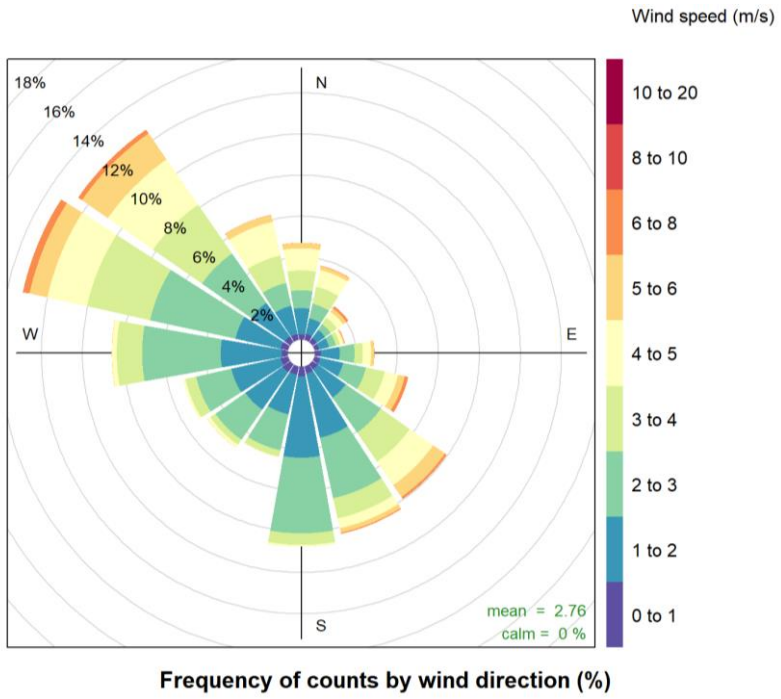

Figure 3-3: July to December 2021 six-month wind rose for Yule

3.1 Tropical Climate Discussion

A pulse of the Madden-Julian Oscillation (MJO) moved across the Indian Ocean (west-east) during the second half of August. However, it weakened prior to reaching Australia and had no discernable effect on rainfall. Pulses occurred every 2-3 weeks from spring through summer, moving from the Indian Ocean to the Maritime Continent.

The Indian Ocean Dipole (IOD) was negative from August to November 2021, when it shifted to neutral. This is typical of its annual pattern.

The Pacific Ocean cooled through November, and a La Niña was declared in December 2021.

Locally, rainfall has been much lower than the 1948 – 2021 average for the July-December period. The period of August – November is typically the driest of the year, but the Port Hedland area has received much less rain than typically occurs. The month with the highest percentage of rain (as compared to average), was September, which received 50% of the climatological average rainfall (1.2 mm expected, 0.6 mm observed). The most rain fell in December, which received 3.4 mm of rain in the month.

In terms of temperature, mean maxima during the July-December period was close to average, with the exception of December. The winter was slightly warmer than average (maximum difference of +2.1 ºC in July), while spring was slightly cooler than average (maximum difference of -0.7 ºC in October). December was significantly warmer than average, with a mean maximum of 40.3 ºC in December compared to the climatological average of 36.7 ºC.

Overall, this extended dry period with average to above-average temperatures in the approach to the wet season may have contributed to increased dustiness in the region.

4. SUMMARY OF AIR QUALITY MONITORING DATA

The following section describes the performance of each pollutant measured by the Port Hedland ambient air quality monitoring network through data capture and comparison of measurements against relevant air quality standards and guidelines.

4.1 PM_{10}

PM_{10} was measured at all eight (8) monitoring stations during the July to December 2021 period.

4.1.1 Data Capture

Data capture rates for 1-hour average concentrations of PM_{10} for each monitoring station during the July to December 2021 period are detailed in Table 4-1. All stations achieved a six-month capture rate for PM_{10} of greater than 92%, meeting the PHIC criterion of 75% data capture. All sites also achieved quarterly capture rates greater than 86%, satisfying the PHIC criterion of 75% data capture. Data capture for PM_{10} at Wedgefield was 86% during Q2 as a result of intermittent instrument faults, power interruption and non-scheduled maintenance during December 2021.

Table 4-1: July to December 2021 Data Capture Summary 1-hour average concentration of PM_{10}

Monitoring Station	PM_{10} Data Capture Rate (%)			Performance
	Q1	Q2	Six-monthly	
BoM	99.8	99.5	99.6	Met
Kingsmill	98.8	99.8	99.3	Met
Neptune	99.8	99.1	99.5	Met
Richardson	98.6	99.7	99.2	Met
South Hedland	98.2	98.8	98.5	Met
Taplin	98.7	99.1	98.9	Met
Wedgefield	98.8	86.0	92.4	Met
Yule	99.1	98.1	98.6	Met

4.1.2 Comparison to Air Quality Standards and Guideline

The maximum measured 24-hour average concentration of PM_{10} (calculated as midnight to midnight) and the number of days above the 24-hour average AAQ NEPM standard and AGV for each station are detailed in Table 4-2. The average concentration of PM_{10} for the six-monthly July to December 2021 period for each station is detailed in Table 4-2.

To assess the progress of the average PM_{10} concentration against the annual performance criteria, the July to December 2021 six-month average concentration has been compared to the six-month average from the previous July to December period (2020) as well as the average from the full July 2020 to June 2021 financial year period. This data is presented in Table 4-3.

The measurements of 24-hour average PM_{10} show that for the July to December 2021 period:

- The Taplin monitoring station recorded five days above the 24-hour average AGV for PM_{10} of 70 µg/m³ (15 August, 23 October, 28 November, 6 December, and 26 December).
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites during the July to December 2021 period. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 1 day at Yule to 76 days at Richardson.

With regards to the six-month July to December 2021 average concentration of PM_{10}:

- Data from the previous year shows that concentrations decreased during the second six months of the financial year, with the annual average concentration lower than the six-month July to December average

across all 8 monitoring sites.

- The six-month average concentration of PM_{10} is above 30 µg/m³ at the Kingsmill, Richardson, Taplin, and Wedgefield monitoring sites.
- The six-month average concentration of PM_{10} is between 20 µg/m³ and 30 µg/m³ at the BoM, Neptune, and South Hedland monitoring sites.
- The six-month average concentration of PM_{10} is below 20 µg/m³ at the Yule monitoring site.

Table 4-2: July to December 2021 data summary average concentrations of PM_{10}

Monitoring Station ID	24-hour average					Six-monthly average concentration of PM_{10} (µg/m³)
	Maximum 24-hour average concentration of PM_{10} (µg/m³)	Number of days >50 µg/m³ (AAQ NEPM)	Performance (AAQ NEPM)	Number of days >70 µg/m³ (AGV) [A]	Performance (AGV)	
BoM	93.4	7	Not met	NA [C]	NA [C]	30.0
Kingsmill	128.7	59	Not met	13	NA [B]	44.5
Neptune	66.9	12	Not met	0	NA [B]	27.3
Richardson	148.9	76	Not met	21	NA [B]	50.2
South Hedland	62.8	3	Not met	0	NA [B]	22.3
Taplin	89.0	29	Not met	5	Met (as per analysis in Section 7) [B]	36.7
Wedgefield	182.6	55	Not met	NA [C]	NA [C]	48.3
Yule	82.9	1	Not met	NA [C]	NA [C]	16.2

Table note:
[A] Applies to residential areas (Richardson, Kingsmill, South Headland, Taplin, and Neptune)
[B] Ten exceedance days allowed per year due to industry as measured at sites east of Taplin, excluding natural events
[C] AGV does not apply at Port (BoM and Wedgefield) or background (Yule) monitors
[D] Assessment of performance against AGV not applied at sites other than Taplin

Table 4-3: July to December 2021 PM_{10} data tracking summary

Monitoring Station ID	Six-month average July to December 2021 concentration of PM_{10} (µg/m³)	Six-month average July to December 2020 concentration of PM_{10} (µg/m³)	Annual average FY 2020/21 concentration of PM_{10} (µg/m³)	Performance criteria (µg/m³) [A]
BoM	30.0	28.2	25.5	25
Kingsmill	44.5	44.6	38.3	
Neptune	27.3	25.1	21.6	
Richardson	50.2	46.1	40.7	
South Hedland	22.3	24.7	20.6	
Taplin	36.7	35.4	29.8	
Wedgefield	48.3	45.7	42.7	
Yule	16.2	21.0	16.4	

Table note:
[A] No criteria for six month average. Annual average AAQ NEPM standard is 25 µg/m³.

4.1.3 PM_{10} Timeseries Analysis

Timeseries plots of the 24-hour average concentrations of PM_{10} for the July to December 2021 period for each monitoring station are shown in Figure 4-1. The timeseries plot for Taplin monitoring station shows that the 24-hour average concentration of PM_{10} was above the AGV of 70 µg/m³ on five occasions during the July to December 2021 period.

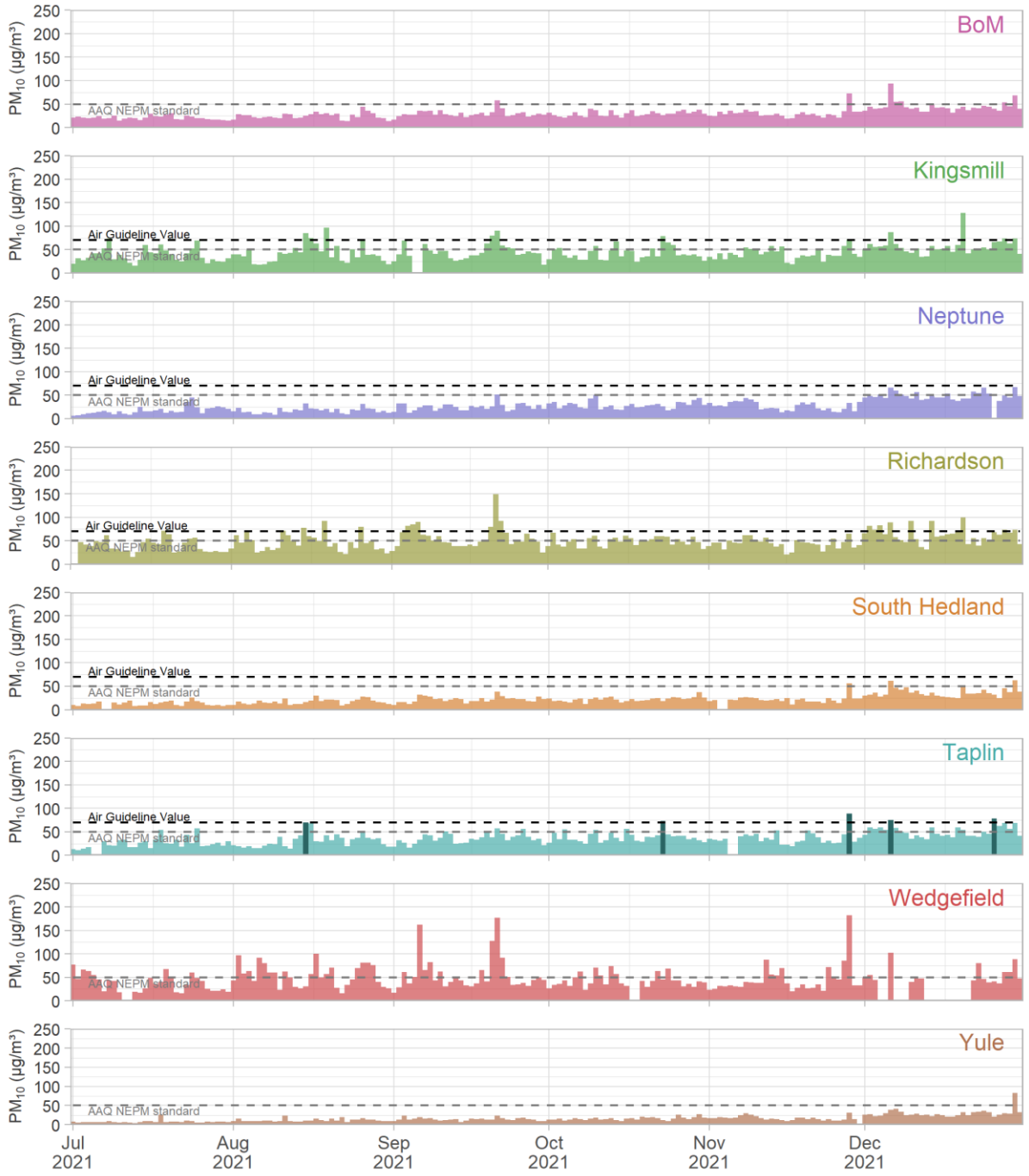

Figure 4-1: July to December 2021 time series plots of 24-hour average concentrations of PM_{10}

4.2 $PM_{2.5}$

$PM_{2.5}$ was measured at four (4) monitoring stations (BoM, Richardson, Taplin and Yule) during the July to December 2021 period.

4.2.1 Data Capture

Data capture rates for 1-hour average concentrations of $PM_{2.5}$ for each monitoring station during the July to December 2021 period are detailed in Table 4-4. All stations achieved a six-month capture rate for $PM_{2.5}$ of greater than 97%, satisfying the PHIC criterion of 75% data capture. All sites also achieved quarterly capture rates greater than 96%, satisfying the PHIC criterion of 75% data capture.

Table 4-4: July to December 2021 data capture summary 1-hour average concentrations of $PM_{2.5}$

Monitoring Station ID	$PM_{2.5}$ Data Capture Rate (%)			Performance
	Q1	Q2	Six-monthly	
BoM	99.7	99.5	99.6	Met
Richardson	97.6	99.5	98.5	Met
Taplin	98.4	99.7	99.0	Met
Yule	96.0	98.0	97.0	Met

4.2.2 Comparison to Air Quality Standards

The maximum 24-hour average (midnight to midnight) and six-month average concentrations of $PM_{2.5}$ are detailed for each station in Table 4-5. The number of days above the AAQ NEPM standard is also presented.

To assess the progress of the average $PM_{2.5}$ concentration against the annual performance criteria, the July to December 2021 six-month average concentration has been compared to the six-month average from the previous July to December period (2020) as well as the average from the full July 2020 to June 2021 financial year period. This data is presented in Table 4-6.

The 24-hour average $PM_{2.5}$ measurements show that for the July to December 2021 period:

- The 24-hour average concentrations of $PM_{2.5}$ were below the AAQ NEPM standard of 25 µg/m³ at all monitoring stations during the July to December 2021 period.

With regards to the six-month July to December 2021 average concentration of $PM_{2.5}$:

- Data from the previous year shows that concentrations tend to drop during the second six months of the financial year, with the annual average concentration lower than the six-month July to December average across all 4 monitoring sites.
- The six-month average concentration of $PM_{2.5}$ is above 8 µg/m³ at the Richardson monitoring site.
- The six-month average concentration of $PM_{2.5}$ is between 6 µg/m³ and 8 µg/m³ at the BoM and Taplin monitoring sites.
- The six-month average concentration of $PM_{2.5}$ is below 3 µg/m³ at the Yule monitoring site.

Table 4-5: July to December 2021 data summary average concentrations of $PM_{2.5}$

Monitoring Station ID	Maximum 24-hour average concentration of $PM_{2.5}$ (µg/m³)	Number of days >25 µg/m³ (AAQ NEPM)	Performance (AAQ NEPM of 25 µg/m³)	Six-month average concentration of $PM_{2.5}$ (µg/m³)
BoM	17.4	0	Met	6.6
Richardson	19.1	0	Met	8.4
Taplin	22.3	0	Met	7.1
Yule	12.5	0	Met	2.9

Table 4-6: July to December 2021 $PM_{2.5}$ data tracking summary

Monitoring Station ID	Six-month average July to December 2021 concentration of $PM_{2.5}$ (µg/m³)	Six-month average July to December 2020 concentration of $PM_{2.5}$ (µg/m³)	Annual average FY 2020/21 concentration of $PM_{2.5}$ (µg/m³)	Performance criteria (µg/m³) [A]
BoM	6.6	5.6	4.9	8
Richardson	8.4	7.5	6.9	
Taplin	7.1	5.7	5.3	
Yule	2.9	2.6	1.8	

Table note:
[A] No criteria for six month average. Annual average AAQ NEPM standard is 8 µg/m³.

4.2.3 $PM_{2.5}$ Timeseries Analysis

A timeseries plot of the 24-hour average concentration of $PM_{2.5}$ for the July to December 2021 period for each monitoring station is shown in Figure 4-2.

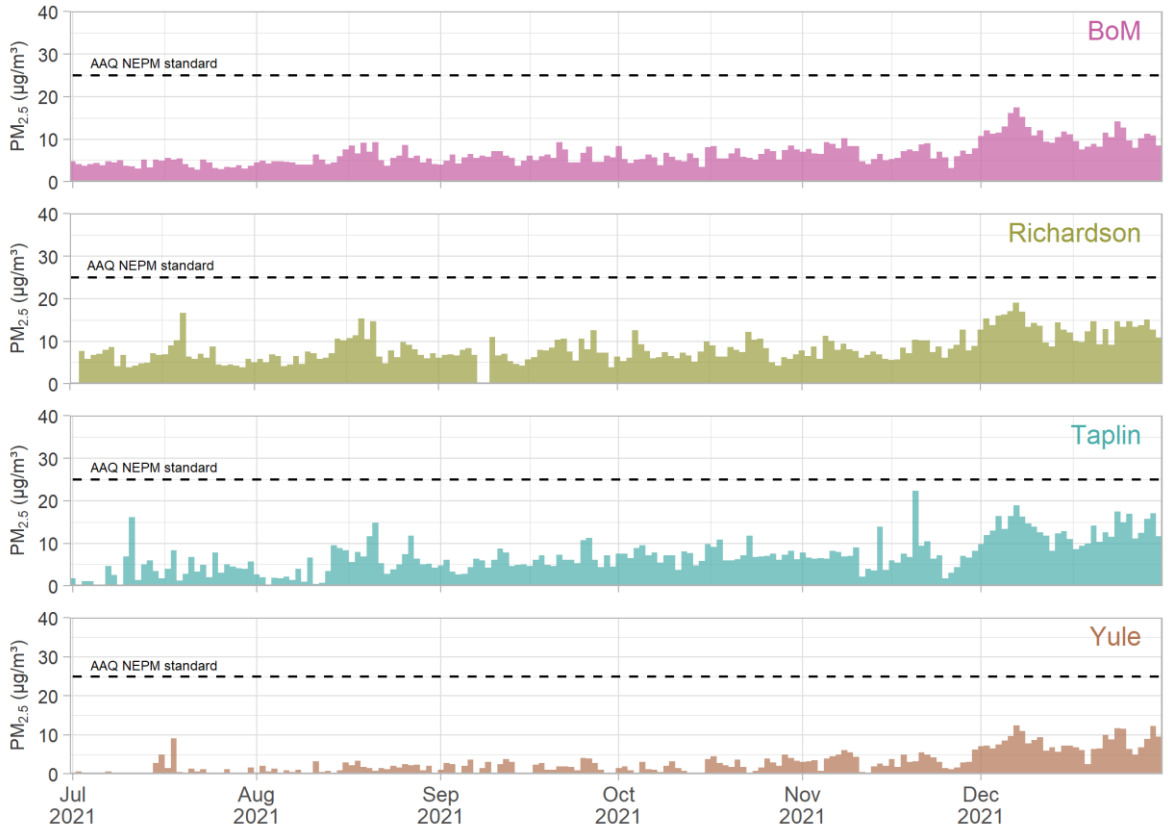

Figure 4-2: July to December 2021 time series plots of 24-hour average concentrations of $PM_{2.5}$

4.3 Oxides of Nitrogen

NO_x was measured at the Taplin monitoring station during the July to December 2021 period. NO_x monitoring included nitrogen dioxide (NO_2), nitric oxide (NO) and total NO_X (reported as NO_2).

4.3.1 Data Capture

Data capture rates for 1-hour average concentrations of NO_x for the Taplin monitoring station are detailed in Table 4-7. The Taplin monitoring station achieved a lower data capture rate of 72% for the six-month July to December 2021 period which is below the PHIC criterion of 75% data capture. The Taplin site achieved a capture rate of 95% for the October to December quarter; however, ongoing instrument faults and non-scheduled maintenance (Section 2.4) lowered the capture during the July to September quarter to 48%, below the criterion.

Table 4-7: July to December 2021 data capture summary 1-hour average concentrations of NO_x

Monitoring Station ID	NO_x Data Capture Rate (%)			Performance
	Q1	Q2	Six-monthly	
Taplin	48.1	95.4	71.8	Not met

4.3.2 Comparison to Air Quality Standards

The maximum measured 1-hour average and six-month average concentrations of NO_2 at Taplin monitoring station are detailed in Table 4-8.

To assess the progress of the average NO_2 concentration against the annual performance criteria, the July to December 2021 six-month average concentration has been compared to the six-month average from the previous July to December period (2020) as well as the average from the full July 2020 to June 2021 financial year period. This data is presented in Table 4-9.

The 1-hour average NO_2 measurements show that for the July to December 2021 period:

- The 1-hour average concentrations of NO_2 were below the AAQ NEPM standard of 164 µg/m³.
- The highest 1-hour average concentration of NO_2 corresponds to 54% of the AAQ NEPM standard.

With regards to the six-month July to December 2021 average concentration of NO_2:

- Data from the previous year shows that NO_2 concentrations at Taplin tend to drop during the second six months of the financial year, with the annual average concentration lower than the six-month July to December average.
- The six-month average concentration of NO_2 is less than half of the AAQ NEPM standard of 31 µg/m³ at the Taplin monitoring site.

For the period of available data, the levels of NO_2 measured at Taplin are low and consistent with the NO_2 levels measured in previous years.

Table 4-8: July to December 2021 data summary average concentrations of NO_2

Monitoring Station ID	Maximum 1-hour average NO_2 concentration (µg/m³)	Performance (AAQ NEPM of 164 µg/m³)	Six-month average NO_2 concentration (µg/m³)
Taplin	88.8	Met	15.2

Table 4-9: July to December 2021 NO_2 data tracking summary

Monitoring Station ID	Six month average July to December 2021 concentration of NO_2 (µg/m³)	Six month average July to December 2020 concentration of NO_2 (µg/m³)	Annual average FY 2020/21 concentration of NO_2 (µg/m³)	Performance criteria [A]
Taplin	15.2	14.9	14.3	31 µg/m³

Table note:
[A] No criteria for six month average. Annual average AAQ NEPM standard is 31 µg/m³.

4.3.3 NO_2 Time Series Analysis

A timeseries plot of the 1-hour average concentrations of NO_2 for the July to December 2021 period at Taplin monitoring station is shown in Figure 4-3. Note that the AAQ NEPM standard is 164 µg/m³ and is not shown on Figure 4-3 due to the low levels measured at the station.

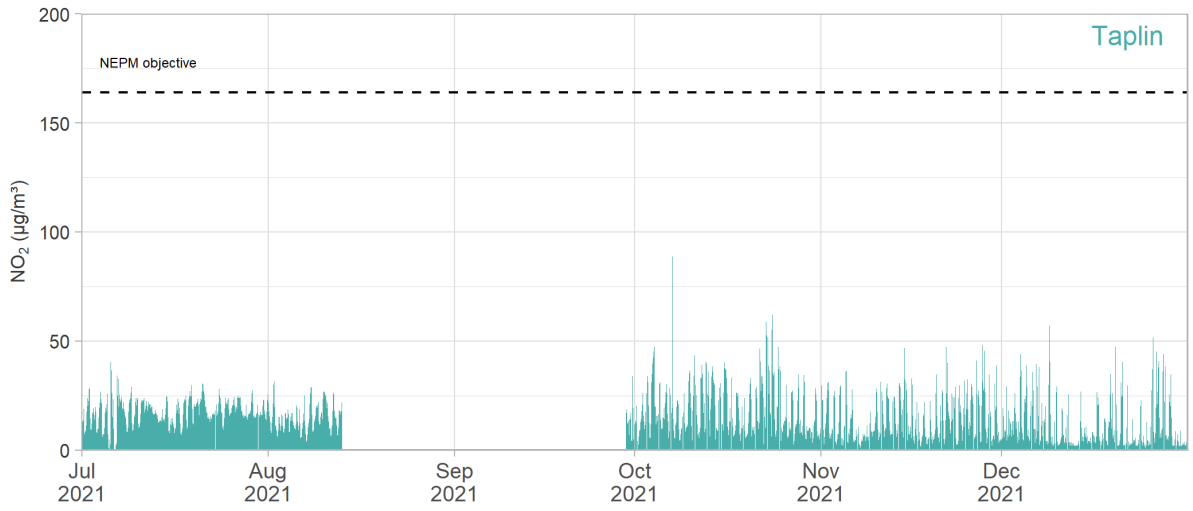

Figure 4-3: July to December 2021 time series plot of 1-hour average concentrations of NO_2 for Taplin

5. AIR QUALITY MONITORING DATA – MONITORING STATION PERFORMANCE

The following section describes the performance of each monitoring station in the Port Hedland ambient air quality monitoring network during the July to December 2021 period. For this assessment, only the 24-hour criteria was assessed because compliance with annual criteria cannot be determined due to the averaging period being less than one year.

5.1 Taplin

The Taplin monitoring station is located in Port Hedland (Figure 2-1) and is generally representative of a residential site in Port Hedland township. Parameters measured at the Taplin station are:

- PM_{10}
- $PM_{2.5}$
- NO_x
- Wind speed, wind direction, temperature, and relative humidity.

The Taplin monitoring station is the only PHIC monitoring network station where measurements of 24-hour average concentrations of PM_{10} are compared with the AGV for PM_{10}.

A summary of the air pollutant performance of the Taplin monitoring station is detailed in Table 5-1.

Table 5-1: Taplin Monitoring Station Performance Summary

Pollutant	Data Capture Performance	AGV / Standard		Number of instances above the AGV / Standard	Performance against AGV / Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	70 (AGV)	24-hour	5	Met
		50 (Standard)	24-hour	29	Not met
$PM_{2.5}$	Met	25 (Standard)	24-hour	0	Met
NO_2	Met	164 (Standard)	1-hour	0	Met

5.2 BoM

The BoM monitoring station is located at Port Hedland Airport (Figure 2-1) and represents a background monitoring site in the Port Hedland region. Parameters measured at the BoM station are:

- PM_{10}
- $PM_{2.5}$
- Wind speed and wind direction.

A summary of the air pollutant performance of the BoM monitoring station is detailed in Table 5-2.

Table 5-2: BoM Monitoring Station Performance Summary

Pollutant	Data Capture Performance	Standard		Number of instances above the Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	50	24-hour	7	Not met
$PM_{2.5}$	Met	25	24-hour	0	Met

5.3 Kingsmill

The Kingsmill monitoring station is located in Port Hedland (Figure 2-1) and is generally representative of a residential monitoring site in Port Hedland township. Parameters measured at the Kingsmill station include:

- PM_{10}
- Wind speed and wind direction.

A summary of the air pollutant performance of the Kingsmill monitoring station is detailed in Table 5-3.

Table 5-3: Kingsmill Monitoring Station Performance Summary

Pollutant	Data Capture Performance	AGV / Standard		Number of instances above the AGV / Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	70 (AGV) [A]	24-hour	13	NA [B]
		50 (standard)	24-hour	59	Not met

Table note:
[A] Applies to residential areas (Richardson, Kingsmill, South Hedland, Taplin, and Neptune)
[B] Assessment of performance against AGV not applied at sites other than Taplin

5.4 Neptune

The Neptune monitoring station is located at Port Hedland (Figure 2-1) and is generally representative of a residential location in the eastern part of Port Hedland township. Parameters measured at the Neptune monitoring station include:

- PM_{10}
- Wind speed and wind direction.

A summary of the air pollutant performance of the Neptune monitoring station is detailed in Table 5-4.

Table 5-4: Neptune Monitoring Station Performance Summary

Pollutant	Data Capture Performance	AGV / Standard		Number of instances above the AGV / Standard	Performance against AGV / Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	70 (AGV) [A]	24-hour	0	NA [B]
		50 (standard)	24-hour	12	Not met

Table note:
[A] Applies to residential areas (Richardson, Kingsmill, South Hedland, Taplin, and Neptune)
[B] Assessment of performance against AGV not applied at sites other than Taplin

5.5 Richardson

The Richardson monitoring station is located at Port Hedland (Figure 2-1) and is generally representative of a residential monitoring site in the western part of Port Hedland township. Parameters measured at the Richardson monitoring station include:

- PM_{10}
- $PM_{2.5}$
- Wind speed and wind direction.

A summary of the air pollutant performance of the Richardson monitoring station is detailed in Table 5-5.

Table 5-5: Richardson Monitoring Station Performance Summary

Pollutant	Data Capture Performance	AGV/Standard		Number of instances above the AGV/Standard	Performance against AGV/Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	70 (AGV) [A]	24-hour	21	NA [B]
		50 (standard)	24-hour	76	Not met
$PM_{2.5}$	Met	25 (standard)	24-hour	0	Met

Table note:
[A] Applies to residential areas (Richardson, Kingsmill, South Hedland, Taplin, and Neptune)
[B] Assessment of performance against AGV not applied at sites other than Taplin

5.6 South Hedland

The South Hedland monitoring station is located in the South Hedland township (Figure 2-1) and is generally representative of the residential community away from the port. Parameters measured at the South Hedland station include:

- PM_{10}
- Wind speed and wind direction.

A summary of the air pollutant performance of the South Hedland monitoring station is detailed in Table 5-6.

Table 5-6: South Hedland Monitoring Station Performance Summary

Pollutant	Data Capture Performance	AGV/Standard		Number of instances above the AGV/Standard	Performance against AGV/Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	70 (AGV) [A]	24-hour	0	NA [B]
	Met	50 (standard)	24-hour	3	Not met

Table note:
[A] Applies to residential areas (Richardson, Kingsmill, South Hedland, Taplin, and Neptune)
[B] Assessment of performance against AGV not applied at sites other than Taplin

5.7 Wedgefield

The Wedgefield monitoring station is located within light industrial and residential areas (Figure 2-1) and is generally representative of the industrial area to the south of Port Hedland township. Parameters measured at the Wedgefield station include:

- PM_{10}
- Wind speed and wind direction.

A summary of the air pollutant performance of the Wedgefield monitoring station is detailed in Table 5-7.

Table 5-7: Wedgefield Monitoring Station Performance Summary

Pollutant	Data Capture Performance	Standard		Number of instances above the Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	50	24-hour	55	Not met

5.8 Yule

The Yule monitoring station is located 40 km away from Port Hedland (Figure 2-1) and is generally representative of a rural background monitoring site, removed from industrial sources. Parameters measured at Yule include:

- PM_{10}
- $PM_{2.5}$
- Wind speed and wind direction.

A summary of the air pollutant performance of the Yule monitoring station is detailed in Table 5-8.

Table 5-8: Yule Monitoring Station Performance Summary

Pollutant	Data Capture Performance	Standard		Number of instances above the Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	50	24-hour	1	Not met
$PM_{2.5}$	Met	25	24-hour	0	Met

6. PM_{10} TRENDS

An analysis of trends in concentrations of PM_{10} measured by the Port Headland ambient air quality monitoring network for the nine years from FY 2012/13 to FY 2020/21 is presented in the FY 2020/21 annual report (Katestone, 2021a). The analysis presented in the 2021 report provides the trend in 24-hour average concentrations of PM_{10} against the AGV and AAQ NEPM standard as well as the trend in annual average concentrations.

The trend to the FY 2021/22 period is difficult to establish without the full twelve months of data. Subsequently, this report provides a brief summary of the first six months of data from the FY 2021/22 with reference to the data from the previous nine years.

6.1 24-hour average concentrations of PM_{10} – Air Guideline Value

The number of days that the 24-hour average concentration of PM_{10} at Taplin was above the AGV of 70 µg/m³ for each year since FY 2012/13 is presented in Table 6-1. The data show that the number of exceedances to date during the FY 2021/22 period (5) has already exceeded the two financial years prior.

Table 6-1: Number of 24-hour average concentrations of PM_{10} above the Air Guideline Value at Taplin, per reporting year

Monitoring Station	Air Guideline Value (µg/m³)	Number of days above Air Guideline Value									
		FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16	FY 2016/17	FY 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22
Taplin	70[A]	17	6	10	10	3	9	No data [B]	3 [C]	1	5 [D]

Table note:
[A] Ten exceedances of 24-hour average allowed per year due to industry
[B] No data presented due to inconsistent data recorded at Taplin during entire FY 2018/19
[C] Exceedances during period of available data only (1 January 2020 to 30 June 2020)
[D] Exceedances during six-month period at time of reporting (July to December 2021)

6.2 24-hour average PM_{10} – AAQ NEPM Standard

The number of 24-hour average concentrations of PM_{10} at each Port Hedland monitoring station above the AAQ NEPM standard of 50 µg/m³ for each reporting year is presented in Table 6-2. The data shows that the number of exceedances to date during the FY 2021/22 period has already exceeded the prior financial year prior at the Neptune and Taplin sites.

Table 6-2: Summary of 24-hour average concentrations of PM_{10} above the AAQ NEPM standard per reporting year

Monitoring Station	AAQ NEPM Standard (µg/m³)	Number of days above the AAQ NEPM standard									
		FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16	FY 2016/17	FY 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22
BoM	50	24	10	17	12	7	4	25	33	8	7 [C]
Kingsmill		89	98	156	112	83	103	155	148	71	59 [C]
Neptune		25	25	67	43	29	15	102	66	10	12 [C]
Richardson		74	50	79	39	90	143	167	173	93	76 [C]
South Hedland		23	13	19	12	8	0	11	22	16	3 [C]
Taplin		48	48	55	48	27	65	No data [A]	10 [B]	21	29 [C]
Wedgefield		157	148	169	150	99	88	165	159	101	55 [C]
Yule		24	8	18	5	1	8	15	13	8	1 [C]

Table note:
[A] No data presented due to inconsistent data recorded at Taplin during entire FY 2018/19
[B] Exceedances during period of available data only (1 January 2020 to 30 June 2020)
[C] Data summary for six-month period at time of reporting (July to December 2021)

6.3 Annual average concentrations of PM_{10} – AAQ NEPM Standard

The annual average concentrations of PM_{10} at each Port Hedland monitoring station (where available) for the last nine reporting years to FY 2020/21 have been compared with the standard in Table 6-3. The six-month average for the July to December 2021 period is also presented.

Table 6-3: Summary of annual average concentrations of PM_{10} for each reporting year

Monitoring Station	AAQ NEPM Standard (µg/m³)	Annual average concentration of PM_{10} (µg/m³)									
		FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16 [A]	FY 2016/17	FY 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22
BoM	25	No data [A]	No data [A]	No data [A]	25.4	21.4	23.8	31.5	32.1	25.5	30.0 [D]
Kingsmill		47.1	44.8	50.4	44.7	40.4	43.7	51.0	50.3	38.3	44.5 [D]
Neptune		28.1	31.6	37.1	32.3	27.4	26.4	40.2	36.6	21.6	27.3 [D]
Richardson		40.7	38.1	40.0	35.2	40.0	47.3	51.4	54.1	40.7	50.2 [D]
South Hedland		No data [A]	No data [A]	No data [A]	26.5	22.2	16.1	24.4	27.9	20.6	22.3 [D]
Taplin		36.8	37.9	36.3	35.6	31.3	34.4	No data [B]	31.1 [C]	29.8	36.7 [D]
Wedgefield		No data [A]	No data [A]	No data [A]	51.1	43.1	42.2	55.0	54.6	42.7	48.3 [D]
Yule		23.1	18.1	21.5	18.5	15.4	17.9	22.2	21.0	16.4	16.2 [D]

Table note:
[A] Site not operating
[B] No data presented due to inconsistent data recorded at Taplin during FY 2018/19
[C] Annual average based on period of available data only (1 January 2020 to 30 June 2020 following installation of replacement BAM monitor at Taplin site). Not a valid average.
[D] Annual average based on six months of data at time of reporting (July to December 2021)

7. INVESTIGATION OF PM_{10} EVENTS

7.1 Investigation methodology

The AGV for 24-hour average concentrations of PM_{10} allows for ten days per year above 70 µg/m³ as measured at Taplin monitoring station that are not due to natural events. The Department of Health requires that appropriate action be caried out to understand the cause of exceedance events. There is no limit on the number of exceedances that are determined to have occurred solely as a result of natural events as per the application of the National Environmental Protection (Ambient Air Quality) Measure, with natural events defined as bushfires, jurisdiction authorised hazard reduction burning, or continental-scale windblown dust. Exceedance events that are determined to have been caused by industry would result in an appropriate and proportionate regulatory response aimed at returning air quality to an acceptable level.

During periods exceeding the 24-hour AGV, source contribution analyses are carried out to demonstrate whether the event day was likely to be a result of industry, regional dust or a local dust source other than industry. The following methodology is used to determine whether an exceedance of the AGV at Taplin was caused by industry. Under the methodology, an event day is not counted where it can be demonstrated to be a result of regional dust or a local dust source other than industry.

The standard routine bimonthly analysis of the air quality monitoring network data includes an investigation of event days at the Taplin, Kingsmill, Richardson and Neptune monitoring stations. The methodology that was developed for Taplin is applied to the investigation of event days at all four sites to monitor site performance. This six-monthly report includes a discussion of event days at Kingsmill, Richardson, and Neptune during the July to December 2021 period.

Step 1. Determine whether the event is likely to be ‘regional’ or ‘local’

a) A ’regional’ event occurs when the 24-hour average concentration of PM_{10} at the site of interest is **greater** than 70 µg/m³ and the 24-hour average concentration of PM_{10} at BoM monitoring station is **greater** than 60 µg/m³. Regional events are not caused by industry and so are not counted as an exceedance of the AGV. The background monitoring station at Yule is also considered when determining regional events.

b) A ’local’ event occurs when the 24-hour average concentration of PM_{10} at the site of interest is greater than 70 µg/m³ and the 24-hour concentration of PM_{10} at BoM monitoring station is less than 60 µg/m³.

c) Further identification of ’local’ versus ‘regional’ events considers the percentile range of the value measured at BoM and Yule compared to the historical dataset (July 2015 to June 2021). Concurrent 24-hour average concentrations at the other PHIC monitoring stations are also extracted to investigate a regional component to the event.

Step 2. For each ‘local’ event, the likelihood that Port Hedland industry contributed to the concentration of PM_{10} above 70 µg/m³ has been investigated through analysis with meteorological conditions (using wind roses, polar frequency plots and time series) and the Port Hedland industry 'arc of influence'. The Port Hedland industry arc of influence is defined as any wind direction that has the potential to carry emissions from industry to the monitoring station of interest and varies between sites.

a) The Port Hedland industry arc of influence at Taplin monitoring station is shown in Figure 7-1 (shaded area) and represents wind directions between 115° and 290°.

b) The Port Hedland industry arc of influence at Richardson monitoring station is shown in Figure 7-2 (shaded area) and represents wind directions between 95° and 320°

c) The Port Hedland industry arc of influence at Kingsmill monitoring station is shown in Figure 7-3 (shaded area) and represents wind directions between 100° and 305°

d) The Port Hedland industry arc of influence at Neptune monitoring station is shown in Figure 7-4 (shaded area) and represents wind directions between 210° and 280°

It is possible for events to occur due to regional influences like bushfires, local activities such as industry or local activities that are not related to industry. It is also possible that a combination of the above may occur during one event.

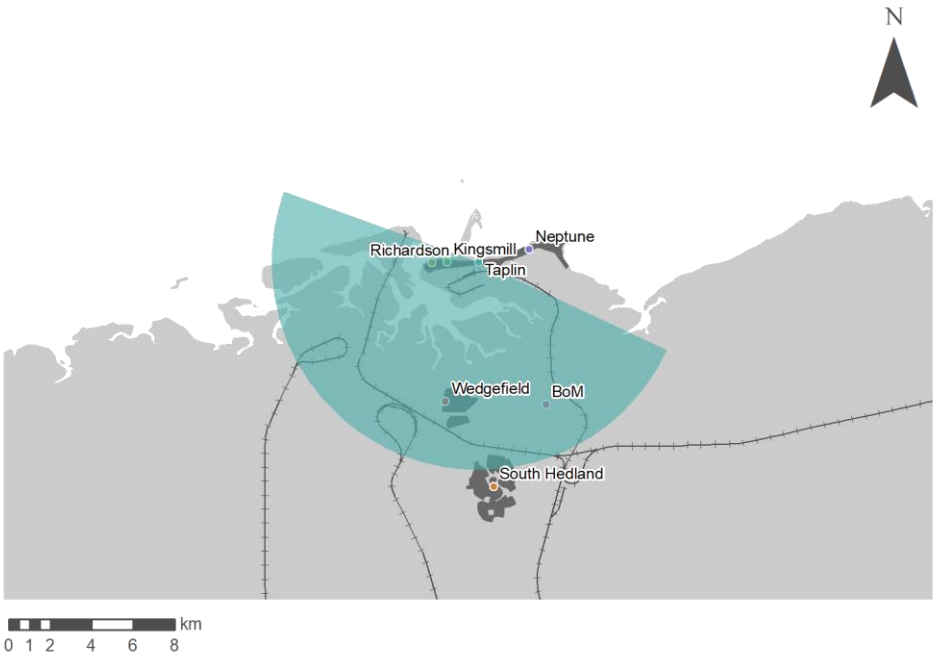

Figure 7-1: Port Hedland industry arc of influence (shaded area) at Taplin monitoring station

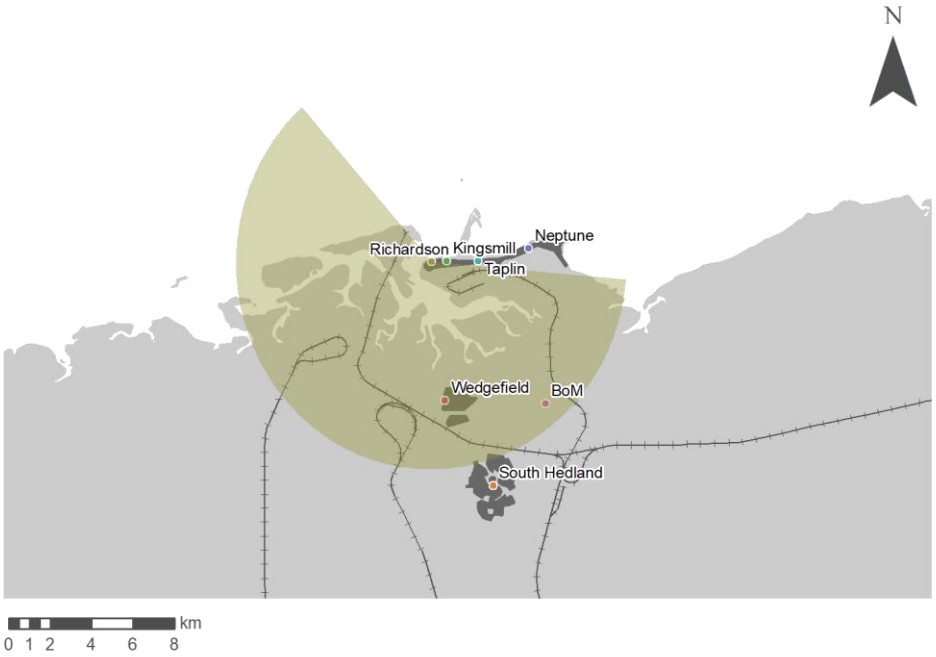

Figure 7-2: Port Hedland industry arc of influence (shaded area) at Richardson monitoring station

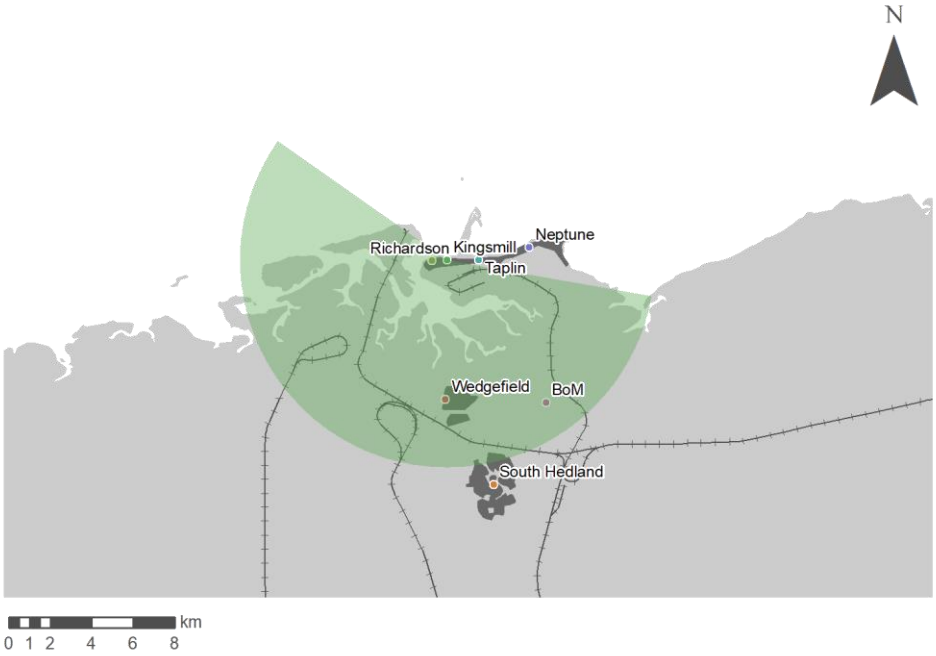

Figure 7-3: Port Hedland industry arc of influence (shaded area) at Kingsmill monitoring station

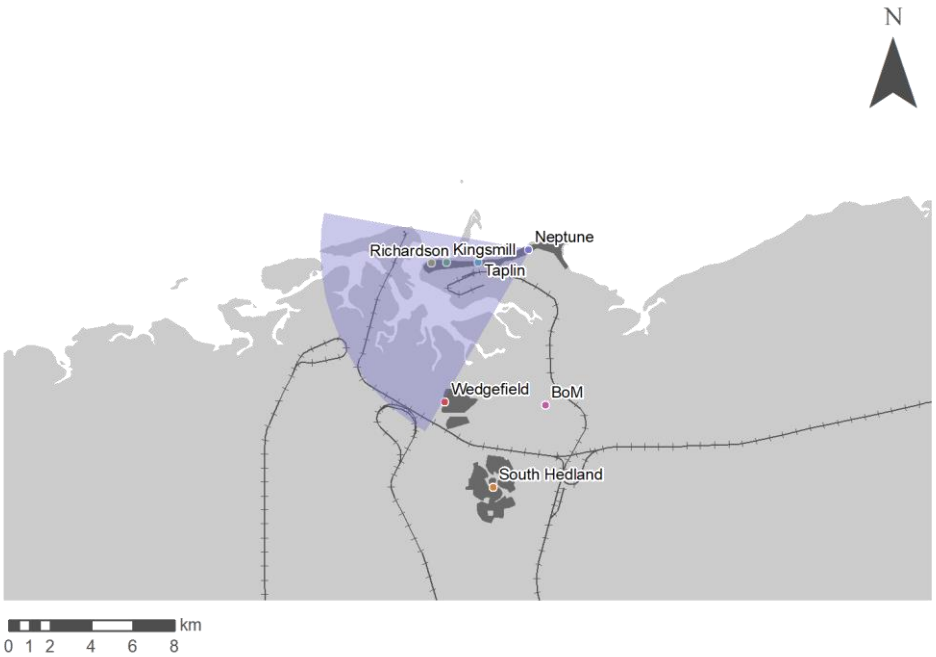

Figure 7-4: Port Hedland industry arc of influence (shaded area) at Neptune monitoring station

7.1.1 Graphical presentation of event days

The likelihood that Port Hedland industry contributed to the concentration of PM_{10} above 70 µg/m³ at each site of interest has been investigated through analysis of meteorological conditions. The 10-minute average data has been used to provide the best resolution. The following types of graphs have been used:

- Wind roses
- Polar frequency plots
- Time series.

A wind rose is a tool used to illustrate the frequency and intensity of a given wind speed and its direction at a chosen location. In the following sections, the 10-minute average wind speed and vector-averaged wind direction measurements for the event days at each site of interest are shown. Wind speeds have been grouped based on the data range for each day. Wind direction is grouped into sixteen, 22.5-degree sectors that represent all possible wind directions. All wind rose graphs have the same wind speed scale and colours.

A polar plot shows the dependence of concentrations of PM_{10} on wind speed and wind direction as measured at the site of interest during each event day (10-minute average data has been used to increase resolution). The colour scale represents the average concentration of PM_{10} with concentrations higher than 200 µg/m³ shown in red graduating to lower concentrations, which are shown in orange, yellow, green, and then blue. All polar plots have the PM_{10} colour scale for ease of comparison. The placement on the polar plot reflects the wind speed and wind direction at the time of measurement. Measurements during stronger winds are placed further from the centre with each ring denoting an increment in wind speeds. The wind direction at the time of measurement is reflected by plotting the point relative to its direction from north. It should be noted that the PM_{10} concentration is the average of the 10-minute data for each wind speed group and wind direction sector.

A time series plot is a tool used to illustrate the change over time. Time series plots for PM_{10} concentration, wind direction and wind speed at the site of interest monitoring station and have been produced for each event day. Again, the 10-minute average data has been used to increase resolution and each event day plot has the same scale.

7.2 Overview

7.2.1 Exceedance events at Taplin

Table 7-1 details the five days when the 24-hour average concentration of PM_{10} was above 70 µg/m³ at Taplin between 1 July 2021 and 31 December 2021. Concentrations of PM_{10} at BoM and Yule for the same period are also displayed.

The likely cause of each PM_{10} event day is detailed in Table 7-1 as determined by the methodology described in Section 7. The detailed analysis described in Section 7.3 shows the following:

- The exceedance at the Taplin site on 15 August 2021 is believed to have likely been the result of local industry and non-industry sources
- The exceedance events at the Taplin site on 23 October 2021 and 26 December 2021 are believed to have likely been the result of a local industry source
- The exceedance at the Taplin site on 28 November 2021 is believed to have likely been the result of a regional event as well as a local non-industry source
- The exceedance at the Taplin site on 6 December 2021 is believed to have likely been the result of local industry and non-industry sources as well as a contribution from a regional event.

Table 7-1 Summary of 24-hour average concentrations of PM_{10} above 70 µg/m³ at Taplin

Date	24-hour average PM_{10} (µg/m³)			Likely cause (as determined by methodology presented in Section 7)
	Taplin	BoM	Yule	
15 August 2021	**70.3**	25.1	10.9	Local (industry and non-industry)
23 October 2021	**72.7**	26.8	11.8	Local (industry)
28 November 2021	**89.0**	**72.9**	31.5	Regional and local (non-industry)
6 December 2021	**75.5**	**93.4**	39.1	Regional and local (industry and non-industry)
26 December 2021	**77.8**	40.1	21.3	Local (industry)

7.2.2 Exceedance events at Kingsmill, Richardson and Neptune

Table 7-2 details the days during the July to December 2021 period when the 24-hour average PM_{10} concentration was above 70 µg/m³ at Kingsmill, Richardson, and Neptune. Concentrations at Taplin, BoM and Yule are also displayed.

The detailed analysis for exceedance events at Kingsmill, Richardson and Neptune during July and August 2021 are presented in the bimonthly report for this period (Katestone, 2021b). Similarly, the detailed analysis for exceedance events at Kingsmill, Richardson and Neptune during September and October 2021 are presented in the bimonthly report for this period (Katestone, 2021c).

The detailed analysis for exceedance events at Kingsmill, Richardson and Neptune during November and December 2021 are presented in Appendix A.

Table 7-2: Summary of 24-hour average concentrations of PM_{10} above 70 µg/m³, July – December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause (as determined by methodology presented in Section 7.1)
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
8 July	61.2	**73.8**	13.0	21.3	20.4	8.8	Local (industry)
19 July	**71.0**	48.4	12.9	25.9	27.7	6.8	Local (industry)
11 August	**71.3**	40.6	14.5	19.0	29.5	23.1	Local (industry)
15 August	**77.5**	**85.0**	32.3	**70.3**	25.1	10.9	Local (industry and non-industry)
16 August	59.2	**74.7**	21.9	67.6	28.5	10.6	Local (industry)
19 August	**91.9**	**96.8**	20.8	42.0	30.6	9.5	Local (industry)
26 August	**80.0**	**72.0**	31.8	49.8	44.3	17.3	Local (industry) and Regional
4 September	**81.6**	36.7	12.0	16.2	27.3	13.0	Local (industry)
5 September	**85.2**	NA	17.5	24.3	27.9	16.3	Local (industry)
6 September	**90.5**	NA	24.2	32.8	35.8	19.9	Local (industry and non-industry)

Date	24-hour average PM_{10} (µg/m³)						Likely cause (as determined by methodology presented in Section 7.1)
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
20 September	**80.1**	**80.2**	26.0	37.8	32.3	13.7	Local (industry)
21 September	**148.9**	**90.5**	51.3	57.3	57.5	23.1	Local (industry)
22 September	**92.6**	58.7	29.1	45.1	40.9	17.5	Local (industry)
23 October	60.0	**78.5**	25.8	**72.7**	26.8	11.8	Local (industry)
28 November	64.6	**71.5**	33.7	**89.0**	**72.9**	31.5	Regional and local (industry)
2 December	**82.0**	62.4	47.8	59.0	44.3	28.0	Regional and local (industry)
3 December	**72.9**	55.3	46.0	56.4	40.5	21.8	Regional and local (industry)
4 December	**83.0**	56.4	51.6	59.8	40.7	23.3	Regional and local (industry)
6 December	**88.5**	**87.3**	65.7	75.5	**93.4**	39.1	Regional and local (industry and non-industry)
10 December	**92.2**	42.7	43.3	34.9	39.9	26.1	Local (industry)
14 December	**92.6**	57.6	48.2	59.4	48.5	21.9	Regional and local (industry)
19 December	**71.8**	60.3	37.8	59.4	40.3	24.6	Regional and local (industry)
20 December	**99.1**	**128.7**	43.3	54.5	43.9	33.2	Local (non-industry)
28 December	**72.9**	**73.3**	49.0	69.1	54.0	30.1	Regional and local (industry)
30 December	**73.5**	**74.0**	66.9	68.6	68.9	82.9	Regional

7.3 Detailed analysis of exceedances at Taplin

7.3.1 15 August 2021

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
15 August 2021	**70.3**	25.1	10.9	Local (industry and non-industry)

On 15 August 2021, the 24-hour average concentration of PM_{10} was 70.3 µg/m³ at Taplin, slightly above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} at BoM and Yule were well below 60 µg/m³, indicating a local event occurring at Taplin.

A wind rose and PM_{10} polar frequency plot of the Taplin data is shown in Figure 7-7 and a time series plot of concentrations of PM_{10} at Taplin, BoM and Yule and wind speed and wind direction at Taplin is shown in Figure 7-8.

The figures indicate the following:

- Winds were generally light and less than 2.5 m/s, and from the southeast through to west-northwest, consistent with the direction of winds from within the industry arc of influence. A proportion of winds also occurred from the northwest through to northeast, outside the industry arc of influence.
- The PM_{10} polar frequency plots indicate that the highest 10-minute average concentrations of PM_{10} (dark red and orange areas) occurred during light winds from the southwest sector as well as light winds from the northwest. The southwest sector winds are within the industry arc of influence, however; those from the northwest are outside the industry arc of influence and can be attributed to other non-industry local source(s).
- The time-series plot shows that concentrations were slightly elevated at Taplin from midnight through to around 8am, while winds were within the industry arc of influence and concentrations were lower at BoM and Yule, indicating a local industry source. Concentrations were lower at Taplin between 8am and 1pm before increasing from 1pm and remaining elevated for the remainder of the 24-hour period. The elevated concentrations between 1pm and 5pm occurred during winds from outside the industry arc of influence and can be attributed to other non-industry local source(s). Elevated concentrations from 1pm occurred during winds from within the industry arc of influence and while winds were lower at BoM and Yule.

Overall, on 15 August 2021, concentrations of PM_{10} were likely the result of local industry and non-industry sources.

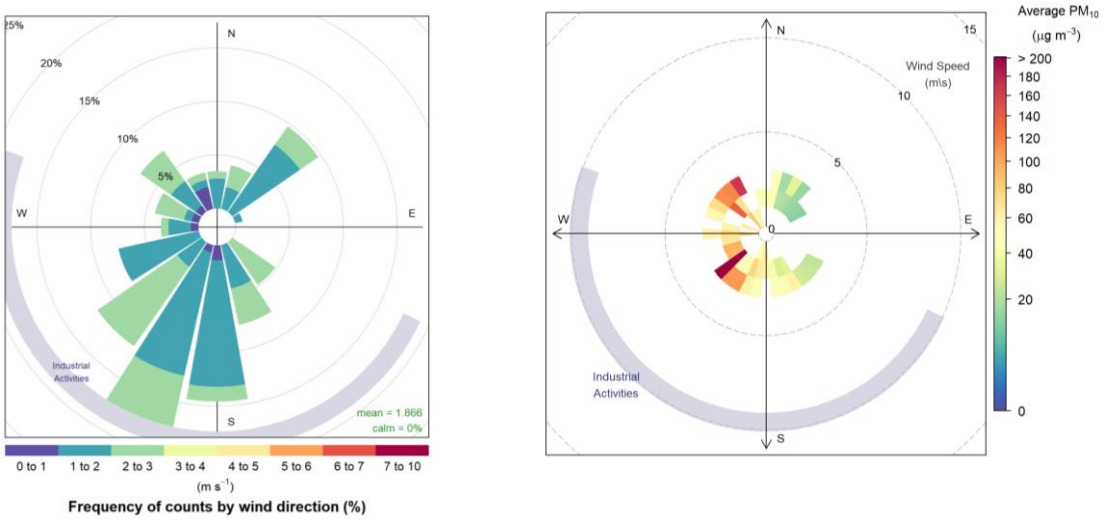

Figure 7-5: Wind rose (left) and PM_{10} polar plot (right) on 15 August 2021 at Taplin

Figure 7-6: Time series of concentrations of PM_{10} at Taplin, BoM and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 15 August 2021

7.3.2 23 October 2021

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
23 October 2021	**72.7**	26.8	11.8	Local (industry)

On 23 October 2021, the 24-hour average concentration of PM_{10} was 72.7 µg/m³ at Taplin, slightly above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} at BoM and Yule were well below 60 µg/m³, indicating a local event occurring at Taplin.

A wind rose and PM_{10} polar frequency plot of the Taplin data is shown in Figure 7-7 and a time series plot of concentrations of PM_{10} at Taplin, BoM and Yule and wind speed and wind direction at Taplin is shown in Figure 7-8.

The figures indicate the following:

- Winds were generally light and less than 2.5 m/s except for slightly stronger winds up to 5.3 m/s during the afternoon period (midday to 6pm). Winds during the day (9am to 6pm), including those stronger winds up to 5.3 m/s, were from the northwest to north direction, outside the industry arc of influence. The lighter night-time winds (up to 9am and then again from 6pm to midnight) were from the east-southeast to west and consistent with the industry arc of influence.
- The PM_{10} polar frequency plots indicate that the highest 10-minute average concentrations of PM_{10} (dark red and orange areas) occurred during the light winds from the south-southeast to southwest direction, within the industry arc of influence.
- The time-series plot shows that the elevated concentrations were measured at Taplin between midnight and 8am and then again between 9pm and midnight while winds were light and from within the industry arc of influence and concentrations were lower at BoM and Yule. This indicates a local industry source at Taplin.

Overall, on 23 October 2021, concentrations of PM_{10} were likely the result of a local industry source.

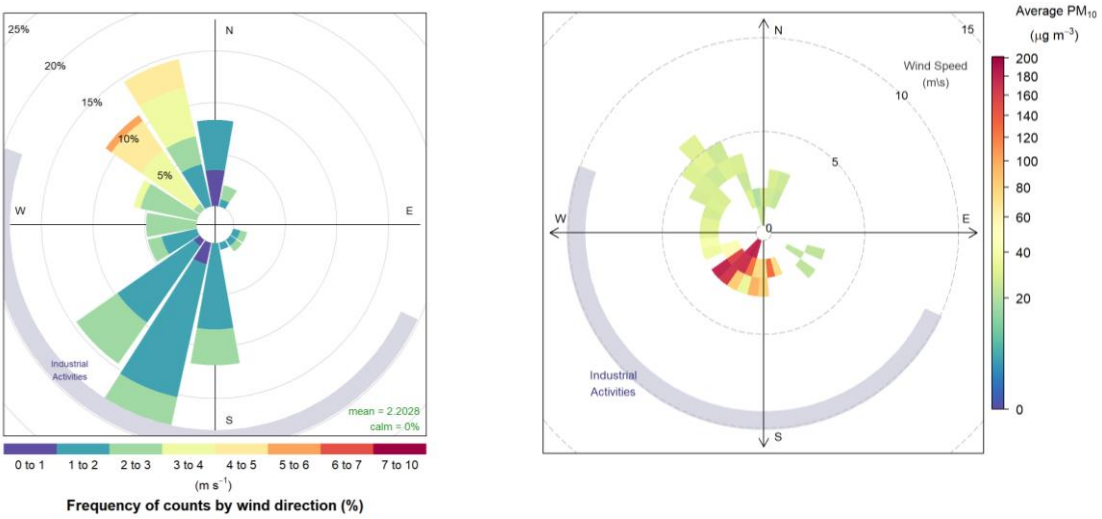

Figure 7-7: **Wind rose (left) and PM_{10} polar plot (right) on 23 October 2021 at Taplin**

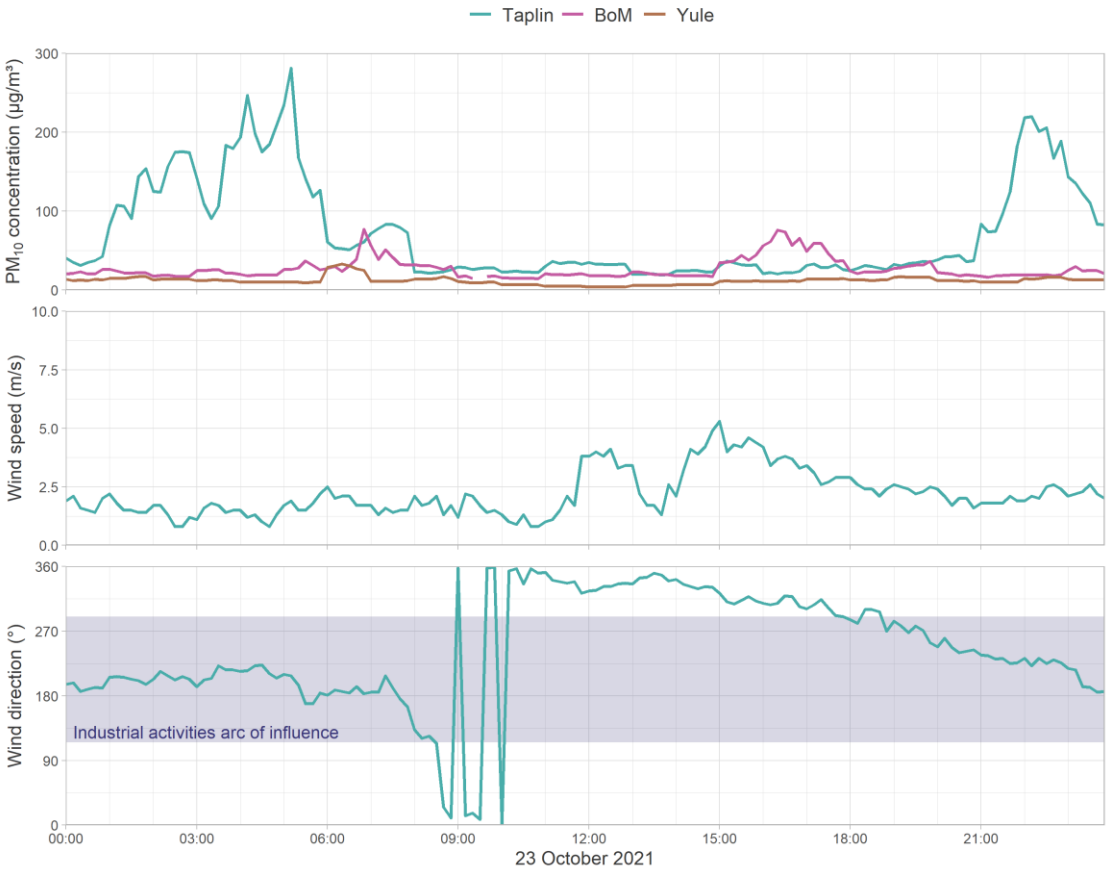

Figure 7-8: **Time series of concentrations of PM_{10} at Taplin, BoM, and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 23 October 2021**

7.3.3 28 November 2021

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
28 November 2021	**89.0**	**72.9**	31.5	Regional and local (non-industry)

On 28 November 2021, the 24-hour average concentration of PM_{10} was 89.0 µg/m³ at Taplin, above the AGV of 70 µg/m³. The 24-hour average concentration of PM_{10} at BoM was 72.9 µg/m³, also above the AGV, while the concentration was well below 60 µg/m³ at Yule. This suggests that, while regional levels may have been slightly elevated, a local event is likely to have occurred at the Taplin site.

A wind rose and PM_{10} polar frequency plot of the Taplin data is shown in Figure 7-9 and a time series plot of concentrations of PM_{10} at Taplin, BoM and Yule and wind speed and wind direction at Taplin is shown in Figure 7-10.

The figures indicate the following:

- Winds were generally light and from the southeast sector, consistent with the industry arc of influence, during the early hours of the morning up to 6am. Between 6am and 5pm winds were moderate to strong up to 8.3 m/s and from the northeast sector, outside the industry arc of influence. From 5pm winds were lighter and from the northwest, shifting to more southwesterlies from 10pm.
- The PM_{10} polar frequency plot indicates that the highest 10-minute average concentrations of PM_{10} (dark red and orange areas) occurred during the moderate to strong winds from the northeast to east-southeast, outside the industry arc of influence.
- The time-series plot shows that the elevated concentrations were measured at Taplin between 8am and 11am while winds were moderate to strong and outside the industry arc of influence. During this period concentrations were also elevated across the background BoM and Yule sites, indicating a regional dust event. The peak dust concentrations at Taplin between 10am and 11am occurred while concentrations were lower at the BoM and Yule sites, indicating that a local non-industry source also contributed to the dust levels at Taplin.

Overall, on 28 November 2021, concentrations of PM_{10} were likely the result of a regional event as well as a local non-industry source.

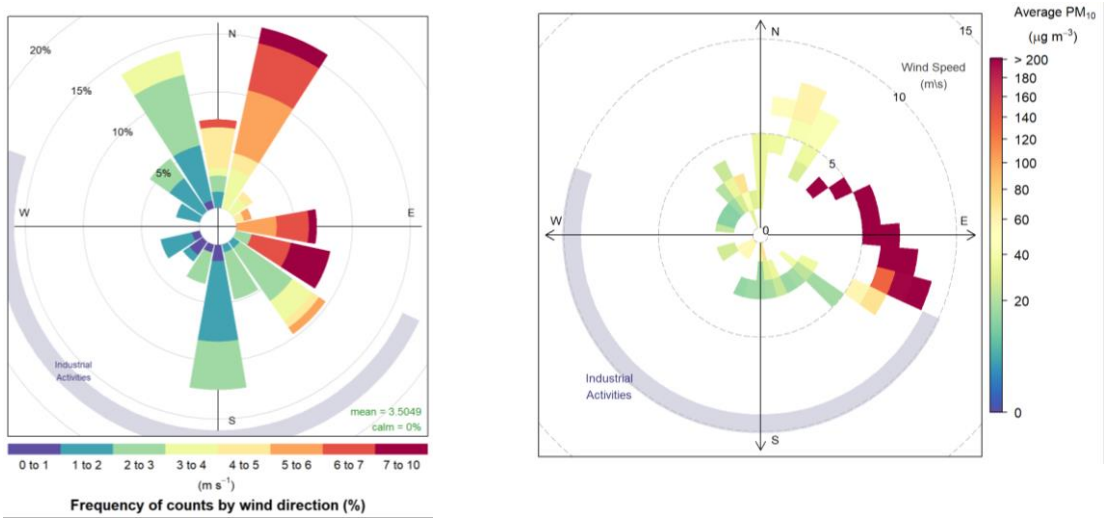

Figure 7-9: **Wind rose (left) and PM_{10} polar plot (right) on 28 November 2021 at Taplin**

Figure 7-10: **Time series of concentrations of PM_{10} at Taplin, BoM, and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 28 November 2021**

7.3.4 6 December 2021

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
6 December 2021	**75.5**	**93.4**	39.1	Regional and local (industry and non-industry)

On 6 December 2021, the 24-hour average concentration of PM_{10} was 75.5 µg/m³ at Taplin, slightly above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} at BoM was 93.4 µg/m³, also above the AGV, while the concentration was below 60 µg/m³ at Yule. This suggests that, while regional levels may have been elevated, a local event is also likely to have occurred at the Taplin site.

A wind rose and PM_{10} polar frequency plot of the Taplin data is shown in Figure 7-11 and a time series plot of concentrations of PM_{10} at Taplin, BoM and Yule and wind speed and wind direction at Taplin is shown in Figure 7-12.

The figures indicate the following:

- Winds were generally moderate from the southwest sector between midnight and 10am, within the industry arc of influence, and moderate from the west-southwest between 10am and 4pm, just outside the industry arc of influence. Winds from 4pm remained moderate and from within the industry arc of influence with the exception of winds from the northwest through to east between 4:30pm and 6pm, and then again between 10:30pm and midnight.
- The PM_{10} polar frequency plots indicate that the highest 10-minute average concentrations of PM_{10} (dark red and orange areas) occurred during the moderate winds south-southwest to northwest, partly within the industry arc of influence, as well as slightly lower concentrations from the northeast to east-southeast, outside the industry arc of influence.
- The time-series plot shows that the BoM site experienced a large spike in concentrations between 4pm and 5pm, with the Taplin and Yule sites experiencing a slight increase during this same period, indicating a regional event. While significantly lower than the peak at BoM, slightly elevated concentrations remained at the BoM and Taplin sites over the next few hours. Slightly elevated concentrations were also measured at Taplin between 5am and 7am while winds were moderate and from within the industry arc of influence and concentrations were lower at BoM and Yule, indicating a local industry source at Taplin.

Overall, on 6 December 2021, concentrations of PM_{10} were likely the result of a regional event as well as local industry and non-industry sources.

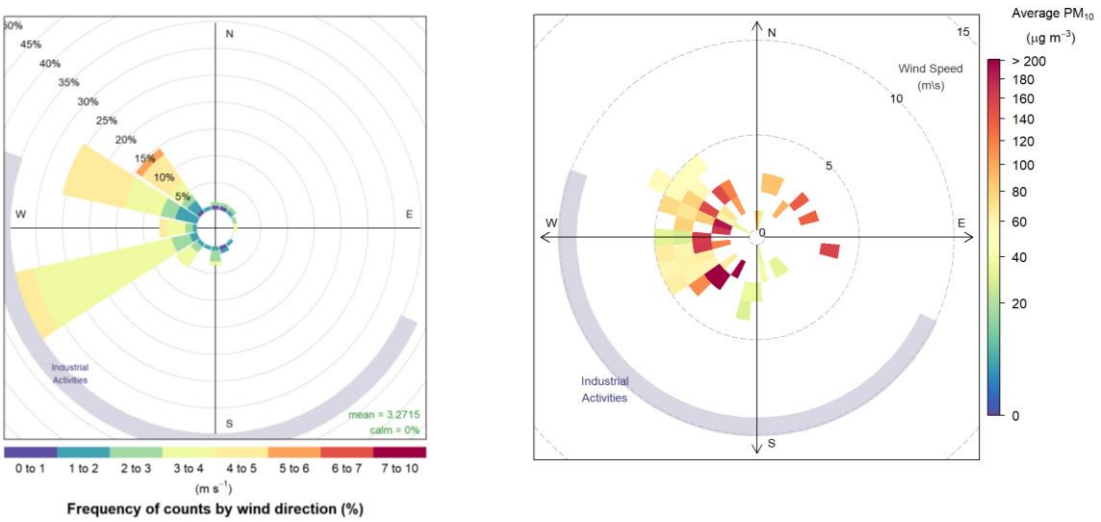

Figure 7-11: Wind rose (left) and PM_{10} polar plot (right) on 6 December 2021 at Taplin

Figure 7-12: Time series of concentrations of PM_{10} at Taplin, BoM, and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 6 December 2021

7.3.5 26 December 2021

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
26 December 2021	**77.8**	40.1	21.3	Local (industry)

On 26 December 2021, the 24-hour average concentration of PM_{10} was 77.8 µg/m³ at Taplin, slightly above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} at BoM and Yule were below 60 µg/m³, indicating a local event occurring at Taplin.

A wind rose and PM_{10} polar frequency plot of the Taplin data is shown in Figure 7-13 and a time series plot of concentrations of PM_{10} at Taplin, BoM and Yule and wind speed and wind direction at Taplin is shown in Figure 7-14.

The figures indicate the following:

- Winds were generally light and from the southeast to southwest between midnight and 10am, within the industry arc of influence. Winds between 10am and 3pm were stronger (up to 5 m/s) and primarily from the northwest sector, just outside the industry arc of influence. From 3pm winds were generally moderate and from within the industry arc of influence.
- The PM_{10} polar frequency plots indicate that the highest 10-minute average concentrations of PM_{10} (dark red and orange areas) occurred during the light to moderate winds from the southwest to west-northwest, within the industry arc of influence.
- The time-series plot shows that the elevated concentrations were measured at Taplin between midnight and 9am and then again between 5pm and midnight while winds were light and from within the industry arc of influence and concentrations were generally lower at BoM and Yule. This indicates a local industry source at Taplin.

Overall, on 26 December 2021, concentrations of PM_{10} were likely the result of a local industry source.

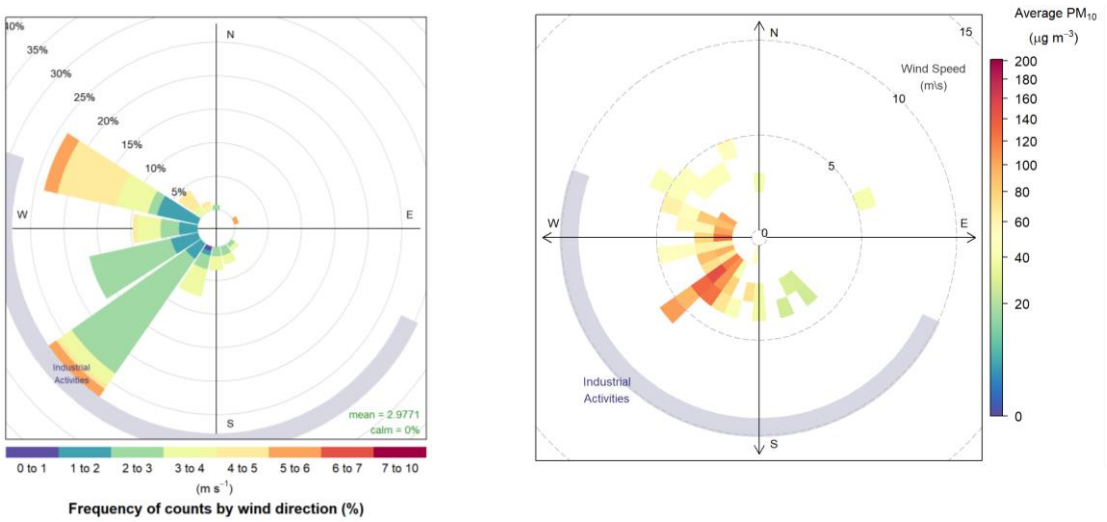

Figure 7-13: Wind rose (left) and PM_{10} polar plot (right) on 26 December 2021 at Taplin

Figure 7-14: Time series of concentrations of PM_{10} at Taplin, BoM, and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 26 December 2021

8. CONCLUSIONS

Port Hedland, a regional town in Western Australia, is home to the world's largest iron ore export port. Air quality, and specifically dust, has been recognised as a significant environmental issue for Port Hedland. PHIC was founded in 2009 and operated the PHIC ambient air quality monitoring network, consisting of eight (8) stations distributed across the region, until January 2022, when operational control was passed to DWER.

PHIC commissioned Katestone Environmental Pty Ltd (Katestone) to prepare this six-month performance report on the Port Hedland ambient air quality monitoring network for the July to December 2021 period.

The report findings are summarised below.

8.1 PM_{10}

Analysis of the PM_{10} data found the following:

- The Taplin monitoring station recorded five days above the 24-hour average AGV for PM_{10} of 70 µg/m³ (15 August, 23 October, 28 November, 6 December, and 26 December).
- Detailed analysis of the monitoring data during each exceedance day showed the following:
    - The exceedance at the Taplin site on 15 August 2021 is believed to have likely been the result of local industry and non-industry sources
    - The exceedance events at the Taplin site on 23 October 2021 and 26 December 2021 are believed to have likely been the result of a local industry source
    - The exceedance at the Taplin site on 28 November 2021 is believed to have likely been the result of a regional event as well as a local non-industry source
    - The exceedance at the Taplin site on 6 December 2021 is believed to have likely been the result of local industry and non-industry sources as well as a contribution from a regional event.
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites during the July to December 2021 period. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 1 day at Yule to 76 days at Richardson.
- The number of days above the PM_{10} AAQ NEPM standard at each monitoring station for the six-month July to December 2021 period and for each year since FY 2012/13 have been presented; however, the trend to FY 2021/22 will be more apparent when the full twelve months of data is available for this financial year.
- The six-month average concentrations of PM_{10} for the July to December 2021 period at each site has been presented in this summary report and an assessment to track levels against the annual AAQ NEPM criteria has been carried out using monitoring data from the previous FY 2020/21 period.

8.2 $PM_{2.5}$

Analysis of the $PM_{2.5}$ data found the following:

- The 24-hour average concentrations of $PM_{2.5}$ were below the AAQ NEPM standard of 25 µg/m³ at all monitoring stations during the July to December 2021 period.
- The six-month average concentrations of $PM_{2.5}$ for the July to December 2021 period at each site has been presented in this summary report and an assessment to track levels against the annual AAQ NEPM criteria has been carried out using monitoring data from the previous FY 2020/21 period.

8.3 NO_2

Analysis of the NO_2 data found that, for the period of available data, the concentrations of NO_2 measured at Taplin during the July to December 2021 period were low and well below the AAQ NEPM standards. Concentrations were consistent with the NO_2 concentrations measured in previous years.

The six-month average concentrations of NO_2 for the July to December 2021 period at each site has been presented in this summary report and an assessment to track levels against the annual AAQ NEPM criteria has been carried out using monitoring data from the previous FY 2020/21 period.

8.4 Data Capture

The Taplin monitoring station achieved a lower data capture rate for NO_X of 72% for the six-month July to December 2021 period which is below the PHIC criterion of 75% data capture. The Taplin site achieved a capture rate of 95% for the October to December quarter; however, ongoing instrument faults and non-scheduled maintenance lowered the capture during the July to September quarter to 48%, below the criterion.

The quarterly and six-monthly data capture criterion of 75% was met for all other pollutants at all monitoring stations during the six-month July to December 2021 period.

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10. APPENDIX A – Exceedance Analysis at Richardson, Kingsmill, and Neptune during November and December 2021

This appendix provides the detailed analysis for exceedance events at Kingsmill, Richardson, and Neptune during November and December 2021 using the methodology outlined in Section 7 of this report. The detailed analysis of exceedance events during the July-August 2021 and September-October 2021 bimonthly periods are provided in the bimonthly reports for these two periods (Katestone, 2021a, 2021b).

10.1 28 November 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
28 November 2021	64.6	**71.5**	33.7	**89.0**	**72.9**	31.5	Regional and local (industry)

On 28 November 2021, the 24-hour average concentration of PM_{10} was 71.5 µg/m³ at Kingsmill, 89.0 µg/m³ at Taplin, and 72.9 µg/m³ at BoM, which are all above the AGV of 70 µg/m³. The elevated concentration across these three sites along with a 24-hour average concentration that was over 60 µg/m³ at the Richardson site indicates that a likely regional event likely occurred at Kingsmill and Taplin during this period.

A wind rose and PM_{10} polar frequency plot of the Kingsmill data for 28 November 2021 is shown in Figure 10-1 and a time series plot of concentrations of PM_{10} at Kingsmill, BoM, and Yule as well as wind speed and wind direction at Kingsmill for this period is shown in Figure 10-2.

A wind rose and PM_{10} polar frequency plot of the Taplin data for 28 November 2021 and a time series plot of concentrations of PM_{10} at Taplin, BoM, and Yule as well as wind speed and wind direction at Taplin for this period is shown in Section 7.3 of the main report.

Overall, on 28 November 2021, winds were from both within and outside the industry arc of influence while concentrations of PM_{10} at Kingsmill were elevated. During the hours of midnight and 5am winds were from within the industry arc of influence and concentrations were lower at BoM and Yule, indicating a local industry source south of the Kingsmill site. Later in the day, during the hours of 7am and 11am, winds outside the industry arc of influence and background concentrations were elevated, particularly at BoM. Therefore, this has been classified as both a regional and local industry event at Kingsmill.

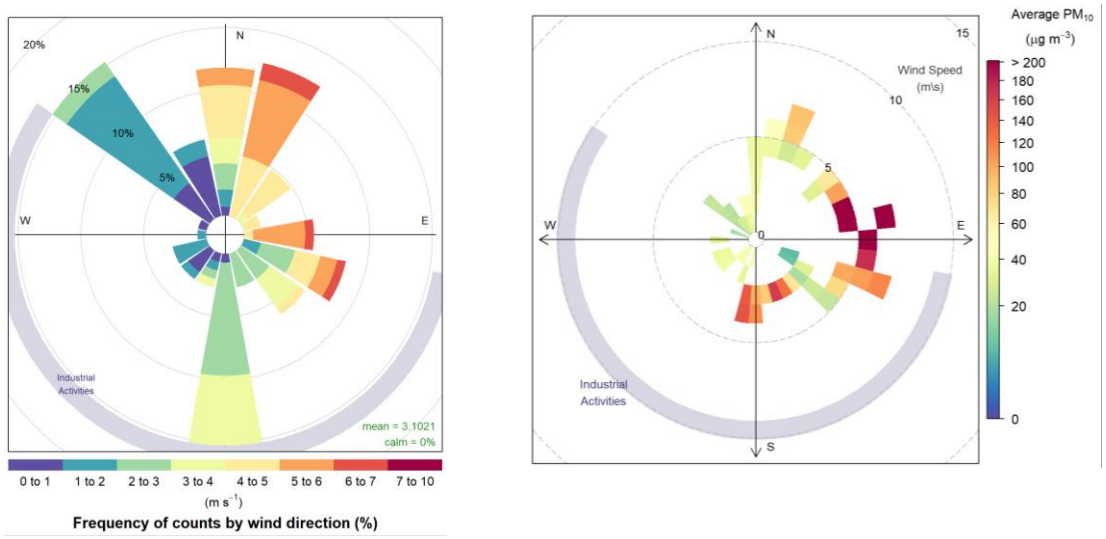

Figure 10-1: **Wind rose (left) and PM_{10} polar frequency plot (right) on 28 November 2021 at Kingsmill monitoring station**

Figure 10-2: **Time series of concentrations of PM_{10} at Kingsmill, BoM, and Yule (top) and wind speed at Kingsmill (middle) and wind direction at Kingsmill (bottom) on 28 November 2021**

10.2 2 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
2 December 2021	**82.0**	62.4	47.8	59.0	44.3	28.0	Regional and local (industry)

On 2 December 2021, the 24-hour average concentration of PM_{10} was 82.0 µg/m³ at Richardson, which is above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} were elevated at the Kingsmill, Neptune, Taplin, and BoM monitoring stations, indicating the influence of elevated regional levels during this period.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 2 December 2021 is shown in Figure 10-3 and a time series plot of concentrations of PM_{10} at Richardson, BoM, and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-4.

Overall, on 2 December 2021, winds were from the direction of industry throughout the full 24-hour period, including those times when concentrations of PM_{10} at Richardson were elevated. With the exception of the period between 10am and 4pm, similar concentrations occurred across the Richardson, BoM, and Yule monitoring sites, indicating the impact of elevated regional levels at Richardson. Between the hours of 10am and 4pm concentrations increased at the Richardson site while levels remained relatively low at the background sites, indicating a local industry source at Richardson during these hours. Therefore, this event has been classified as both a regional and local industry event.

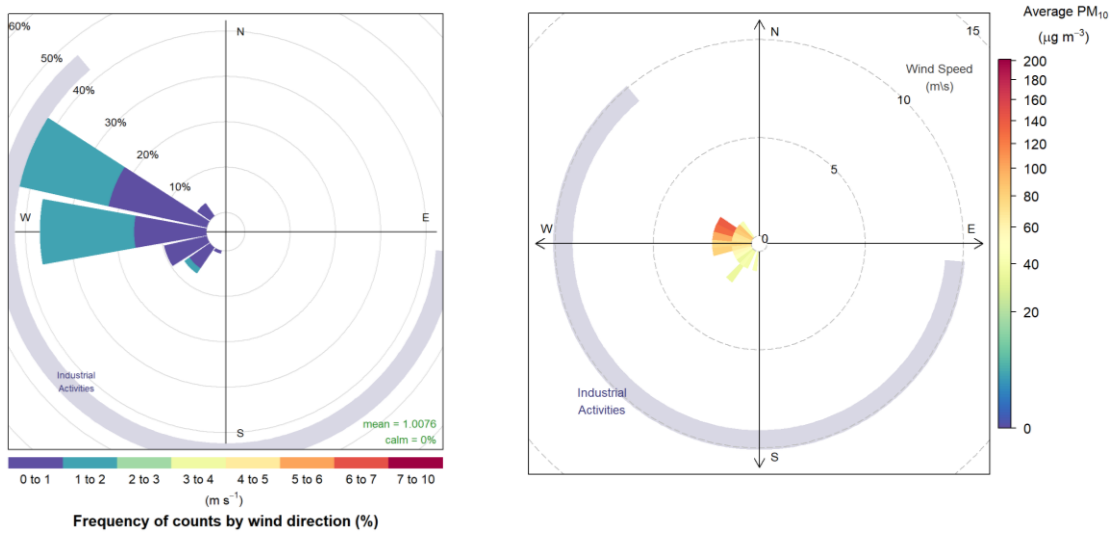

Figure 10-3: **Wind rose (left) and PM_{10} polar frequency plot (right) on 2 December 2021 at Richardson monitoring station**

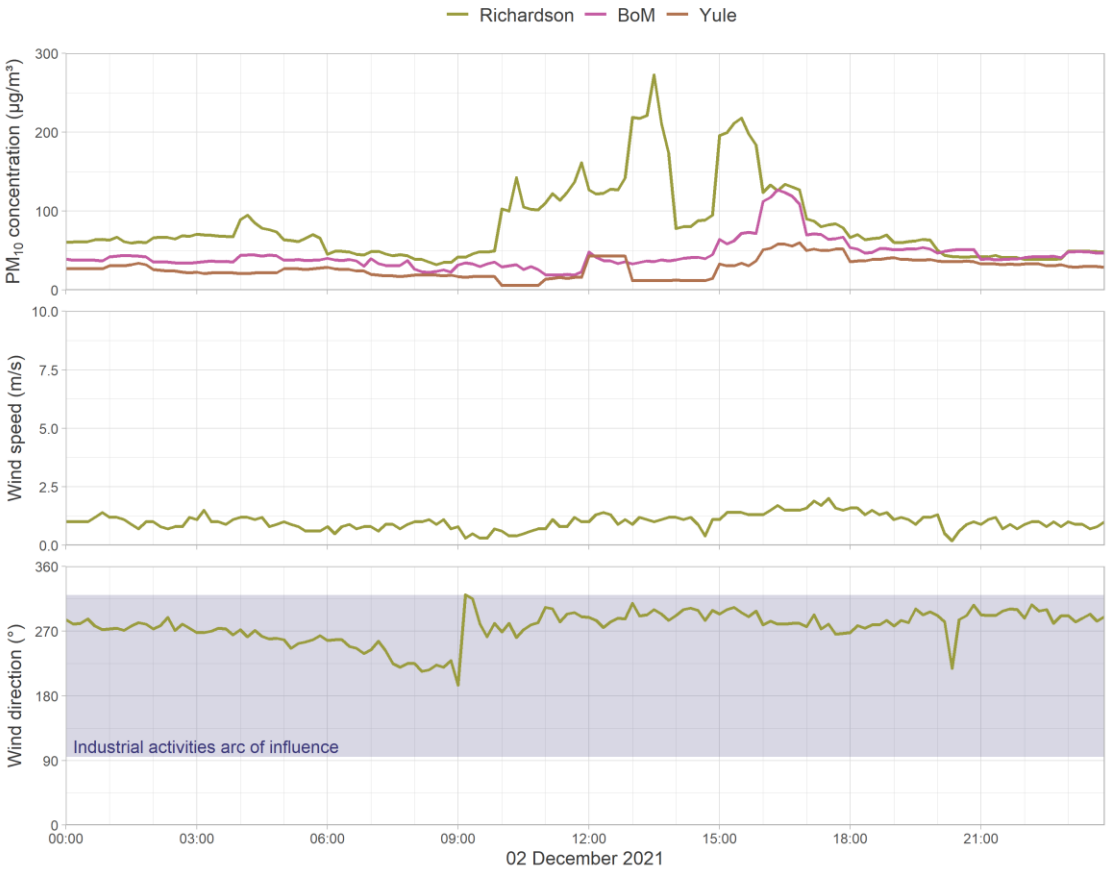

Figure 10-4: **Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 2 December 2021**

10.3 3 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
3 December 2021	**72.9**	55.3	46.0	56.4	40.5	21.8	Regional and local (industry)

On 3 December 2021, the 24-hour average concentration of PM_{10} was 72.9 µg/m³ at Richardson, which is above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} were slightly elevated at the Kingsmill, Neptune, Taplin, and BoM monitoring stations, indicating the influence of elevated regional levels during this period.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 3 December 2021 is shown in Figure 10-5 and a time series plot of concentrations of PM_{10} at Richardson, BoM, and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-6.

Overall, on 3 December 2021, winds were from the direction of industry throughout the full 24-hour period, including those times when concentrations of PM_{10} at Richardson were elevated. With the exception of the period between 4am and 5pm, similar concentrations occurred across the Richardson, BoM, and Yule monitoring sites, indicating the impact of elevated regional levels at Richardson. Between the hours of 4am and 5pm concentrations increased at the Richardson site while levels remained relatively low at the background sites, indicating a local industry source at Richardson during these hours. Therefore, this event has been classified as both a regional and local industry event.

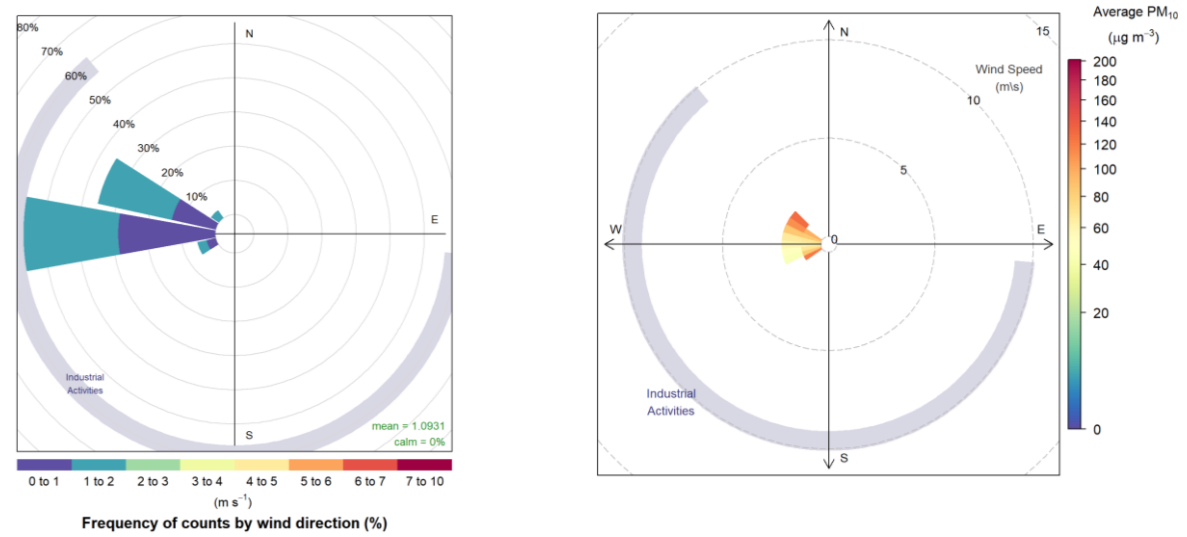

Figure 10-5: **Wind rose (left) and PM_{10} polar frequency plot (right) on 3 December 2021 at Richardson monitoring station**

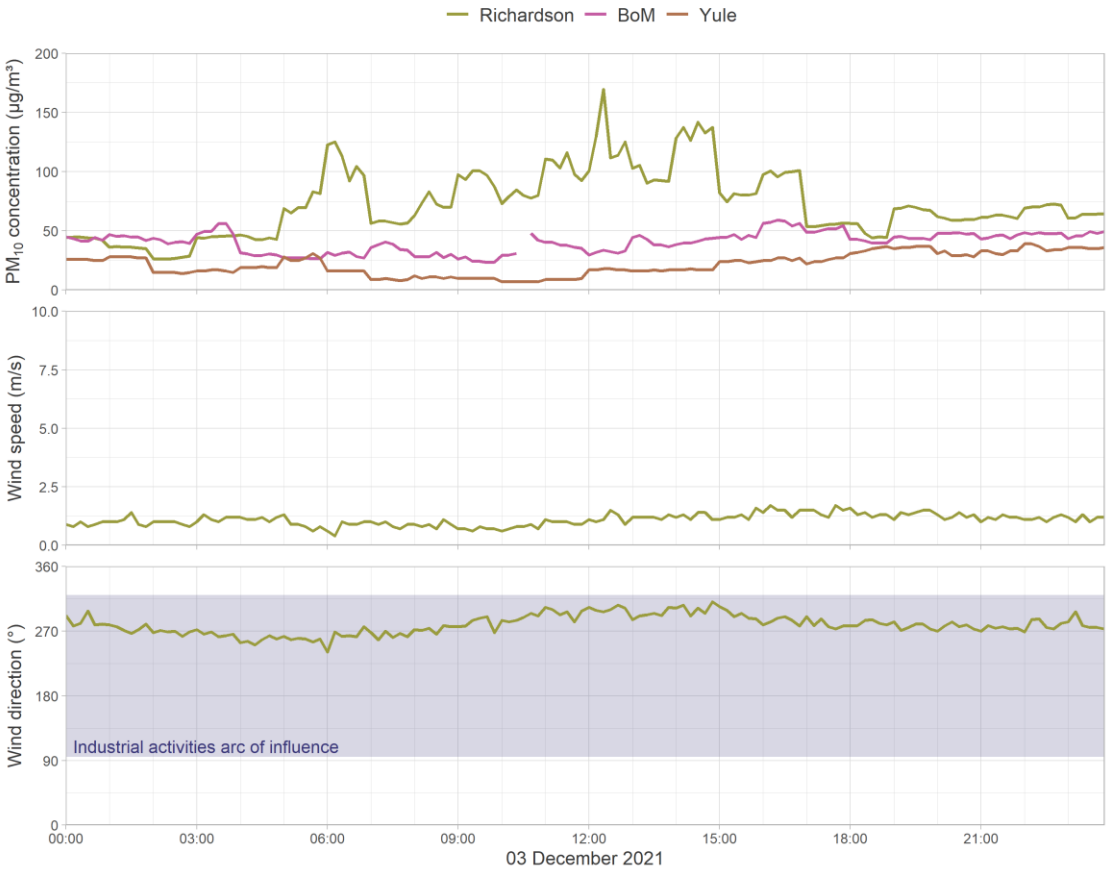

Figure 10-6: **Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 3 December 2021**

10.4 4 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
4 December 2021	**83.0**	56.4	51.6	59.8	40.7	23.3	Regional and local (industry)

On 4 December 2021, the 24-hour average concentration of PM_{10} was 83.0 µg/m³ at Richardson, which is above the AGV of 70 µg/m³. The 24-hour average concentrations of PM_{10} were slightly elevated at the Kingsmill, Neptune, Taplin, and BoM monitoring stations, indicating the influence of elevated regional levels during this period.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 4 December 2021 is shown in Figure 10-7 and a time series plot of concentrations of PM_{10} at Richardson, BoM, and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-8.

Overall, on 4 December 2021, winds were from the direction of industry throughout the full 24-hour period, including those times when concentrations of PM_{10} at Richardson were elevated. With the exception of the period between 8am and 5pm, similar concentrations occurred across the Richardson, BoM, and Yule monitoring sites, indicating the impact of elevated regional levels at Richardson. Between the hours of 8am and 5pm concentrations increased at the Richardson site while levels remained relatively low at the background sites, indicating a local industry source at Richardson during these hours. Therefore, this event has been classified as both a regional and local industry event.

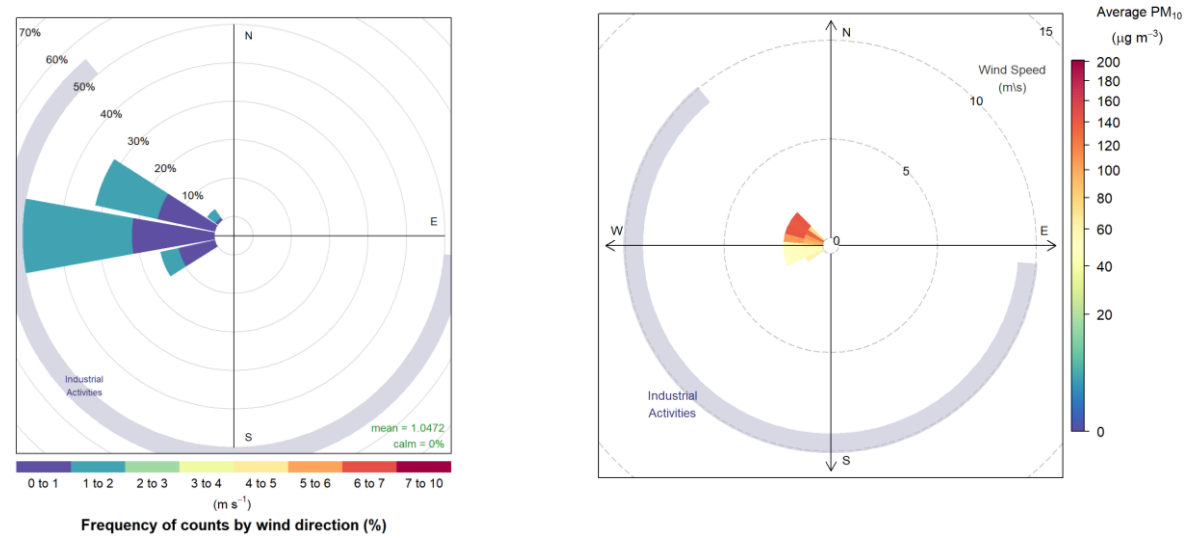

Figure 10-7: **Wind rose (left) and PM_{10} polar frequency plot (right) on 4 December 2021 at Richardson monitoring station**

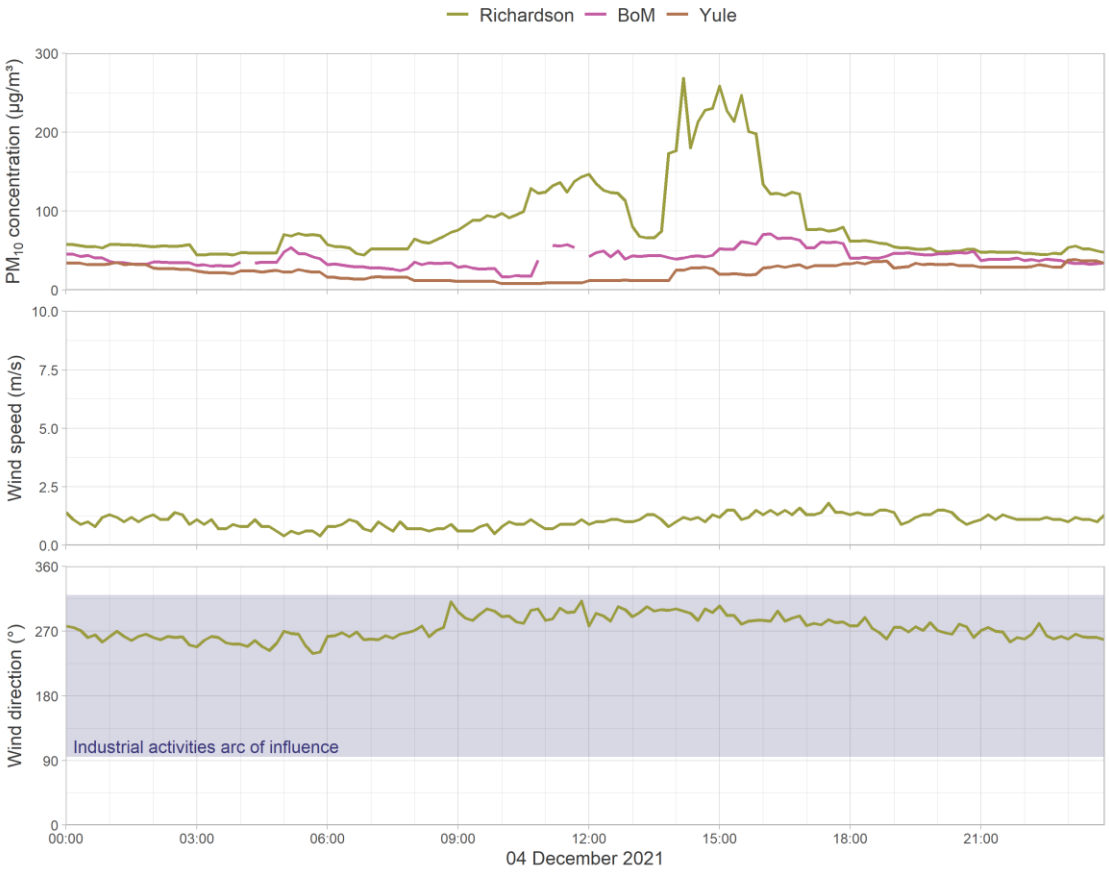

Figure 10-8: **Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 4 December 2021**

10.5 6 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
6 December 2021	**88.5**	**87.3**	65.7	**75.5**	**93.4**	39.1	Regional and local (industry and non-industry)

On 6 December 2021, the 24-hour average concentration of PM_{10} was 88.5 µg/m³ at Richardson, 87.3 µg/m³ at Kingsmill, 75.5 µg/m³ at Taplin, and 93.4 µg/m³ at BoM, all above the AGV of 70 µg/m³. The 24-hour average concentration was also above 60 µg/m³ at Neptune. Elevated concentrations across all five sites indicates a regional event occurred at Richardson, Kingsmill, and Taplin.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 6 December 2021 is shown in Figure 10-9 and a time series plot of concentrations of PM_{10} at Richardson, BoM, and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-10.

A wind rose and PM_{10} polar frequency plot of the Kingsmill data for 6 December 2021 is shown in Figure 10-11 and a time series plot of concentrations of PM_{10} at Kingsmill, BoM, and Yule as well as wind speed and wind direction at Kingsmill for this period is shown in Figure 10-12.

A wind rose and PM_{10} polar frequency plot of the Taplin data for 6 December 2021 and a time series plot of concentrations of PM_{10} at Taplin, BoM, and Yule as well as wind speed and wind direction at Taplin for this period is shown in Section 7.3 of the main report.

Overall, on 6 December 2021, peak concentrations occurred across all sites between 4pm and 5pm, including a large spike in concentration at the BoM site, indicating a regional event. While significantly lower than the peak at BoM, slightly elevated concentrations remained at the BoM, Richardson, Kingsmill, and Taplin sites over the next few hours. Slightly elevated concentrations were also measured at Richardson and Kingsmill between 7am and 8am while winds were light and from within the industry arc of influence and concentrations were lower at BoM and Yule, indicating a local industry source at Taplin and Kingsmill. Therefore, this has been classified as a regional and local industry and non-industry event.

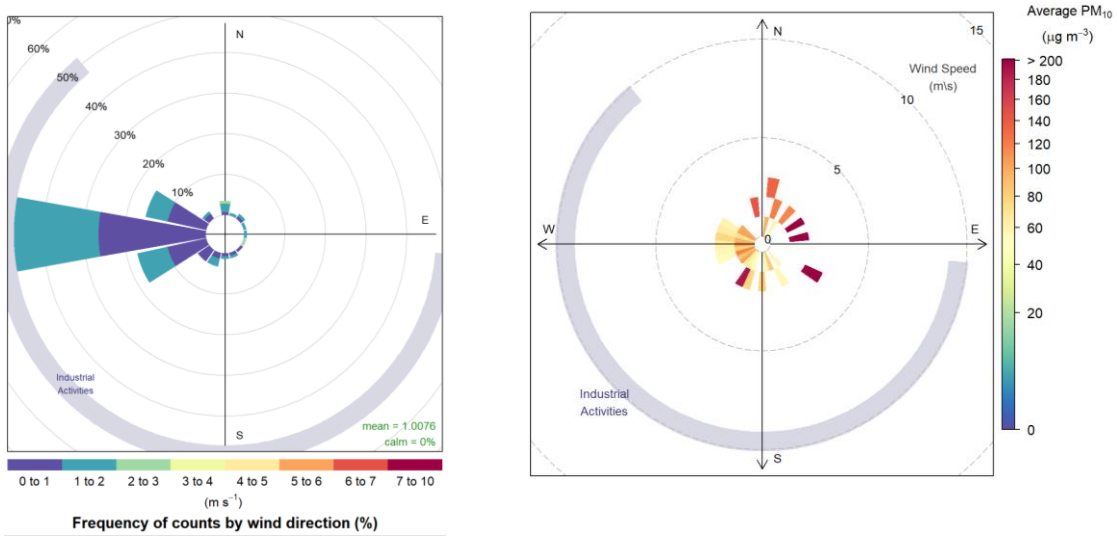

Figure 10-9: **Wind rose (left) and PM_{10} polar frequency plot (right) on 6 December 2021 at Richardson monitoring station**

Figure 10-10: **Time series of concentrations of PM_{10} at Kingsmill, BoM and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 6 December 2021**

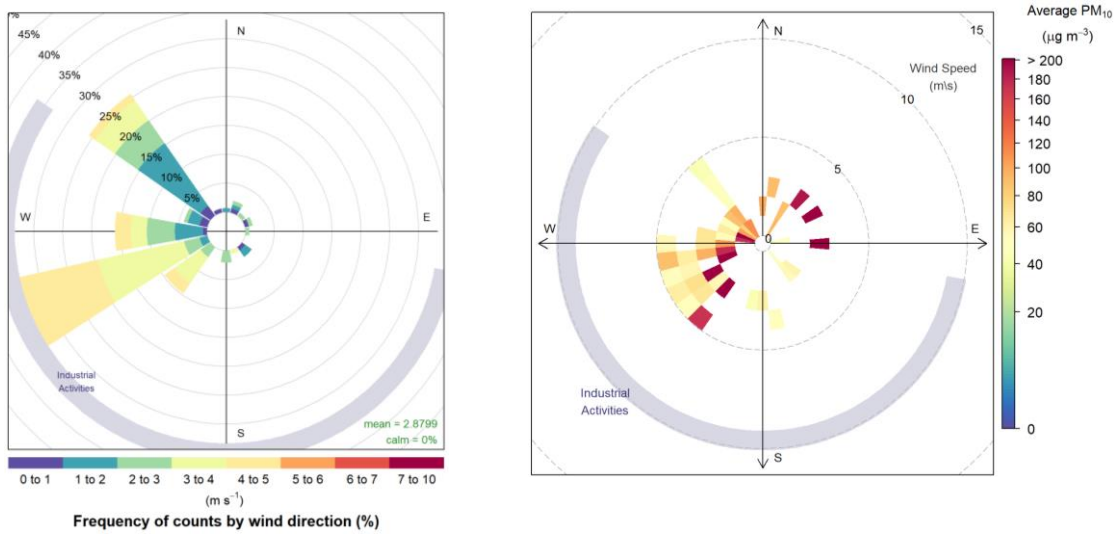

Figure 10-11: Wind rose (left) and PM_{10} polar frequency plot (right) on 6 December 2021 at Kingsmill monitoring station

Figure 10-12: Time series of concentrations of PM_{10} at Kingsmill, BoM, and Yule (top) and wind speed at Kingsmill (middle) and wind direction at Kingsmill (bottom) on 6 December 2021

10.6 10 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
10 December 2021	**92.2**	42.7	43.3	34.9	39.9	26.1	Local (industry)

On 10 December 2021, the 24-hour average concentration of PM_{10} was 92.2 µg/m³ at Richardson, above the AGV of 70 µg/m³. Concentrations were below 60 µgm³ at the Kingsmill, Neptune, Taplin, BoM, and Yule sites which indicates a local event occurred at the Richardson site.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 10 December 2021 is shown in Figure 10-13 and a time series plot of concentrations of PM_{10} at Richardson, BoM and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-14.

Overall, on 10 December 2021, the exceedance event at Richardson is due to peak concentrations that occurred at the site between 1pm and 6pm while winds were from within the industry arc of influence and concentrations were lower at BoM and Yule. Therefore, this has been classified as a local industry event.

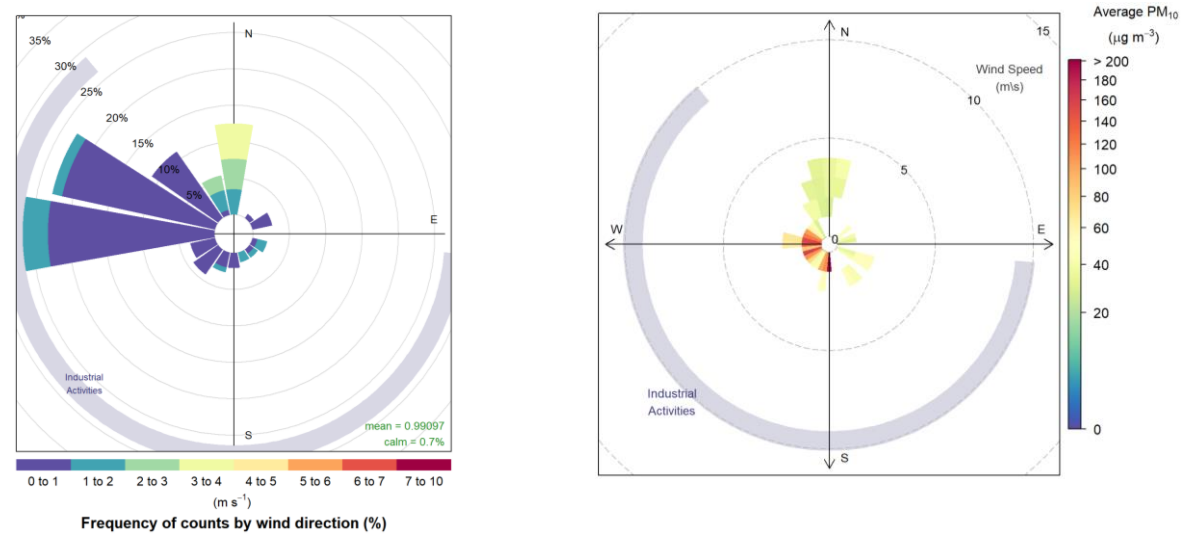

Figure 10-13: **Wind rose (left) and PM_{10} polar frequency plot (right) on 10 December 2021 at Richardson monitoring station**

Figure 10-14: **Time series of concentrations of PM_{10} at Richardson, BoM and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 10 December 2021**

10.7 14 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
14 December 2021	**92.6**	57.6	48.2	59.4	48.5	21.9	Regional and local (industry)

On 14 December 2021, the 24-hour average concentration of PM_{10} was 92.6 µg/m³ at Richardson, above the AGV of 70 µg/m³. Concentrations were elevated but below 60 µgm³ at Kingsmill, Neptune, Taplin, and BoM, indicating that, while regional levels may have been slightly elevated, a local event is likely to have occurred at the Richardson site during this period.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 14 December 2021 is shown in Figure 10-15 and a time series plot of concentrations of PM_{10} at Richardson, BoM and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-16.

Overall, on 14 December 2021, winds were from the direction of industry throughout the full 24-hour period, including those times when concentrations of PM_{10} at Richardson were elevated. With the exception of the period between 8am and 6pm, similar concentrations occurred across the Richardson and BoM monitoring sites, indicating the impact of elevated regional levels at Richardson. Between the hours of 8am and 6pm concentrations increased at the Richardson site while levels remained relatively low at the background sites, indicating a local industry source at Richardson during these hours. Therefore, this event has been classified as both a regional and local industry event.

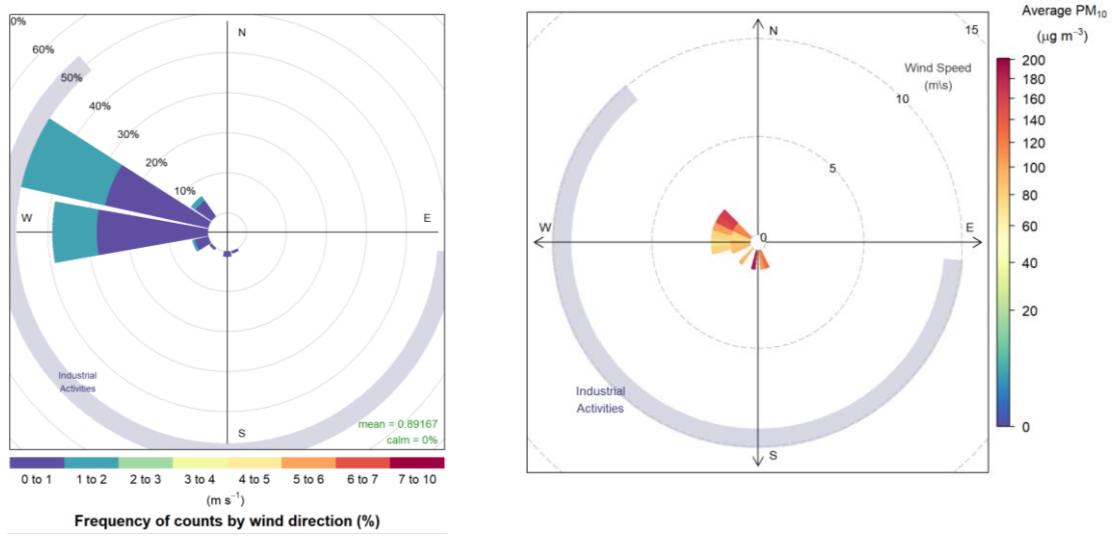

Figure 10-15: **Wind rose (left) and PM_{10} polar frequency plot (right) on 14 December 2021 at Richardson monitoring station**

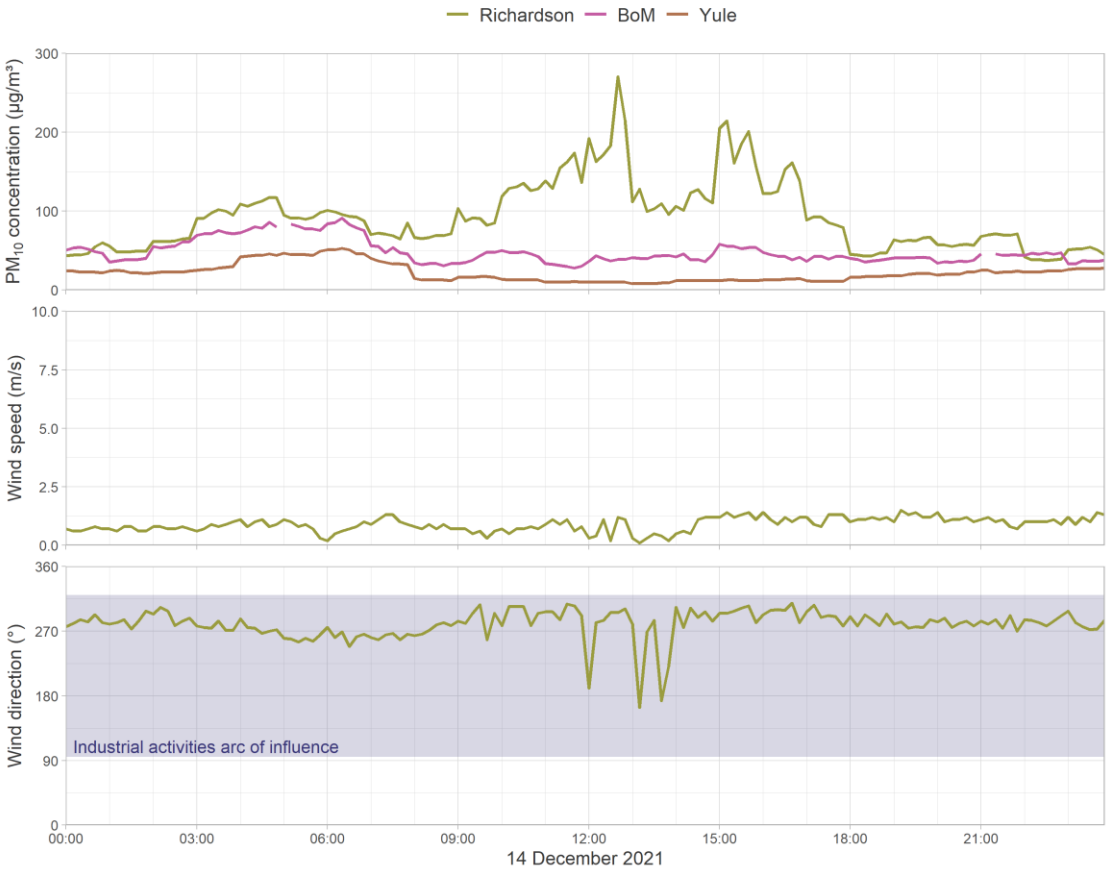

Figure 10-16: **Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 14 December 2021**

10.8 19 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
19 December 2021	**71.8**	60.3	37.8	59.4	40.3	24.6	Regional and local (industry)

On 19 December 2021, the 24-hour average concentration of PM_{10} was 71.8 µg/m³ at Richardson, above the AGV of 70 µg/m³. The 24-hour average concentration at Kingsmill was over 60µg/m³ which indicates a possible regional event occurring at Richardson and Kingsmill. Concentrations were also elevated but below 60 µgm³ at Neptune, Taplin, and BoM, indicating that, while regional levels may have been elevated, a local event is also likely to have occurred at the Richardson site during this period.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 19 December 2021 is shown in Figure 10-17 and a time series plot of concentrations of PM_{10} at Richardson, BoM and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-18.

Overall, on 19 December 2021, winds were predominantly from the direction of industry throughout the full 24-hour period, including those times when concentrations of PM_{10} at Richardson were elevated. Concentrations were elevated at Richardson between 7am and 11pm, while lower levels were generally recorded at the BoM and Yule monitoring sites, indicating a local industry source at Richardson. Concentrations increased slightly at the BoM site during the afternoon period, indicating the potential influence of elevated regional dust levels at Richardson. Therefore, this has been classified as a regional and local industry event.

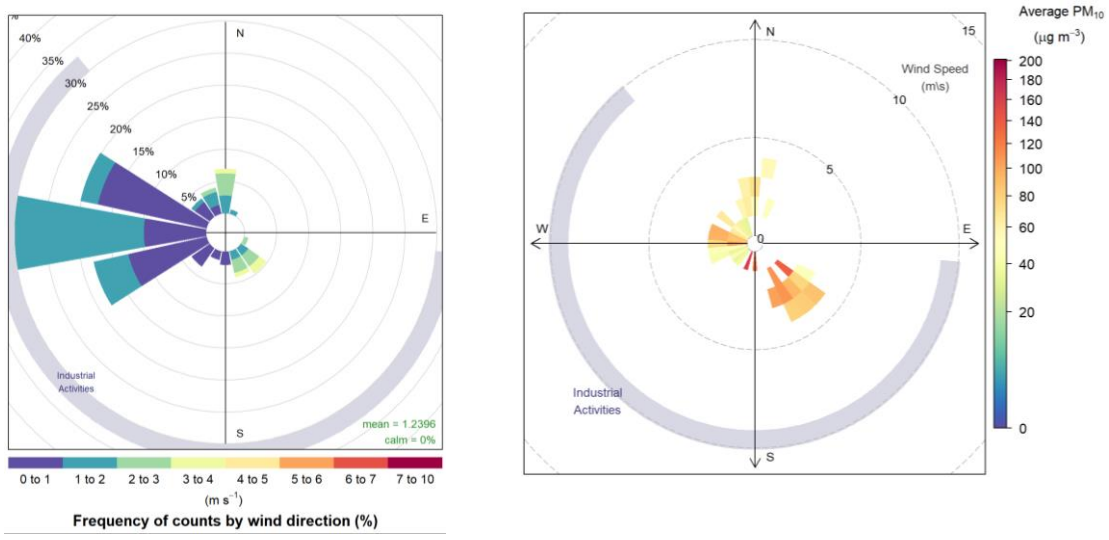

Figure 10-17: Wind rose (left) and PM_{10} polar frequency plot (right) on 19 December 2021 at Richardson monitoring station

Figure 10-18: Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 19 December 2021

10.9 20 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
20 December 2021	**99.1**	**128.7**	43.3	54.5	43.9	33.2	Local (non-industry)

On 20 December 2021, the 24-hour average concentration of PM_{10} was 99.1 µg/m³ at Richardson and 128.7 µg/m³ at Kingsmill, both above the AGV of 70 µg/m³. Concentrations were also elevated but below 60 µgm³ at Neptune, Taplin, and BoM, indicating that, while regional levels may have been slightly elevated, a local event is also likely to have occurred at the Richardson and Kingsmill sites during this period.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 20 December 2021 is shown in Figure 10-19 and a time series plot of concentrations of PM_{10} at Richardson, BoM and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-20.

A wind rose and PM_{10} polar frequency plot of the Kingsmill data for 20 December 2021 is shown in Figure 10-21 of the main report, and a time series plot of concentrations of PM_{10} at Kingsmill, BoM and Yule as well as wind speed and wind direction at Kingsmill for this period is shown in Figure 10-22.

Overall, on 20 December 2021, the exceedance event at Richardson and Kingsmill was due to peak concentrations that occurred at both sites between 4am and 6am and then again between 7am and 9am. These peak concentrations occurred while winds were predominantly from outside the industry arc of influence, and while regional levels were lower. Therefore, this has been classified as a local non-industry event.

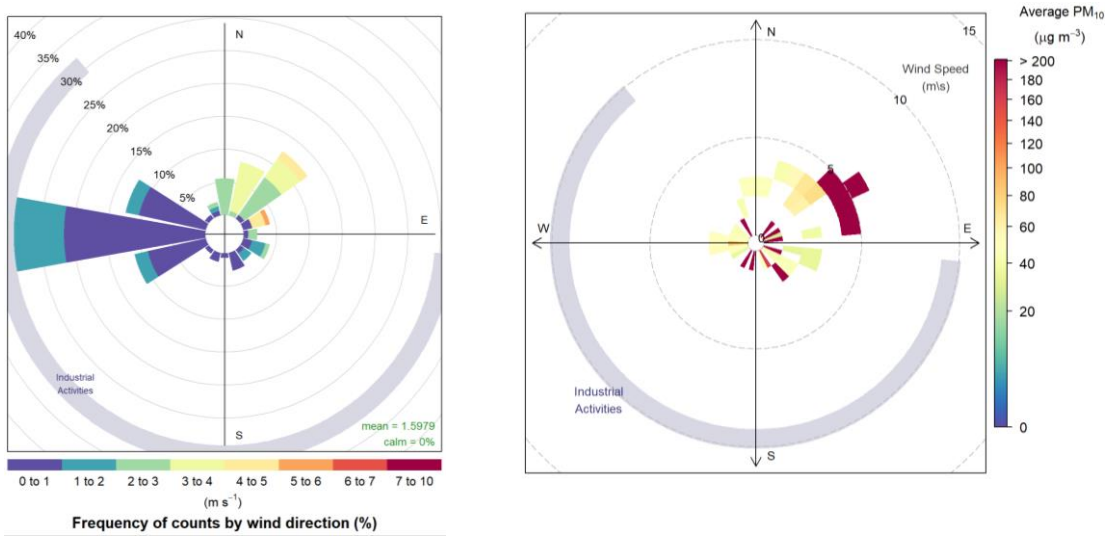

Figure 10-19: Wind rose (left) and PM_{10} polar frequency plot (right) on 20 December 2021 at Richardson monitoring station

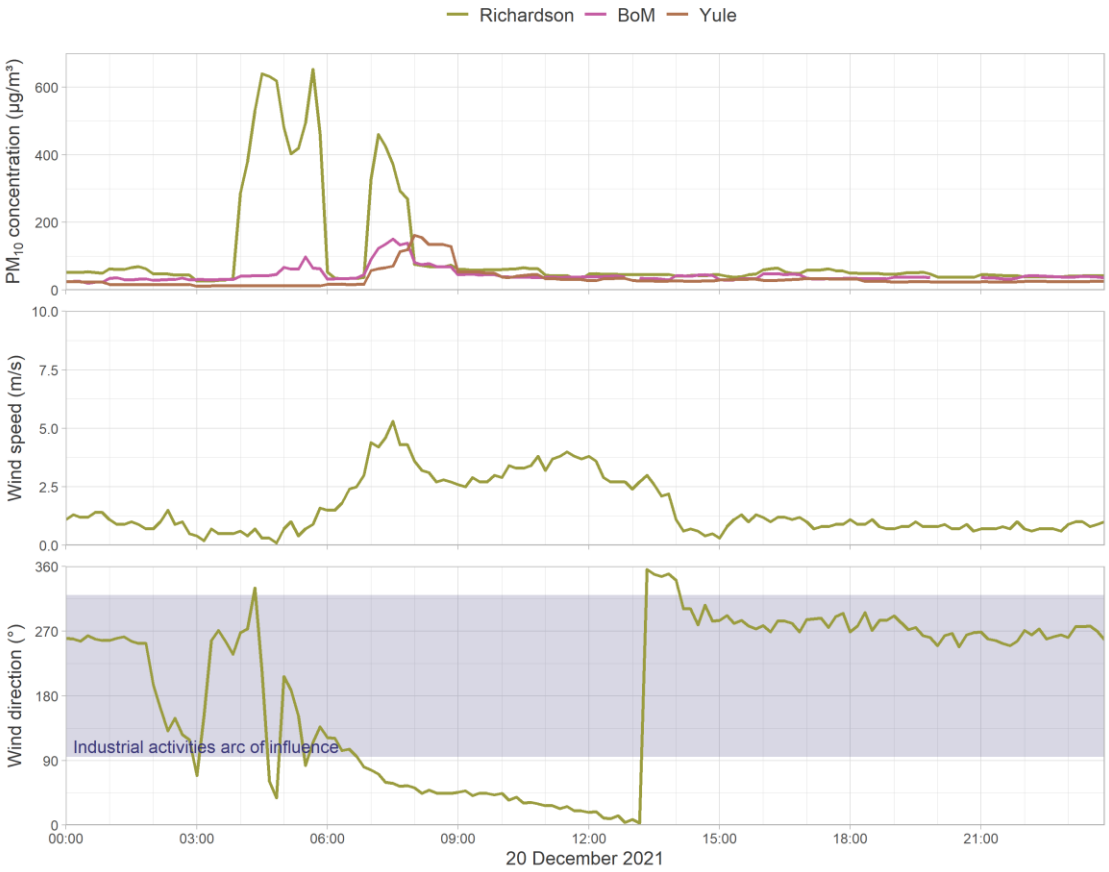

Figure 10-20: Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 20 December 2021

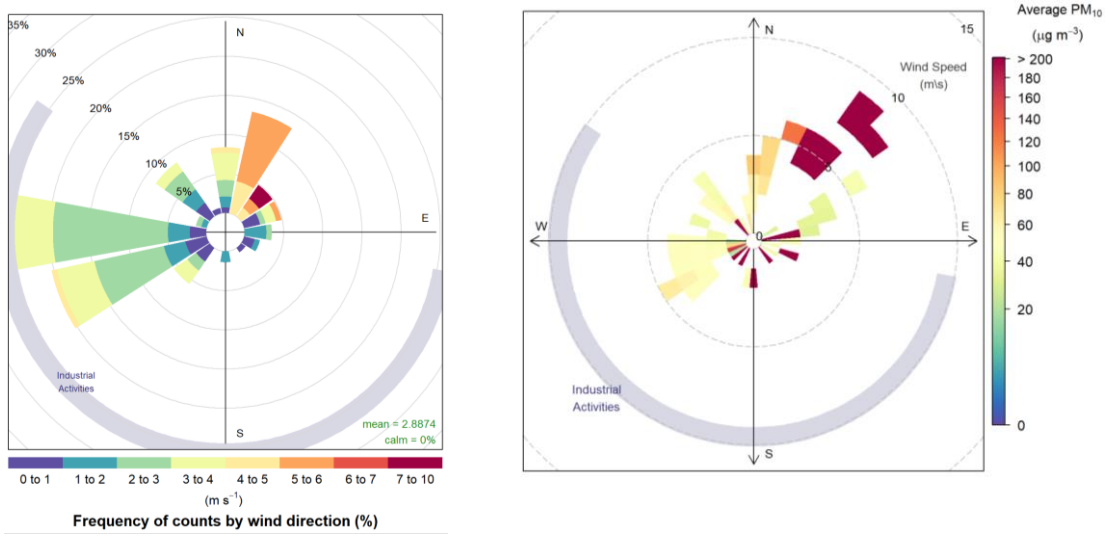

Figure 10-21: Wind rose (left) and PM_{10} polar frequency plot (right) on 20 December 2021 at Kingsmill monitoring station

Figure 10-22: Time series of concentrations of PM_{10} at Kingsmill, BoM, and Yule (top) and wind speed at Kingsmill (middle) and wind direction at Kingsmill (bottom) on 20 December 2021

10.10 28 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
28 December 2021	**72.9**	**73.3**	49.0	69.1	54.0	30.1	Regional and local (industry)

On 28 December 2021, the 24-hour average concentration of PM_{10} was 72.9 µg/m³ at Richardson and 73.3 µg/m³ at Kingsmill, both above the AGV of 70 µg/m³, while the concentration at the Taplin site was also elevated at 69.1 µg/m³. The 24-hour average concentrations of PM_{10} at the Neptune and BoM monitoring stations were slightly elevated but below 60 µg/m³, indicating that, while regional levels may have been slightly elevated, a local event likely occurred at Richardson and Kingsmill.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 28 December 2021 is shown in Figure 10-23 and a time series plot of concentrations of PM_{10} at Richardson, BoM and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-24.

A wind rose and PM_{10} polar frequency plot of the Kingsmill data for 28 December 2021 is shown in Figure 10-25 of the main report, and a time series plot of concentrations of PM_{10} at Kingsmill, BoM and Yule as well as wind speed and wind direction at Kingsmill for this period is shown in Figure 10-26.

Overall, on 28 December 2021, winds were predominantly from the direction of industry throughout the full 24-hour period, including those times when concentrations of PM_{10} at Richardson and Kingsmill were elevated. Concentrations were elevated at Richardson between 5am and 4pm, and at Kingsmill between 2am and 3pm. During these periods concentrations were generally lower at BoM and Yule, indicating a local industry source at Richardson and Kingsmill; however, elevated concentrations at BoM between 8am and 11am indicate a regional dust source during these hours. Therefore, this has been classified as a regional and local industry event.

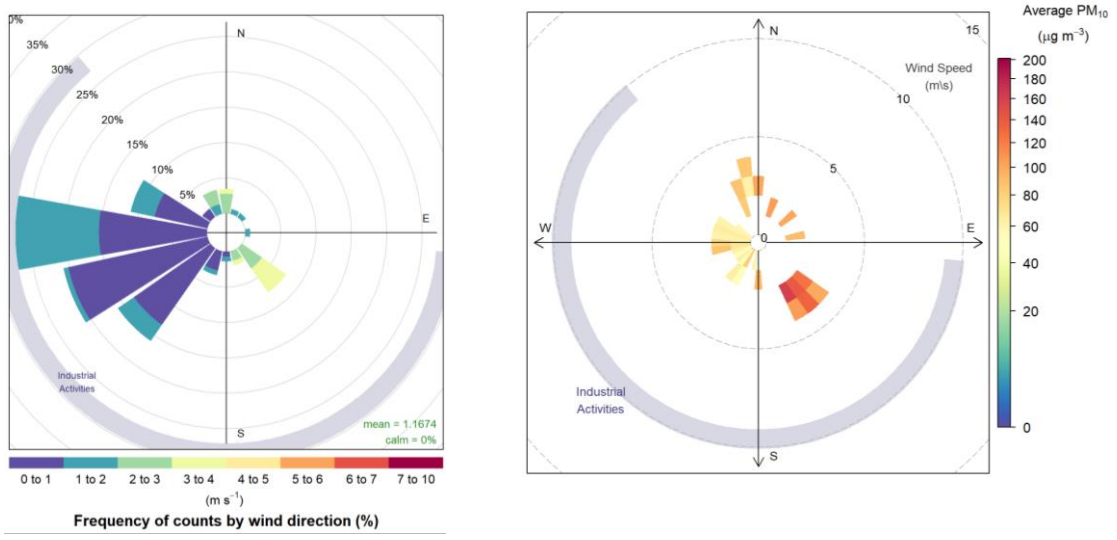

Figure 10-23: **Wind rose (left) and PM_{10} polar frequency plot (right) on 28 December 2021 at Richardson monitoring station**

Figure 10-24: **Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 28 December 2021**

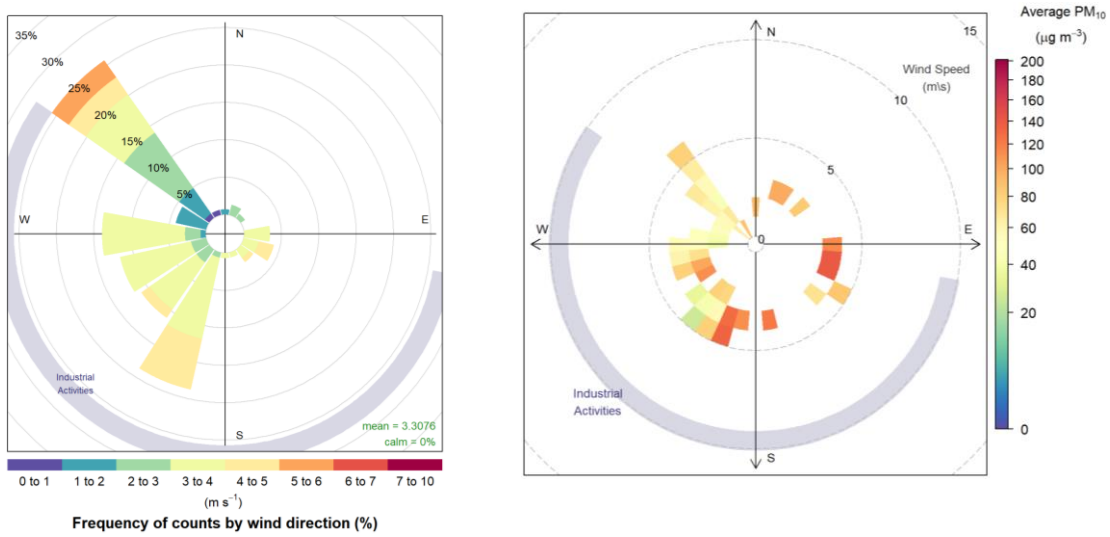

Figure 10-25: **Wind rose (left) and PM_{10} polar frequency plot (right) on 28 December 2021 at Kingsmill monitoring station**

Figure 10-26: **Time series of concentrations of PM_{10} at Kingsmill, BoM, and Yule (top) and wind speed at Kingsmill (middle) and wind direction at Kingsmill (bottom) on 28 December 2021**

10.11 30 December 2021

Date	24-hour average PM_{10} (µg/m³)						Likely cause
	Richardson	Kingsmill	Neptune	Taplin	BoM	Yule	
30 December 2021	**73.5**	**74.0**	66.9	68.6	68.9	**82.9**	Regional

On 30 December 2021, the 24-hour average concentration of PM_{10} was 73.5 µg/m³ at Richardson, 74.0 µg/m³ at Kingsmill, and 82.9 µg/m³ at Yule, all above the AGV of 70 µg/m³, while the concentration at the Neptune, Taplin, and BoM sites were also elevated above 60.0 µg/m³ but below the AGV of 70 µg/m³. Elevated concentrations across all six sites indicates a regional event occurring at Richardson and Kingsmill.

A wind rose and PM_{10} polar frequency plot of the Richardson data for 30 December 2021 is shown in Figure 10-27 and a time series plot of concentrations of PM_{10} at Richardson, BoM and Yule as well as wind speed and wind direction at Richardson for this period is shown in Figure 10-28.

A wind rose and PM_{10} polar frequency plot of the Kingsmill data for 30 December 2021 is shown in Figure 10-29 of the main report, and a time series plot of concentrations of PM_{10} at Kingsmill, BoM and Yule as well as wind speed and wind direction at Kingsmill for this period is shown in Figure 10-30.

Overall, on 30 December 2021, the exceedance event at Richardson and Kingsmill was due to peak concentrations that occurred at all sites between 6pm and 9pm, including the background BoM and Yule monitoring sites. Therefore, this has been classified as a regional event.

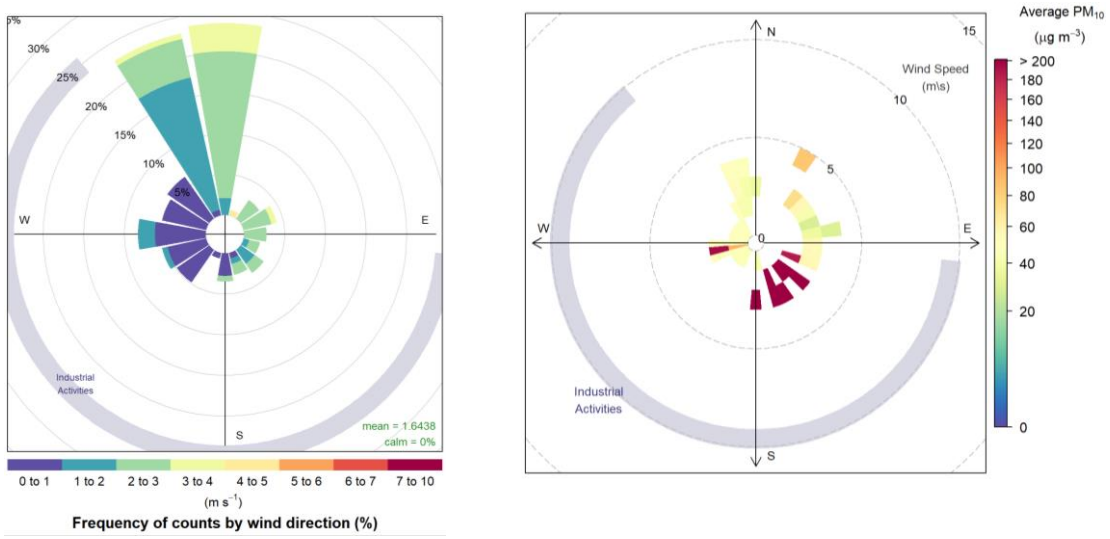

Figure 10-27: **Wind rose (left) and PM_{10} polar frequency plot (right) on 30 December 2021 at Richardson monitoring station**

Figure 10-28: **Time series of concentrations of PM_{10} at Richardson, BoM, and Yule (top) and wind speed at Richardson (middle) and wind direction at Richardson (bottom) on 30 December 2021**

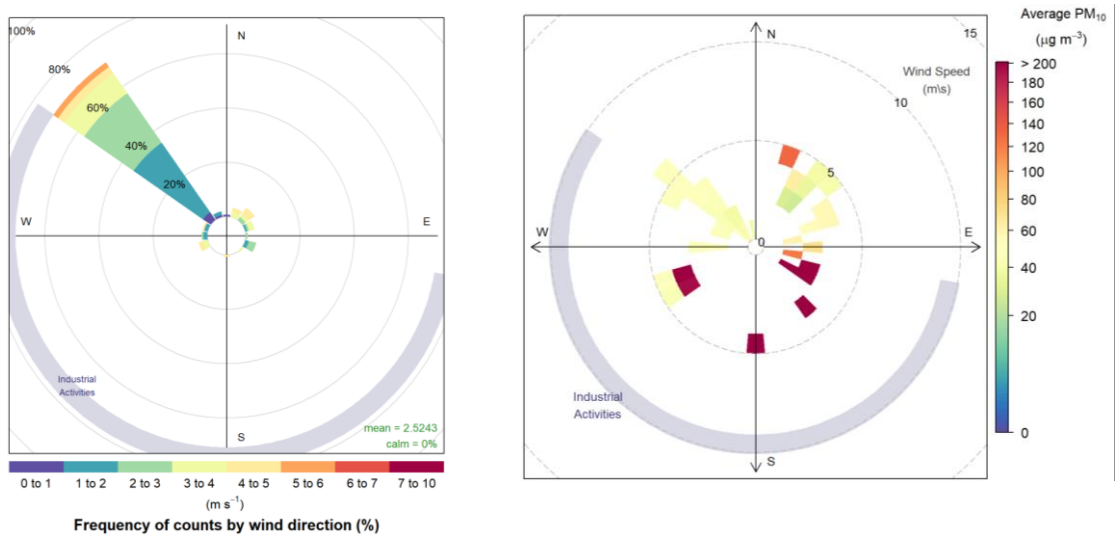

Figure 10-29: Wind rose (left) and PM_{10} polar frequency plot (right) on 30 December 2021 at Kingsmill monitoring station

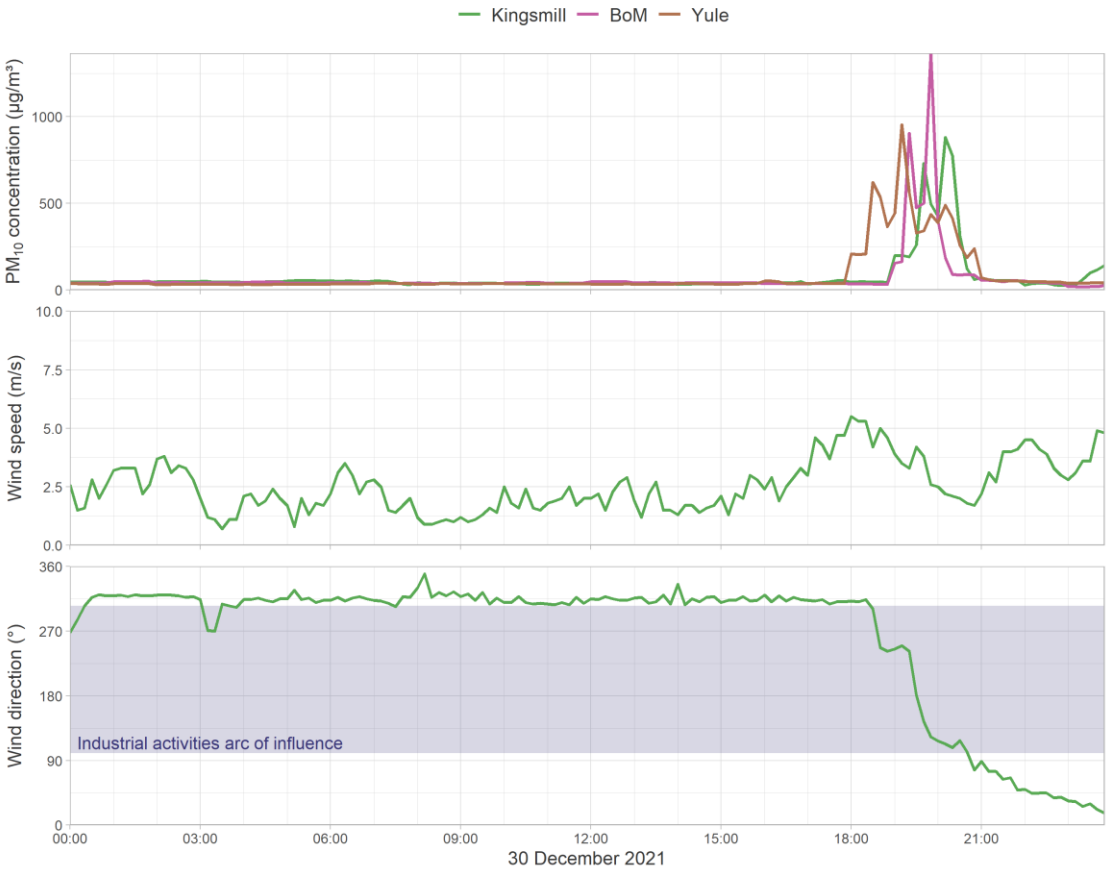

Figure 10-30: Time series of concentrations of PM_{10} at Kingsmill, BoM, and Yule (top) and wind speed at Kingsmill (middle) and wind direction at Kingsmill (bottom) on 30 December 2021