PORT HEDLAND
INDUSTRIES COUNCIL

Annual Report – FY 2020/21 Port Hedland Ambient Air Quality Monitoring Program

FINAL

Port Hedland Industries Council

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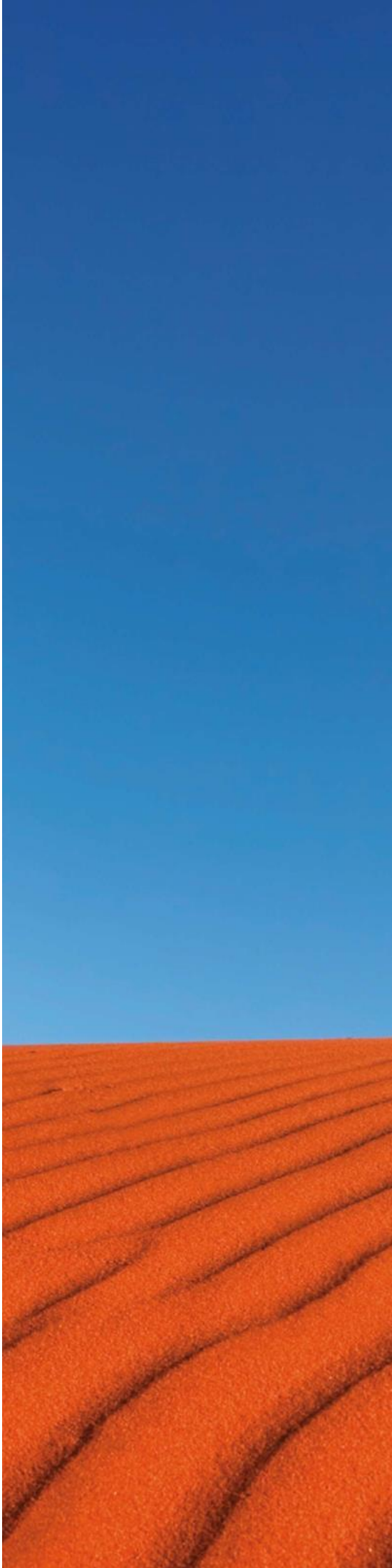
Prepared by Katestone Environmental Pty Ltd



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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 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.phicmonitoring.com.au/**).

PHIC commissioned Katestone Environmental Pty Ltd (Katestone) to prepare this annual performance report on the Port Hedland ambient air quality monitoring network for FY 2020/21. This is the ninth annual performance report of its kind and the fifth annual report prepared by Katestone.

A summary of the PHIC ambient air quality monitoring network in FY 2020/21 is provided in the table below.

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

This annual report presents a summary of the Port Hedland ambient air quality monitoring network performance for FY 2020/21. 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 PM10 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 per calendar quarter and annually, as per the AAQ NEPM protocol.

PM_{10}

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

- The Taplin monitoring station recorded one day above the 24-hour average AGV for PM_{10} of 70 µg/m³ (3 October 2020).
- The exceedance at the Taplin site on 3 October 2020 was attributed to a local industry source as well as a regional event.
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites in FY 2020/21. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 8 days at BoM and Yule to 101 days at Wedgefield.
- The number of days per year above the AAQ NEPM standard for PM_{10} at each monitoring station have been compared for the last nine years, which shows the following:
    - With the exception of Taplin, the number of 24-hour average concentrations above the AAQ NEPM standard decreased compared to the year prior at all monitoring stations.
    - The Richardson site recorded a gradual increase in the number of days recording 24-hour average concentrations above the AAQ NEPM standard over the 4 years from FY 2016/17 to FY 2019/20 which may have been in part due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017. The number of days recording 24-hour average concentrations above the AAQ NEPM standard at this site dropped significantly between the FY 2019/20 and FY 2020/21.
    - The Taplin site was unavailable for the full FY 2018/19 year and for the first six months of FY 2019/20; however, the low number of days above the AGV for the second half of FY 2019/20 (3) as well as for the full FY 2020/21 (1) suggests a slight downward trend in the number of days exceeding the AGV since the FY 2017/18.
- The annual average concentration of PM_{10} was above the AAQ NEPM standard of 25 µg/m³ at BoM, Kingsmill, Richardson, Taplin and Wedgefield sites during FY 2020/21.
- The annual average concentration of PM_{10} was below the AAQ NEPM standard of 25 µg/m³ at Neptune, South Hedland and Yule.
- Annual average concentrations of PM_{10} over the past nine years (FY 2012/13 to FY 2020/21) show that:
    - Peaks occured in the annual average concentration in FY 2014/15 and in FY 2018/19, while troughs occurred in FY 2016/17 and in FY 2020/21.
    - The trend in the annual average concentration at the sites that have been in operation since FY 2015/16 is generally consistent with the longer-term trend, with a lower concentration recorded during FY 2016/17 and FY 2017/18, a peak in FY 2018/19 and FY 2019/20, followed by another drop in FY 2020/21.
    - The Richardson monitoring site shows a gradual increase in the annual average concentration from FY 2015/16 through to the peak in concentration in FY 2019/20. The average concentration dropped again in FY 2020/21, with the gradual increase prior likely due, in part, to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.
    - While the Taplin monitoring site had a gap in monitoring data between May 2018 and December 2019, the available long-term data across all of the sites, including Taplin, can provide an inference as to the long-term trend at this site. The available data shows that this site generally experienced a similar long term trend to that observed at the other monitoring stations up to the period of missing data at the Taplin site, and then again after monitoring at the site recommenced in January 2020. While it cannot be determined whether the concentrations increased at Taplin during the FY 2018/19 and FY 2019/20 ,similar to the trend at other stations,, the data suggests that this may have been the case.

$PM_{2.5}$

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 FY 2020/21.

- The annual average concentration of $PM_{2.5}$ was below the AAQ NEPM standard of 8 µg/m³ at BoM (background), Richardson, Taplin and Yule (background) monitoring stations.

NO_2

Analysis of the NO_2 data found that the concentrations of NO_2 measured at Taplin in FY 2020/21 were low and well below the AAQ NEPM standards. Concentrations were consistent with the NO_2 concentrations measured in previous years.

Data Capture

The annual data capture criterion of 75% was met for each pollutant at all monitoring stations during FY 2020/21. The quarterly data capture criterion of 75% was met for each pollutant and at all monitoring stations with the exception of $PM_{2.5}$ in Q3 at Yule as a result of the extended tropical low shut-down period between 29 January 2021 and 16 February 2021.

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).

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 has reported annually on the outcome and performance of the Port Hedland ambient air quality network, consistent with the format approved by the Taskforce. The FY 2020/2021 report is the ninth annual performance report and the fifth to be completed by Katestone.

This annual performance report for the FY 2020/21 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 PM_{10} trends (**Section 6**).
- Investigation of PM_{10} events (**Section 7**)
- Annual 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. 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 Wedgfield 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 (www.phicmonitoring.com.au).

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

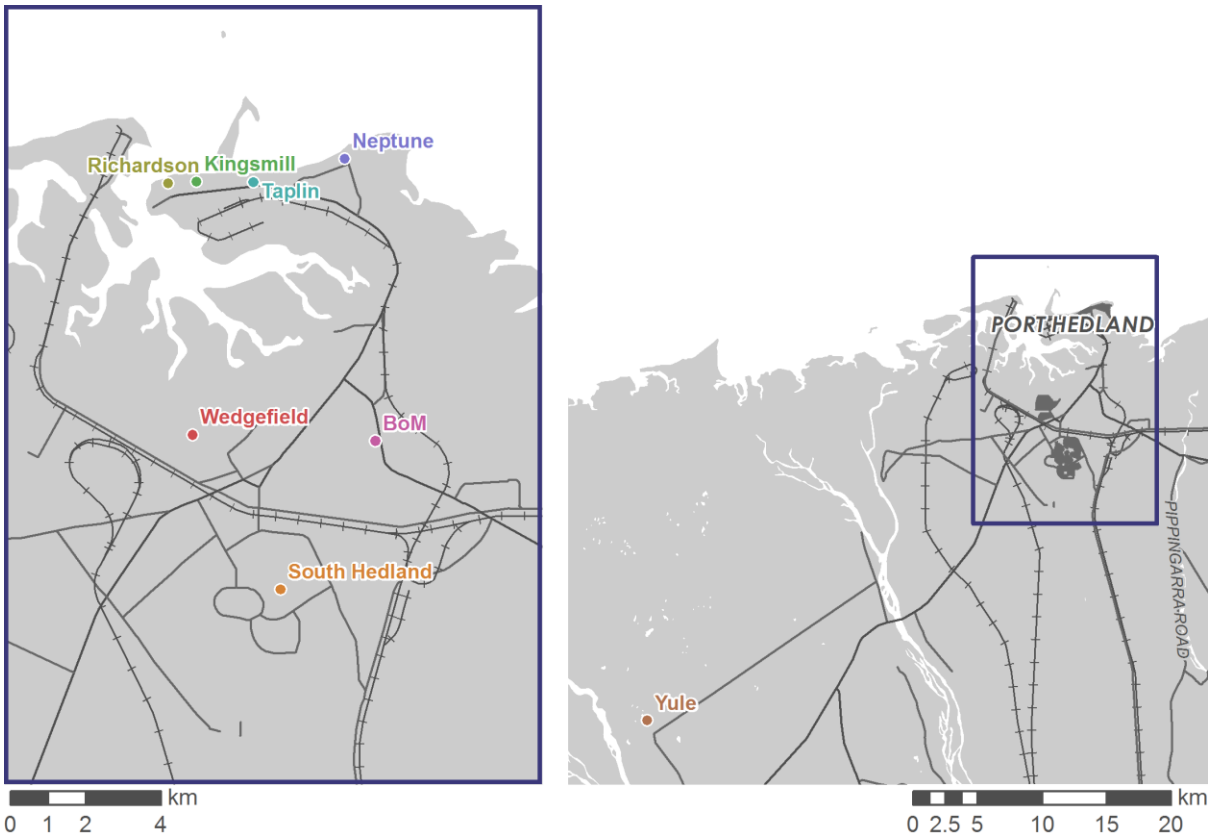


Figure 2-1: Port Hedland Ambient Air Quality Monitoring Network

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 carred 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. FY 2020/21 Activities

The Port Hedland ambient air quality monitoring network activities for FY 2020/21 are detailed in Table 2-3. Notable data gaps outside of the routine maintenance occurred due to the following:

- All stations experienced a loss of data during the end of January and the beginning of February due to a tropical low that was predicted to intensify into a tropical cyclone, with all stations shut down in anticipation of the cyclone and experienced varied legnths of shutdown dependent on the remoteness of the site and access to start the monitor. The periods of shutdown due to the tropical low were:
    - 29 January to 16 February at Yule
    - 30 January to 5 February at Wedgefield
    - 30 January to 6 February at Kingsmill, Neptune and Richardson
    - 31 January to 4 February at BoM and Taplin
    - 31 January to 5 February at South Hedland
- Despite these periods of shutdown, over the January and February bimonthly period the BoM, Neptune, South Hedland, Taplin and Wedgefield monitoring sites all achieved monthly capture rates that satisfied the PHIC criterion of 75%.
- Data capture at the Kingsmill site was 58% during February as a result of the tropical low shut-down period that was extended to 12 February due to instrument fault. The BAM failed to restart after the shut-down period. The BAM was then replaced on 8 February along with the installation of an overnight zero test filter. Data collection then resumed on 12 February following the removal of the zero filter.

- Data capture at the Richardson site was 73% during February as a result of the tropical low shut-down period in addition to intermittent periods of instrument fault, error data, and unscheduled maintenance throughout the month.
- Data capture at the Yule site was 45% during February as a result of the tropical low shut-down period and the remoteness of the site meaning that it was offline until it could be accessed on 16 February.
- Data capture at the Yule site was 70% during May as a result of instrument fault and a 72 hour background test between 3 May and 12 May.
- Data capture at the BoM site was 65% during June as a result of instrument fault between 11 June and 21 June.

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

Station	Parameter	Averaging time [A]	Q1			Q2			Q3			Q4		
			July 20	August 20	September 20	October 20	November 20	December 20	January 21	February 21	March 21	April 21	May 21	June 21
BoM	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓ [G]
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
Kingsmill	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,C]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,C]	✓	✓	✓	✓
Neptune	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
Richardson	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,D]	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,D]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,D]	✓	✓	✓	✓
South Hedland	PM_{10}	5-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	Meteorology	5-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
Taplin	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	NO_x	5-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
Wedgefield	PM_{10}	5-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B]	✓	✓	✓	✓
Yule	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,E]	✓	✓	✓ [F]	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,E]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓ [B]	✓ [B,E]	✓	✓	✓	✓

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

[B] All stations experienced a loss of data during the end of January and the beginning of February due to a tropical low that was predicted to intensify into a tropical cyclone. All stations were shut down in anticipation of the cyclone and experienced varied lengths of shutdown dependent on the remoteness of the site and access to the monitor. Despite these periods of shutdown, over the January and February bimonthly period the BoM, Neptune, South Hedland, Taplin and Wedgefield sites achieved monthly capture rates that satisfied the PHIC criterion of 75%.

[C] Data capture at the Kingsmill site was 58% during February as a result of the tropical low shut-down period that was extended to 12 February due to instrument fault.

[D] Data capture at the Richardson site was 73% during February as a result of the tropical low shut-down period in addition to intermittent periods of instrument fault, error data, and unscheduled maintenance throughout the month.

[E] Data capture at the Yule site was 45% during February as a result of the tropical low shut-down period and the remoteness of the site meaning that it was offline until it could be accessed on 16 February.

[F] Data capture at the Yule site was 70% during May as a result of instrument fault and a 72 hour background test between 3 May and 12 May.

[G] Data capture at the BoM site was 65% during June as a result of instrument fault between 11 June and 21 June.

2.5. Data Processing

The FY 2020/21 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 Department of Environment Regulation (DER)).
- 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 two BAM1020 and light scattering datasets (real-time and beta data) showed good correlation.
- The quality assurance checks conducted by Katestone found that all FY 2020/21 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 was one day during the FY 2020/21 when the Taplin monitoring station recorded a 24-hour average concentration of PM_{10} above the AGV of 70 µg/m³. Further analysis of this event day is provided in Section7.

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).

2.6.1. 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.

2.6.2. 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 FY 2020/21 monitoring 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}, now referred to as AGV, is defined as follows:

- Maximum concentration of 70 µg/m³ 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/m³ for 24-hour average concentration of PM_{10}
- Maximum concentration of 25 µg/m³ for annual average concentration of PM_{10}
- Maximum concentration of 25 µg/m³ for 24-hour average concentration of $PM_{2.5}$
- Maximum concentration of 8 µg/m³ for annual average concentration of $PM_{2.5}$
- Maximum concentration of 164 µg/m³ for 1-hour average concentration of NO_2
- Maximum concentration of 31 µg/m³ 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: Ambient Air Quality Standards / Guideline

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 east of Taplin Street
[C] Calculated at 25 ºC

3. SUMMARY OF FY2020/21 METEOROLOGICAL CONDITIONS

The focus of this annual 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.

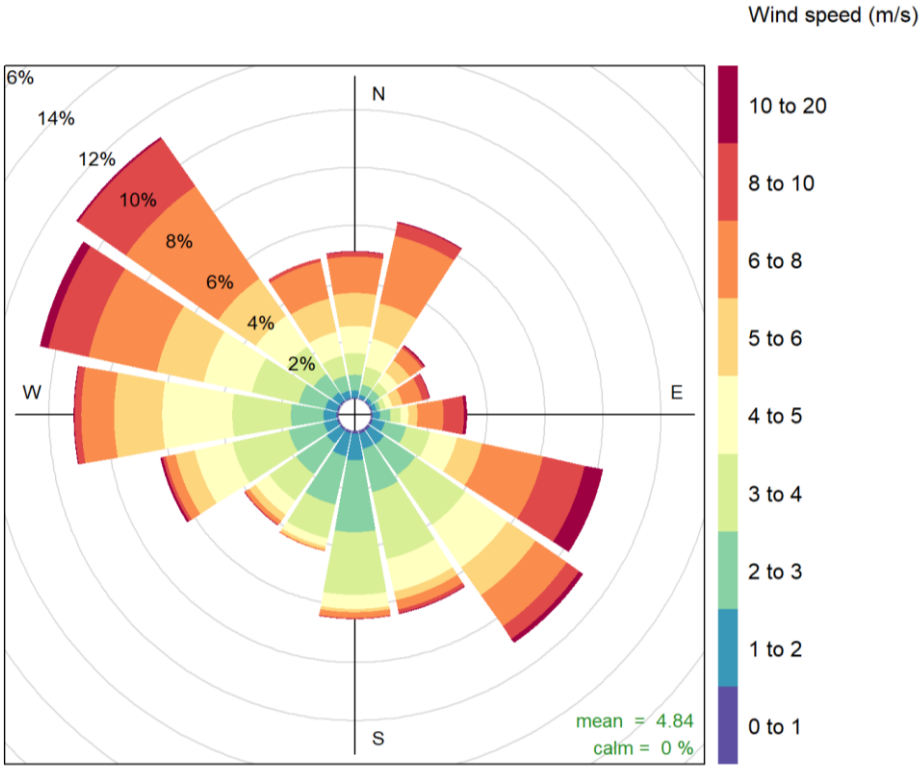
Exposed dust sources (be it from industry sources, other anthropogenic sources or natural sources), will have higher dust emissions during dry conditions and strong winds. The dust emissions will also have a greater radius of impact during periods of stronger wind speeds due to dust remaining suspended 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 FY 2020/21 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 are the northwest (west to northwest) and southeast (east-southeast to south) quadrants.
- Winds from the southwest and northeast quadrants are less common but do occur on occasion at all sites.
- Wind speeds measured at all three monitoring stations are relatively strong (important for dust generation and dispersion) with FY 2020/21 annual average wind speeds of 4.8 m/s, 2.4 m/s and 2.7 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.
- Yule tends to have slightly stronger winds than Taplin due to the Yule being located in an open area that is more exposed to winds than Taplin, which is within a residential area where structures and urban development are likely to reduce wind speeds.
- The seasonal distribution of winds is characterised by the climate drivers in Port Hedland. During spring and summer (wet season) the winds are generally from the northwest quadrant. During autumn and winter (dry season), the winds are predominately from the southeast quadrant.



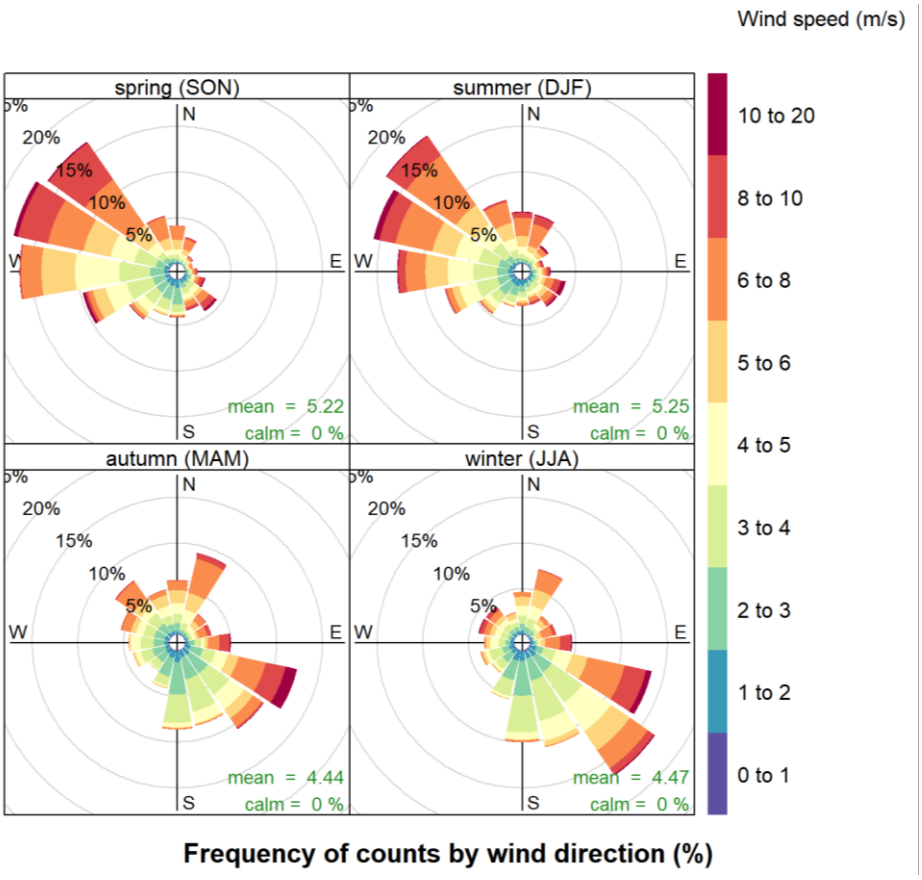
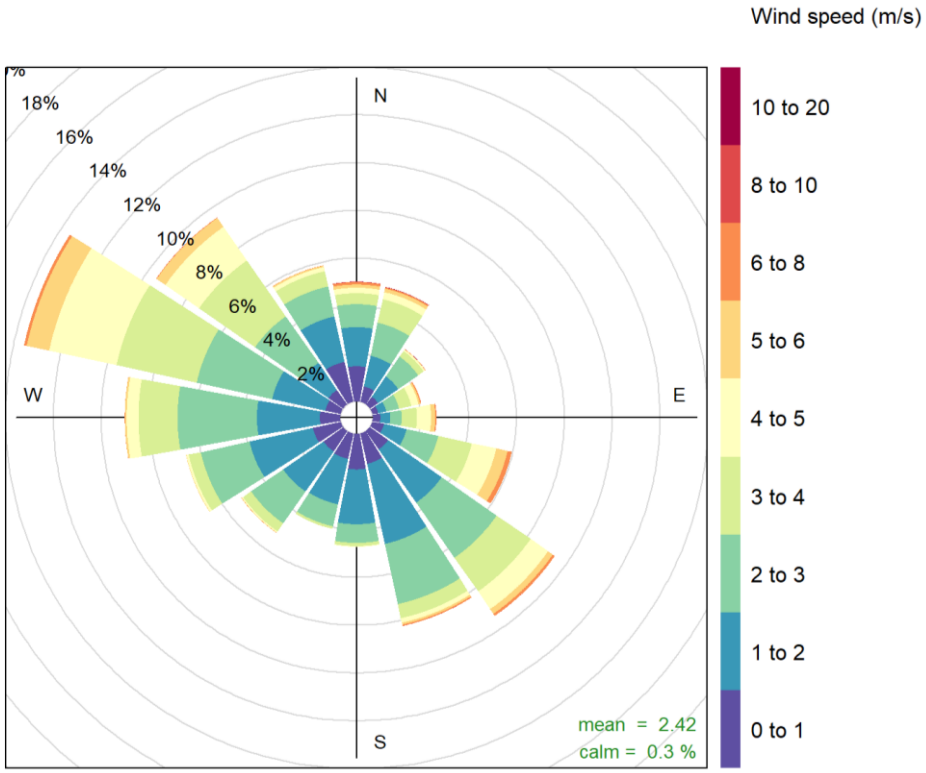


Figure 3-1: FY 2020/21 wind roses for BoM annual (top) seasonal (bottom)



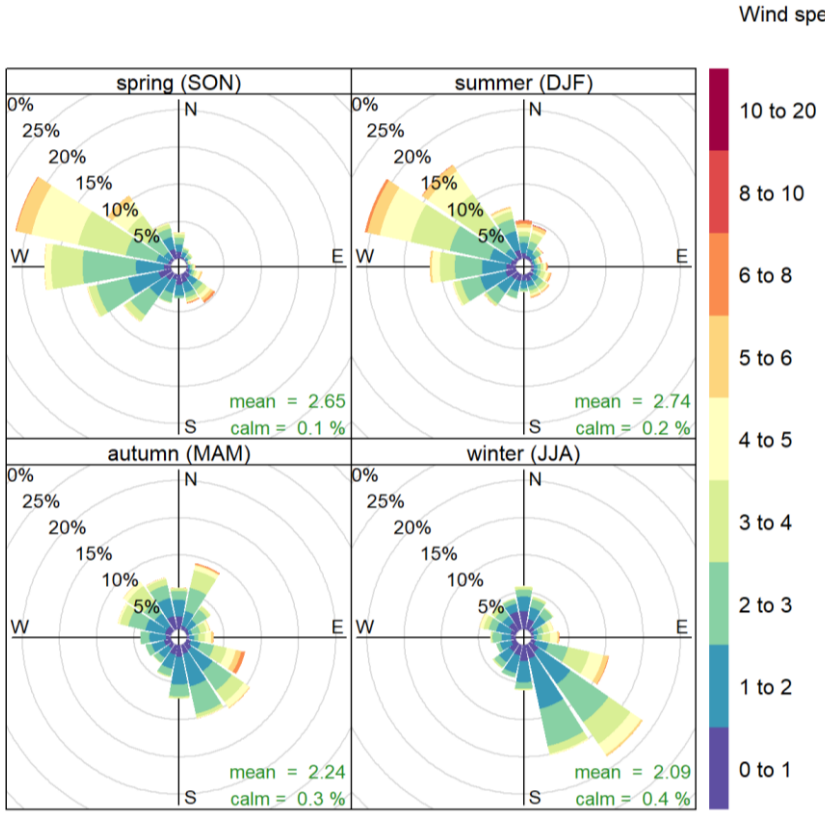
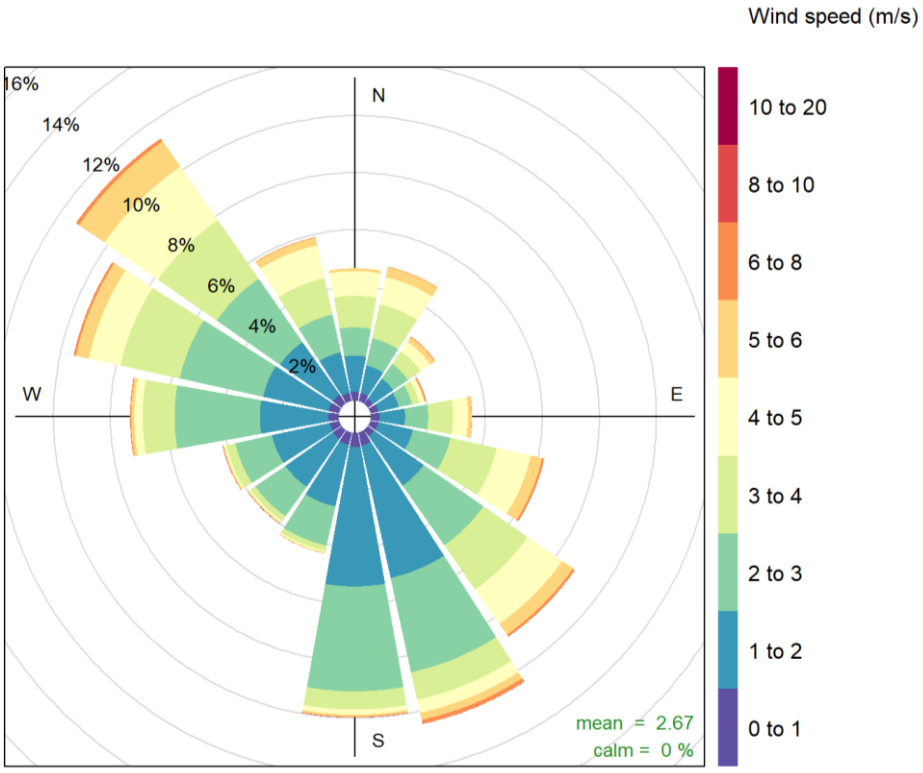


Figure 3-2: FY 2020/21 wind roses for Taplin annual (top) seasonal (bottom)



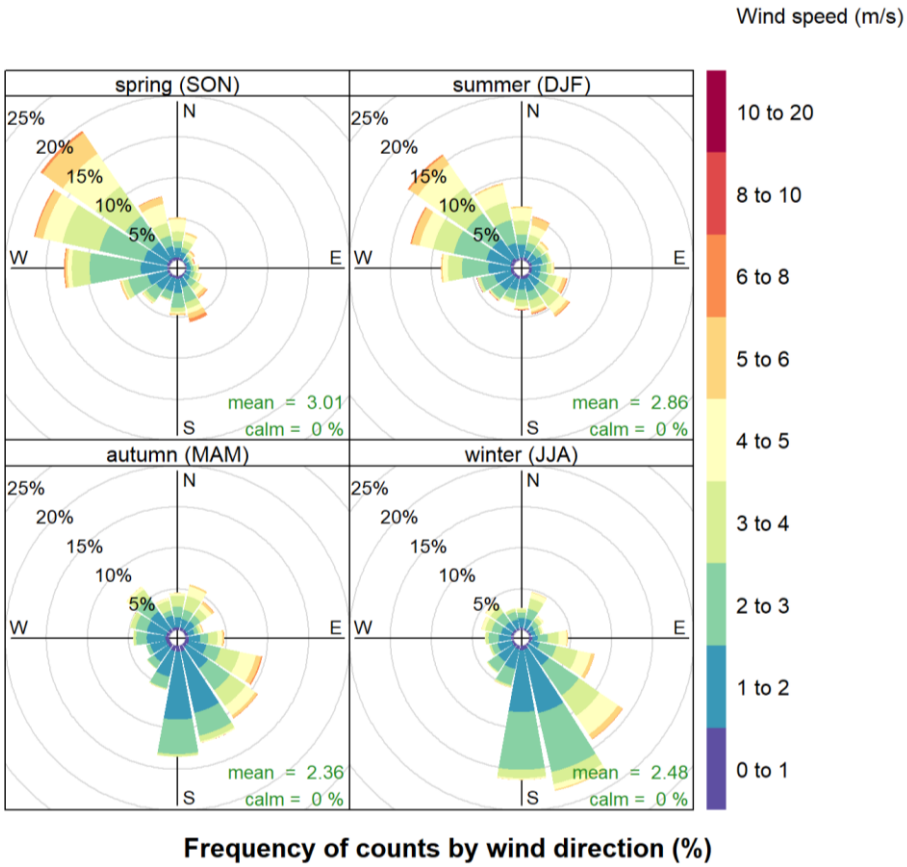


Figure 3-3: FY 2020/21 wind roses for Yule annual (top) seasonal (bottom)

4. AIR QUALITY MONITORING DATA - AIR POLLUTANT PERFORMANCE

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 FY 2020/21.

4.1.1. Data Capture

Data capture rates for 1-hour average concentrations of PM_{10} for each monitoring station in FY 2020/21 are detailed in Table 4-1. All stations achieved an annual capture rate for PM_{10} of greater than 90%, meeting the PHIC criterion of 75% data capture. All sites also achieved quarterly capture rates greater than 79%, satisfying the PHIC criterion of 75% data capture. Data capture at Yule during Q3 was reduced to 79% as a result of the extended tropical low shut-down period between 29 January 2021 and 16 February 2021.

Table 4-1: FY 2020/21 Data Capture Summary 1-hour average concentration of PM_{10}

Monitoring Station	2020/21 PM_{10} Data Capture Rate (%)					Performance
	Q1	Q2	Q3	Q4	Annual	
BoM	99.5	99.6	95.3	87.6	95.5	Met
Kingsmill	96.3	99.2	85.3	98.2	94.8	Met
Neptune	98.5	99.6	91.8	91.2	95.3	Met
Richardson	97.6	99.8	89.9	99.7	96.7	Met
South Hedland	97.8	99.6	92.1	98.9	97.1	Met
Taplin	92.6	99.8	95.2	99.7	96.8	Met
Wedgefield	95.7	99.8	88.8	88.5	93.2	Met
Yule	94.7	98.2	78.6 [A]	88.3	90.0	Met

Table note:
[A] Data capture at the Yule site was reduced to 79% during Q3 as a result of the extended tropical low shut-down period between 29 January 2021 and 16 February 2021

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 FY 2020/21 for each station is detailed in Table 4-3.

The measurements of PM_{10} show that for FY 2020/21:

- The Taplin monitoring station recorded one day above the 24-hour average AGV for PM_{10} of 70 µg/m³ (3 October 2020).
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites in FY 2020/21. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 8 days at BoM and Yule to 101 days at Wedgefield.
- The annual average concentration of PM_{10} was above the AAQ NEPM standard of 25 µg/m³ at BoM, Kingsmill, Richardson, Taplin and Wedgefield sites during FY 2020/21.

Table 4-2: FY 2020/21 data summary 24-hour average concentrations of PM_{10}

Monitoring Station ID	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)	Performance (Taskforce)
BoM	71.6	8	Not met	-	-
Kingsmill	174.2	71	Not met		
Neptune	86.4	10	Not met		
Richardson	143.0	93	Not met		
South Hedland	90.2	16	Not met		
Taplin	90.6	21	Not met	1	Met (as per analysis in Section 7)
Wedgefield	159.5	101	Not met	-	-
Yule	233.8	8	Not met		

Table 4-3: FY 2020/21 data summary annual average concentrations of PM_{10}

Monitoring Station ID	Annual average concentration of PM_{10} (µg/m³)	Performance (AAQ NEPM of 25 µg/m³)
BoM	25.5	Not met
Kingsmill	38.3	Not met
Neptune	21.6	Met
Richardson	40.7	Not met
South Hedland	20.6	Met
Taplin	29.8	Not met
Wedgefield	42.7	Not met
Yule	16.4	Met

4.1.3. PM_{10} Timeseries Analysis

Timeseries plots of the 24-hour average concentrations of PM_{10} for FY 2020/21 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 one occasion during the FY 2020/21 period, with this exceedance occurring while concentrations were also elevated across all other monitoring stations.

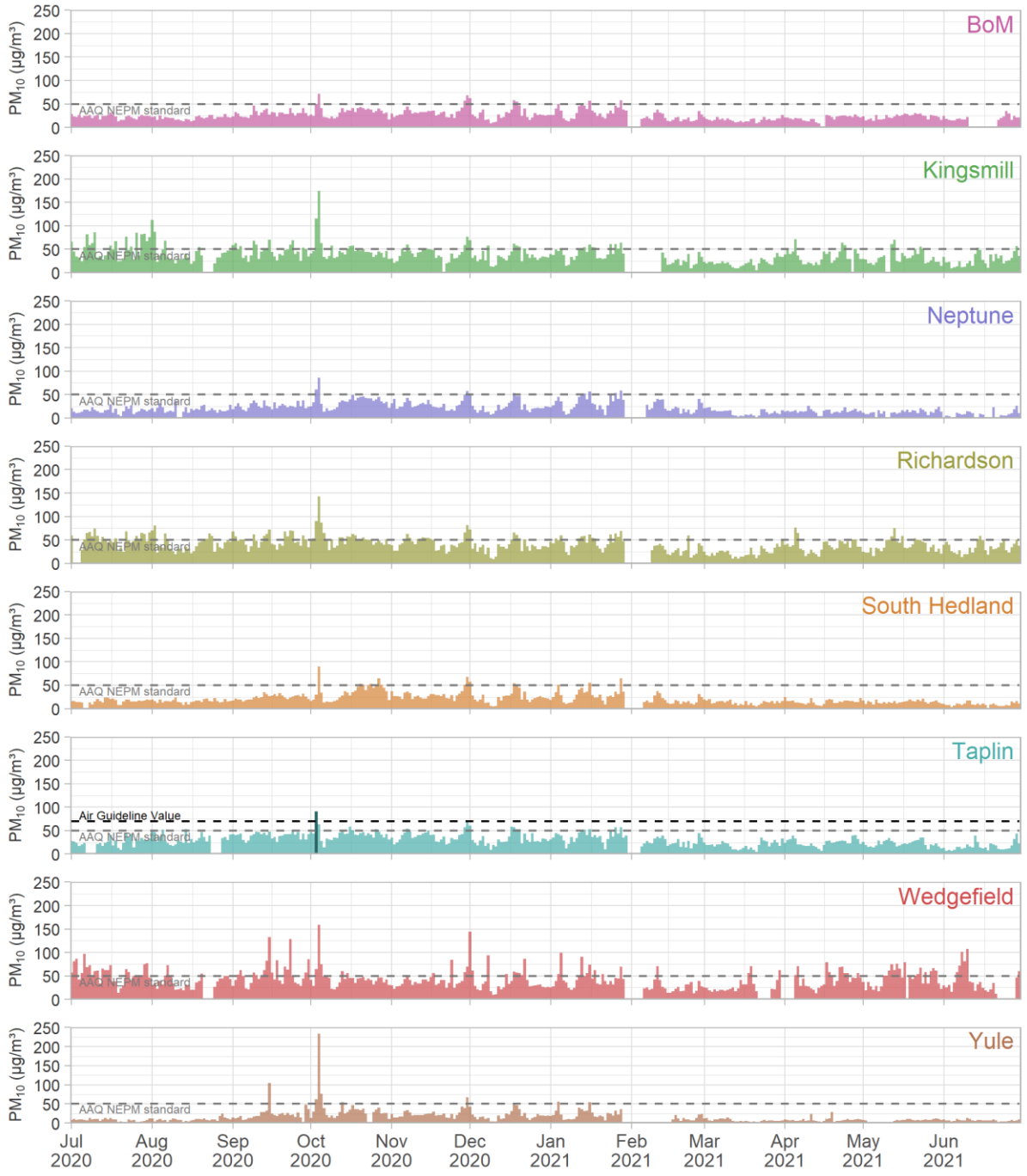


Figure 4-1: FY 2020/21 time series plots of 24-hour average concentrations of PM_{10}

4.2. $PM_{2.5}$

$PM_{2.5}$ was measured at four (4) monitoring stations (BoM, Richardson, Taplin and Yule) during FY 2020/21.

4.2.1. Data Capture

Data capture rates for 1-hour average concentrations of $PM_{2.5}$ for each monitoring station in FY 2020/21 are detailed in Table 4-4. All stations achieved an annual capture rate for $PM_{2.5}$ of greater than 90%, satisfying the PHIC annual criterion of 75% data capture. The BoM, Richardson and Taplin monitoring stations achieved quarterly capture rates greater than 92%, satisfying the PHIC quarterly criterion of 75% data capture.

Data capture at Yule during Q3 was reduced to 71% due to the extended tropical low shut-down period between 29 January 2021 and 16 February 2021; however, the annual data capture rate of 90% satisfied the PHIC annual criterion of 75% data capture.

Table 4-4: FY 2020/21 data capture summary 1-hour average concentrations of $PM_{2.5}$

Monitoring Station ID	2020/21 $PM_{2.5}$ Data Capture Rate (%)					Performance
	Q1	Q2	Q3	Q4	Annual	
BoM	98.5	99.5	95.2	98.6	98.0	Met
Richardson	98.7	99.8	92.1	99.7	97.6	Met
Taplin	98.4	99.7	95.2	99.5	98.2	Met
Yule	91.6	99.3	70.9 [A]	98.5	90.1	Not Met [B]

Table note:
[A] Data capture at the Yule site was reduced to 71% during Q3 as a result of the extended tropical low shut-down period between 29 January 2021 and 16 February 2021.
[B] Data capture rate in Q3 at Yule was less than 75%.

4.2.2. Comparison to Air Quality Standards

The maximum 24-hour average (midnight to midnight) and annual 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.

The $PM_{2.5}$ measurements show that for FY 2020/21:

- The 24-hour average concentrations of $PM_{2.5}$ were below the AAQ NEPM standard of 25 µg/m³ at all monitoring stations during FY 2020/21.
- The annual average concentration of $PM_{2.5}$ was below the AAQ NEPM standard of 8 µg/m³ at BoM (background), Richardson, Taplin and Yule (background) monitoring stations.

Table 4-5: FY 2020/21 data summary 24-hour and annual 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)	Annual average concentration of $PM_{2.5}$ (µg/m³)	Performance (AAQ NEPM of 8 µg/m³)
BoM	14.8	0	Met	4.9	Met
Richardson	15.5	0	Met	6.9	Met
Taplin	19.5	0	Met	5.3	Met
Yule	21.1	0	Met	1.8	Not demonstrated [A]

Table note:
[A] $PM_{2.5}$ data capture rate in Q3 at Yule was less than 75% resulting in invalid annual average concentration.

4.2.3. $PM_{2.5}$ Timeseries Analysis

A timeseries plot of the 24-hour average concentration of $PM_{2.5}$ for FY 2020/21 for each monitoring station is shown in Figure 4-2.

Figure 4-2: FY 2020/21 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 FY 2020/21. 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 4-6. Taplin monitoring station achieved quarterly and annual NO_x capture rates greater than 95%, which meets the PHIC annual criterion of 75% data capture.

Table 4-6: FY 2020/21 data capture summary 1-hour average concentrations of NO_x

Monitoring Station ID	2020/21 NO_x Data Capture Rate (%)					Performance
	Q1	Q2	Q3	Q4	Annual	
Taplin	97.2	99.3	95.0	98.6	97.5	Met

4.3.2. Comparison to Air Quality Standards

The maximum measured 1-hour average and annual average concentrations of NO_2 at Taplin monitoring station are detailed in Table 4-7. The NO_2 measurements show that for FY 2020/21:

- 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 48% of the AAQ NEPM standard.
- The annual average concentration of NO_2 was below the AAQ NEPM standard of 31 µg/m³.
- The annual average concentration of NO_2 corresponds to 46% of the AAQ NEPM standard.

The levels of NO_2 measured at Taplin are low and consistent with the NO_2 levels measured in previous years.

Table 4-7: FY 2020/21 data summary 1-hour average and annual average concentrations of NO_2

Monitoring Station ID	Maximum 1-hour average NO_2 concentration (µg/m³)	Performance (AAQ NEPM of 164 µg/m³)	Annual average NO_2 concentration (µg/m³)	Performance (AAQ NEPM of 31 µg/m³)
Taplin	79.0	Met	14.3	Met

4.3.3. NO_2 Time Series Analysis

A timeseries plot of the 1-hour average concentrations of NO_2 for FY 2020/21 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.

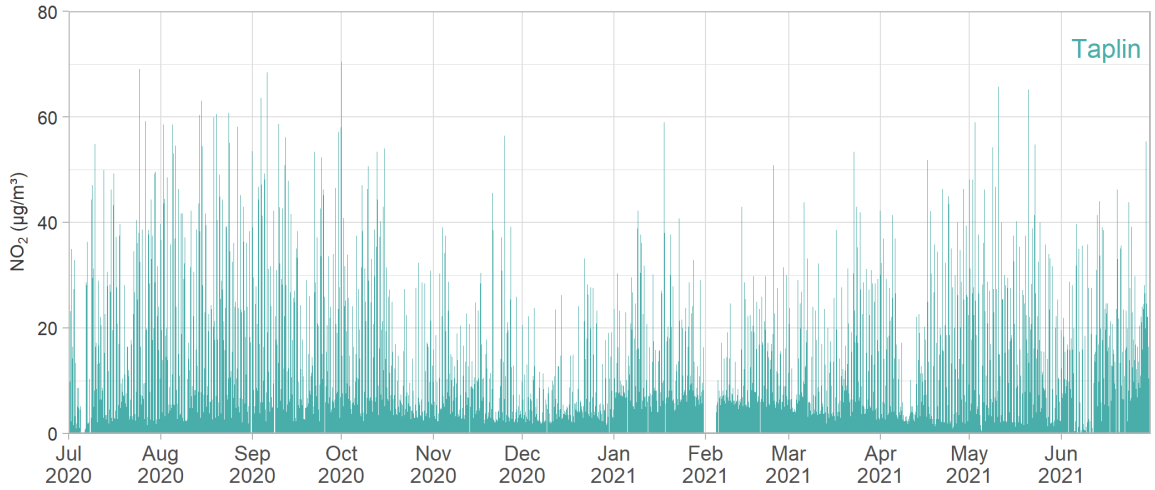


Figure 4-3: FY 2020/21 time series plot of 1-hour average concentrations of NO_2 for Taplin

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 FY 2020/21.

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	24-hour	1	Met
		50	24-hour	21	Not met
		25	Annual	1	Not met
$PM_{2.5}$	Met	25	24-hour	0	Met
		8	Annual	0	Met
NO_2	Met	164	1-hour	0	Met
		31	Annual	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	8	Not met
		25	Annual	1	Not met
$PM_{2.5}$	Met	25	24-hour	0	Met
		8	Annual	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	Standard		Number of instances above the Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	50	24-hour	71	Not met
		25	Annual	1	Not met

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

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	Standard		Number of instances above the Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	50	24-hour	93	Not met
		25	Annual	1	Not met
$PM_{2.5}$	Met	25	24-hour	0	Met
		8	Annual	0	Met

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	Standard		Number of instances above the Standard	Performance against Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Met	50	24-hour	16	Not met
		25	Annual	0	Met

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	101	Not met
		25	Annual	1	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	8	Not met
		25	Annual	0	Met
$PM_{2.5}$	Not Met [A]	25	24-hour	0	Not demonstrated [B]
		8	Annual	0	Not demonstrated [B]

Table note:
[A] $PM_{2.5}$ data capture rate in Q3 at Yule was less than 75%.

6. PM_{10} TRENDS

This section presents analysis of trends in concentrations of PM_{10} measured by the Port Hedland ambient air quality monitoring network for the eight years from FY 2012/13 to FY 2020/21.

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 the past nine years is presented in Table 6-1.

The data shows the following:

- The number of days above the AGV at the Taplin monitoring station showed a gradual downward trend over the six years between July 2012 and June 2018.
- The site was unavailable for the full FY 2018/19 year and for the first six months of FY 2019/20; however, the low number of days above the AGV for the second half of FY 2019/20 (3) as well as for the full FY 2020/21 (1) suggests a slight downward trend in the number of days exceeding the AGV since the FY 2017/18.

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
Taplin	70[A]	17	6	10	10	3	9	No data [B]	3 [C]	1

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)

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 and Figure 6-1.

The data shows that:

- With the exception of Taplin, the number of 24-hour average concentrations above the AAQ NEPM standard decreased compared to the year prior at all monitoring stations.
- The Richardson site recorded a gradual increase in the number of days recording 24-hour average concentrations above the AAQ NEPM standard over the 4 years from FY 2016/17 to FY 2019/20 which may have been in part due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017. The number of days recording 24-hour average concentrations above the AAQ NEPM standard at this site dropped significantly between the FY 2019/20 and FY 2020/21.
- At the Taplin monitoring site, the annual number of days above the AAQ NEPM standard was reasonably stable during the six-year period from July 2012 to June 2018, increasing slightly up to 65 days during the July 2018 to June 2018 period. The site was unavailable for the full FY 2018/19 year and for the first six months of FY 2019/20; however, the low number of days above the AAQ NEPM standard for the second half of FY 2019/20 as well as for the full FY 2020/21 suggests a slight downward trend in the number of days exceeding the standard since the FY 2017/18.
-

Table 6-2: Summary of 24-hour average concentrations of PM_{10} above the AAQ NEPM standard for the last nine reporting years

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
BoM	50	24	10	17	12	7	4	25	33	8
Kingsmill		89	98	156	112	83	103	155	148	71
Neptune		25	25	67	43	29	15	102	66	10
Richardson		74	50	79	39	90	143	167	173	93
South Hedland		23	13	19	12	8	0	11	22	16
Taplin		48	48	55	48	27	65	No data [A]	10 [B]	21
Wedgefield		157	148	169	150	99	88	165	159	101
Yule		24	8	18	5	1	8	15	13	8

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)

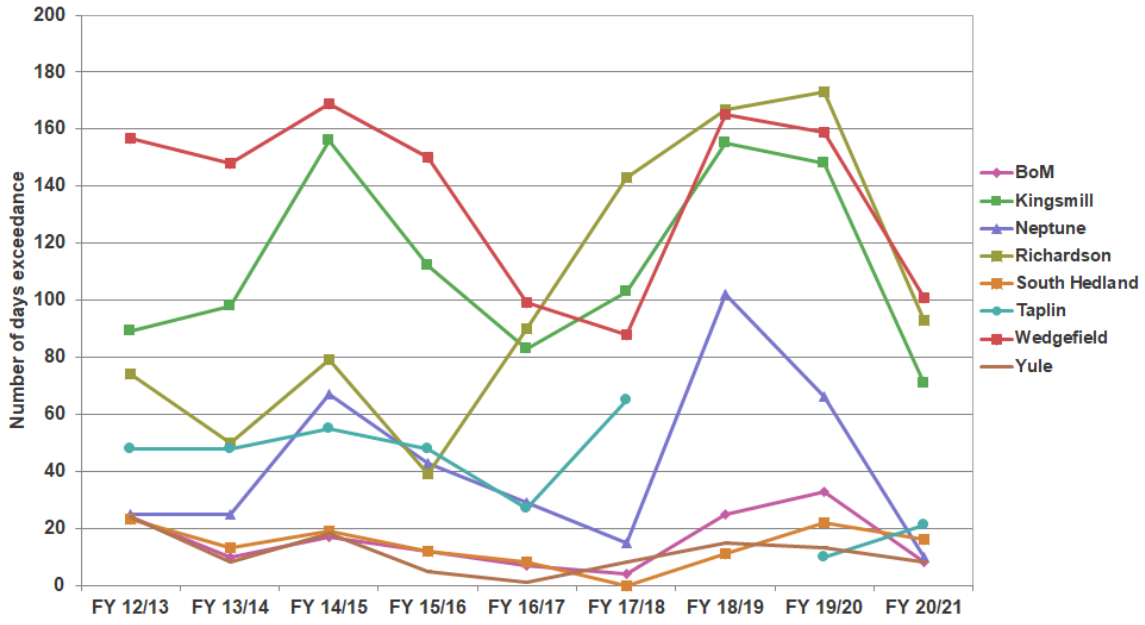


Figure 6-1: Number of the 24-hour average concentration of PM_{10} above the AAQ NEPM standard for each reporting year

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

An annual average standard for PM_{10} was introduced into the AAQ NEPM in 2016. Accordingly, the annual average concentrations of PM_{10} at each Port Hedland monitoring station for the last six reporting years (FY 2015/16 to FY 2020/21) have been compared with the standard in Table 6-3 and Figure 6-2.

The data shows the following:

- The long-term trend at the sites that have been in operation since FY 2012/13 shows peaks occured in the annual average concentration in FY 2014/15 and in FY 2018/19, while troughs occurred in FY 2016/17 and in FY 2020/21.

- The trend in the annual average concentration at the sites that have been in operation since FY 2015/16 is generally consistent with the longer-term trend, with a lower concentration recorded during FY 2016/17 and FY 2017/18, a peak in FY 2018/19 and FY 2019/20, followed by another drop in FY 2020/21.
- The Richardson monitoring site shows a gradual increase in the annual average concentration from FY 2015/16 through to the peak in concentration in FY 2019/20. The average concentration dropped again in FY 2020/21, with the gradual increase prior likely due, in part, to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.
- While the Taplin monitoring site had a gap in monitoring data between May 2018 and December 2019, the available long-term data across all of the sites, including Taplin, can provide an inference as to the long-term trend at this site. The available data shows that this site generally experienced a similar long term trend to that observed at the other monitoring stations up to the period of missing data at the Taplin site, and then again after monitoring at the site recommenced in January 2020. While it cannot be determined whether the concentrations increased at Taplin during the FY 2018/19 and FY 2019/20 along with all of the other monitoring stations, the data from the other sites suggests that this may have been the case.

Table 6-3: Summary of annual average concentrations of PM_{10} for the last nine reporting years

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
BoM	25	No data [A]	No data [A]	No data [A]	25.4	21.4	23.8	31.5	32.1	25.5
Kingsmill		47.1	44.8	50.4	44.7	40.4	43.7	51.0	50.3	38.3
Neptune		28.1	31.6	37.1	32.3	27.4	26.4	40.2	36.6	21.6
Richardson		40.7	38.1	40.0	35.2	40.0	47.3	51.4	54.1	40.7
South Hedland		No data [A]	No data [A]	No data [A]	26.5	22.2	16.1	24.4	27.9	20.6
Taplin		36.8	37.9	36.3	35.6	31.3	34.4	No data [B]	31.1 [C]	29.8
Wedgefield		No data [A]	No data [A]	No data [A]	51.1	43.1	42.2	55.0	54.6	42.7
Yule		23.1	18.1	21.5	18.5	15.4	17.9	22.2	21.0	16.4

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.

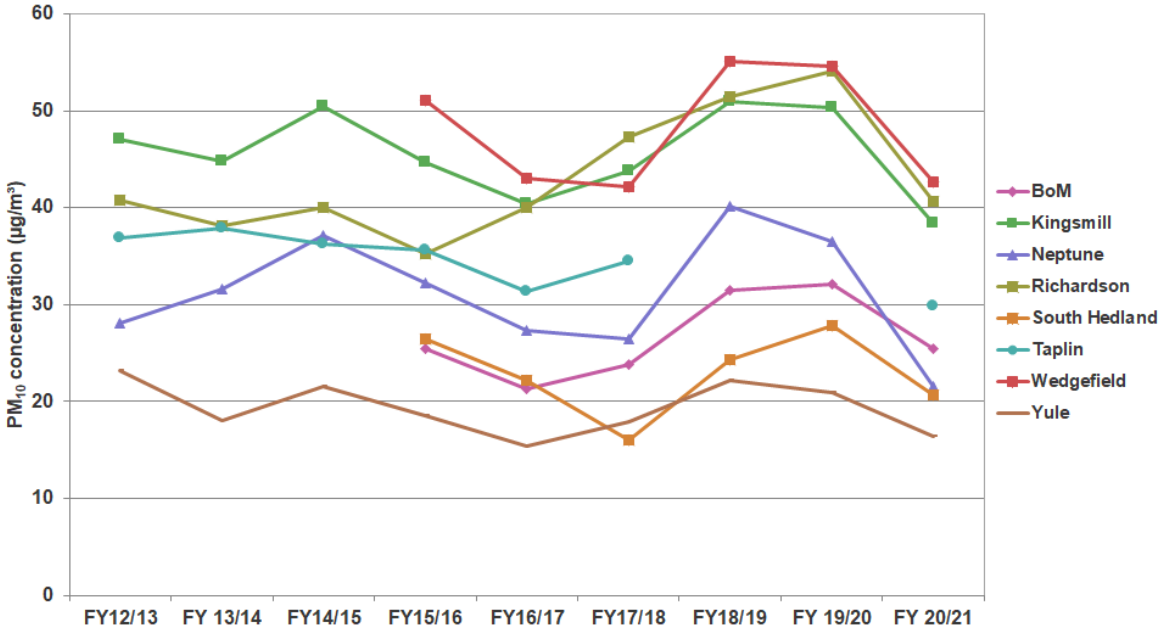


Figure 6-2: Annual average concentrations of PM_{10} for the last nine years

6.4. PM_{10} Statistics

The following summary statistics for 24-hour average concentrations of PM_{10} are displayed graphically in Appendix A for the past nine reporting years:

- Maximum
- 99th percentile
- 98th percentile
- 95th percentile
- 50th percentile.

The graphs in Appendix A show the following:

- Maximum 24-hour average concentrations of PM_{10} have a decreasing trend at all monitoring stations over the six reporting years to FY 2017/18, with a gradual increase in FY 2018/19, a significant increase in FY 2019/20, and a significant decrease in FY 2020/21.
- 99th, 98th and 95th percentile 24-hour average concentrations of PM_{10} have a slightly decreasing or stable trend at all monitoring stations over the six reporting years to FY 2017/18, a slight increase during FY 2018/19 and FY 2019/20, and a decrease in FY 2020/21.
- 50th percentile 24-hour average concentration of PM_{10} exhibit a generally stable trend at all monitoring stations over the nine reporting years, with a slight increase during FY 2018/19 and then a slight drop in FY 2019/20, and a further drop in FY 2020/21.

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.

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 Taplin 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 Taplin 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 2019). Concurrent 24-hour average concentrations at the other PHIC monitoring stations are also extracted to investigate any 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 – discussed in Section 7.1.1) 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. 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°.

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.

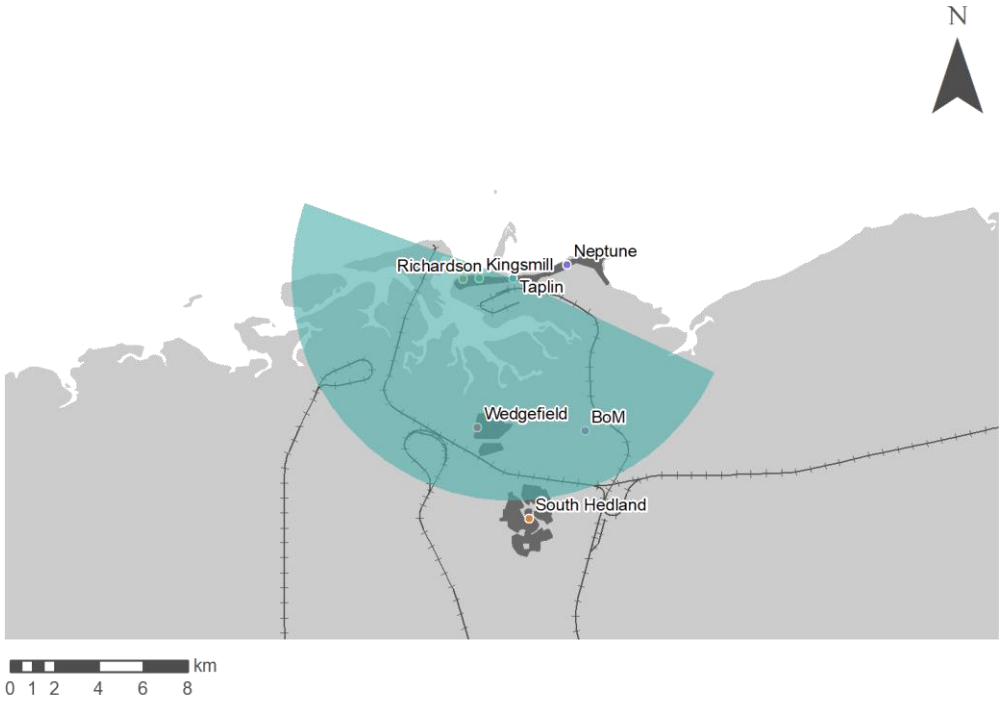


Figure 7-1: Port Hedland industry arc of influence (shaded area) at Taplin monitoring station

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 Taplin 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 Taplin 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 Taplin 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 Taplin 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

Table 7-1 details the one day when the 24-hour average concentration of PM_{10} was above 70 µg/m³ at Taplin during between 1 July 2020 to 30 June 2021. Concentrations of PM_{10} at BoM and Yule for the same period are also displayed.

The likely cause of the 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 3 October 2020 is believed to have likely been the result of a local industry source 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, BoM and Yule

Date	24-hour average PM_{10} (µg/m³)			Likely cause (as determined by methodology presented in Section 7)
	Taplin	BoM	Yule	
3 October 2020	**90.6**	49.9	61.7	Local (industry) and Regional

7.3. Detailed analysis of exceedances

7.3.1. 3 October 2021

On 3 October 2020, the 24-hour average concentration of PM_{10} was 90.6 µg/m³ at Taplin, above the AGV of 70 µg/m³. The 24-hour average concentration of PM_{10} at Yule was also elevated (61.7 µg/m³) but below the AGV indicating a potential regional event. However, the 24-hour average concentration of PM_{10} at BoM was 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 7-2 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 7-3.

The figures indicate the following:

- Winds were generally moderate to strong (up to 8.3 m/s,) and from the southeast through to west, consistent with the direction of winds 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 moderate (3 to 6 m/s) winds from the southwest sector as well as moderate to strong winds (up to the maximum of 8.3 m/s) from the south-southeast. Both sectors are within the industry arc of influence.
- The time-series plot shows that concentrations were slightly elevated at Taplin throughout the 24-hour period, including during the periods when concentrations were lower at BoM and Yule. However, during the afternoon (midday to 6pm) and late evening (10pm to midnight) periods concentrations also increased across the BoM and Yule sites which indicates a possible regional component to concentrations at Taplin.

Overall, on 3 October 2020, concentrations of PM_{10} were likely the result of a local industry source as well as a contribution from a regional event.

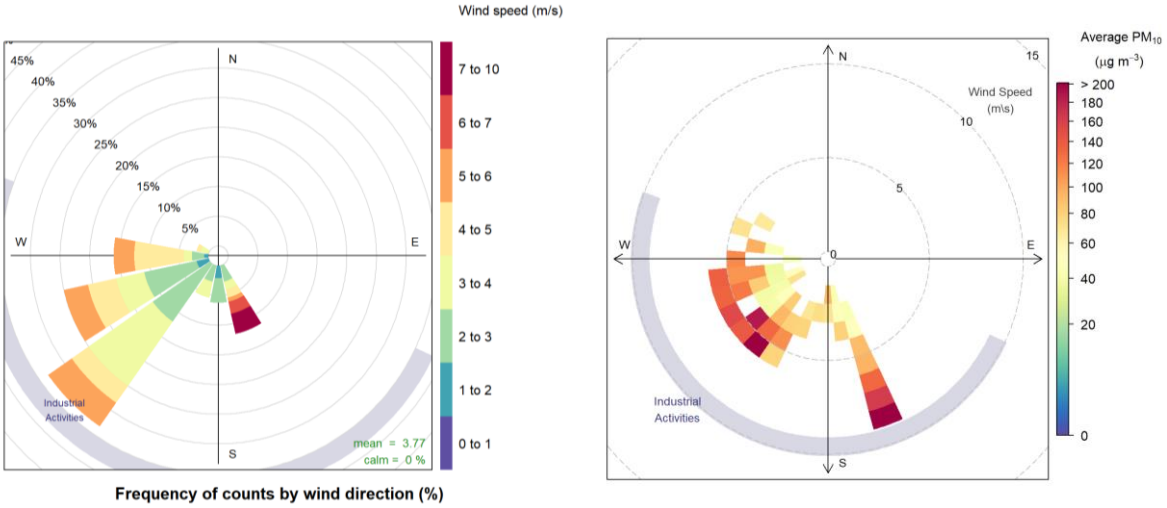


Figure 7-2: Wind rose (left) and PM_{10} polar plot (right) on 3 October 2020 at Taplin

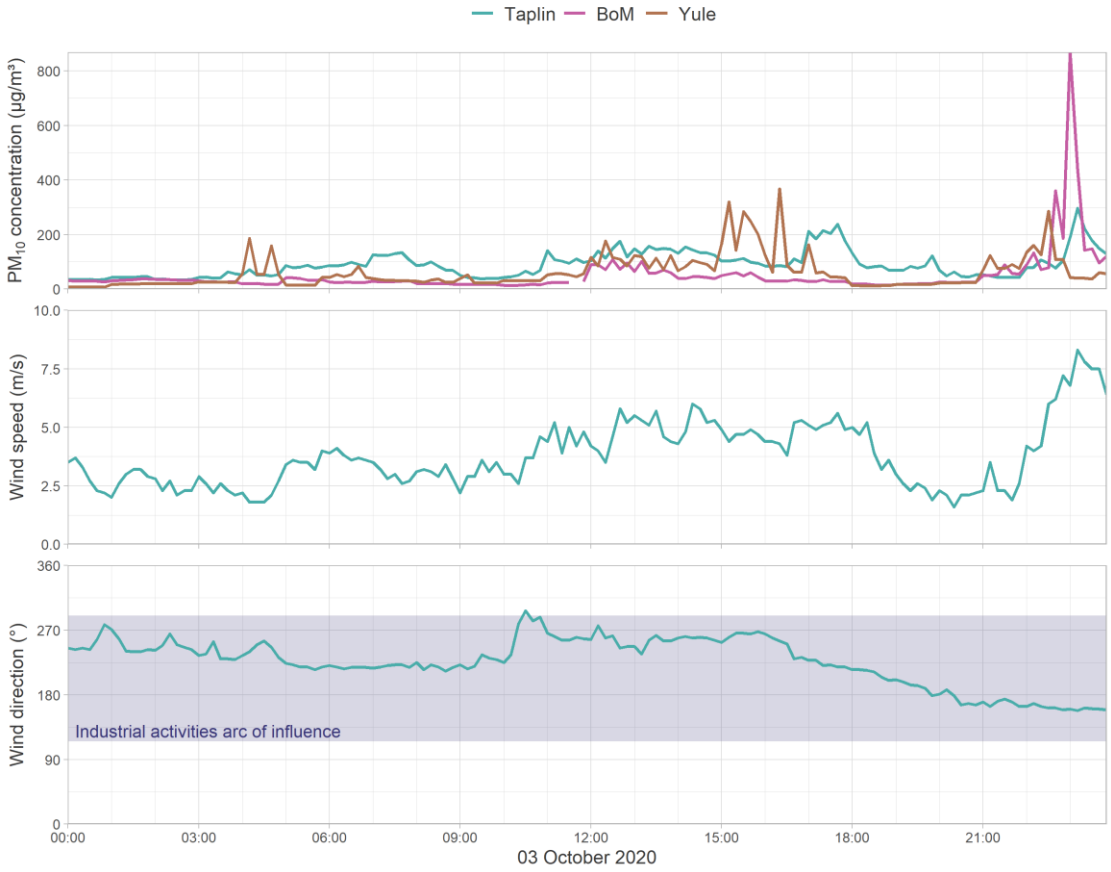


Figure 7-3: Time series of concentrations of PM_{10} at Taplin, BoM and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 3 October 2020

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 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 consists of eight (8) stations distributed across the region.

PHIC commissioned Katestone Environmental Pty Ltd (Katestone) to prepare this annual performance report on the Port Hedland ambient air quality monitoring network for FY 2020/21. This is the ninth annual performance report of its kind and the fifth annual report prepared by Katestone.

The annual report findings are summarised below.

8.1. PM_{10}

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

- The Taplin monitoring station recorded one day above the 24-hour average AGV for PM_{10} of 70 µg/m³ (3 October 2020).
- The exceedance at the Taplin site on 3 October 2020 was attributed to a local industry source as well as a regional event.
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites in FY 2020/21. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 8 days at BoM and Yule to 101 days at Wedgefield.
- The number of days per year above the AAQ NEPM standard for PM_{10} at each monitoring station have been compared for the last nine years, which shows the following:
    - With the exception of Taplin, the number of 24-hour average concentrations above the AAQ NEPM standard decreased compared to the year prior at all monitoring stations.
    - The Richardson site recorded a gradual increase in the number of days recording 24-hour average concentrations above the AAQ NEPM standard over the 4 years from FY 2016/17 to FY 2019/20 which may have been in part due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017. The number of days recording 24-hour average concentrations above the AAQ NEPM standard at this site dropped significantly between the FY 2019/20 and FY 2020/21.
    - The Taplin site was unavailable for the full FY 2018/19 year and for the first six months of FY 2019/20; however, the low number of days above the AGV for the second half of FY 2019/20 (3) as well as for the full FY 2020/21 (1) suggests a slight downward trend in the number of days exceeding the AGV since the FY 2017/18.
- The annual average concentration of PM_{10} was above the AAQ NEPM standard of 25 µg/m³ at BoM, Kingsmill, Richardson, Taplin and Wedgefield sites during FY 2020/21.
- The annual average concentration of PM_{10} was below the AAQ NEPM standard of 25 µg/m³ at Neptune, South Hedland and Yule.
- Annual average concentrations of PM_{10} over the past nine years (FY 2012/13 to FY 2020/21) show that:
    - Peaks occured in the annual average concentration in FY 2014/15 and in FY 2018/19, while troughs occurred in FY 2016/17 and in FY 2020/21.
    - The trend in the annual average concentration at the sites that have been in operation since FY 2015/16 is generally consistent with the longer-term trend, with a lower concentration recorded during FY 2016/17 and FY 2017/18, a peak in FY 2018/19 and FY 2019/20, followed by another drop in FY 2020/21.
    - The Richardson monitoring site shows a gradual increase in the annual average concentration from FY 2015/16 through to the peak in concentration in FY 2019/20. The average concentration dropped again in FY 2020/21, with the gradual increase prior likely due, in part, to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.

- While the Taplin monitoring site had a gap in monitoring data between May 2018 and December 2019, the available long-term data across all of the sites, including Taplin, can provide an inference as to the long-term trend at this site. The available data shows that this site generally experienced a similar long term trend to that observed at the other monitoring stations up to the period of missing data at the Taplin site, and then again after monitoring at the site recommenced in January 2020. While it cannot be determined whether the concentrations increased at Taplin during the FY 2018/19 and FY 2019/20 ,similar to the trend at other stations,, the data suggests that this may have been the case.

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 FY 2020/21.
- The annual average concentration of $PM_{2.5}$ was below the AAQ NEPM standard of 8 µg/m³ at BoM (background), Richardson, Taplin and Yule (background) monitoring stations.

8.3. NO_2

Analysis of the NO_2 data found that the concentrations of NO_2 measured at Taplin in FY 2020/21 were low and well below the AAQ NEPM standards. Concentrations were consistent with the NO_2 concentrations measured in previous years.

8.4. Data Capture

The annual data capture criterion of 75% was met for each pollutant at all monitoring stations during FY 2020/21. The quarterly data capture criterion of 75% was met for each pollutant and at all monitoring stations with the exception of $PM_{2.5}$ in Q3 at Yule as a result of the extended tropical low shut-down period between 29 January 2021 and 16 February 2021.

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Appendix A PM_{10} TREND SUMMARY GRAPHS

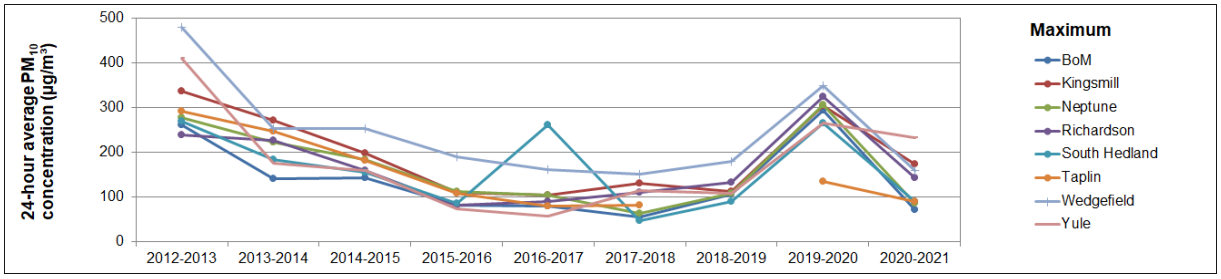

Figure A-1: Maximum 24-hour average PM_{10} Trends

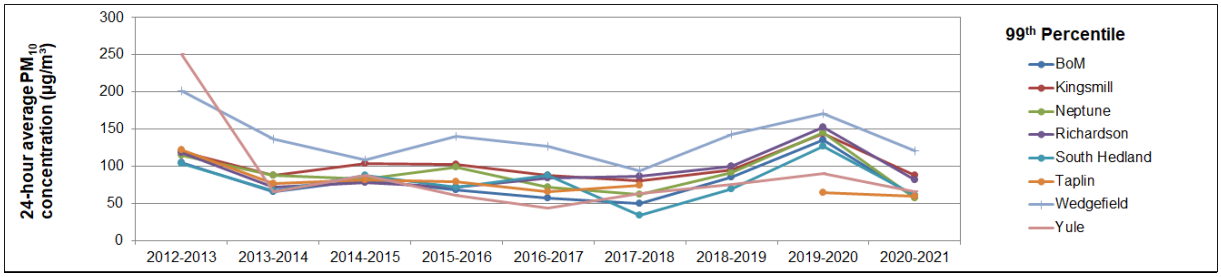

Figure A-2: 99th percentile 24-hour average PM_{10} Trends

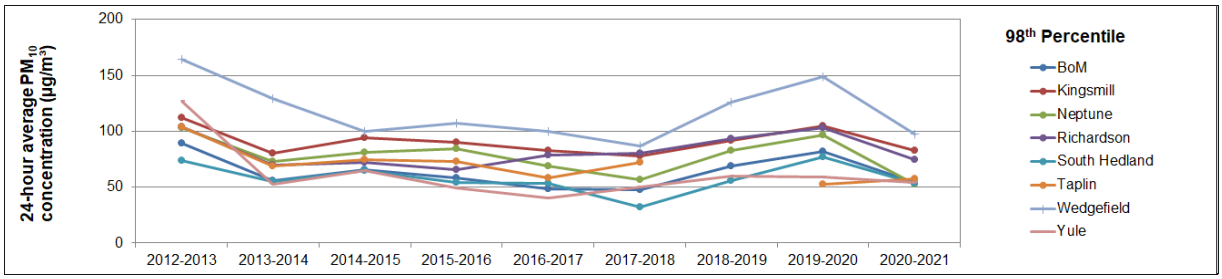

Figure A-3: 98th percentile 24-hour average PM_{10} Trends

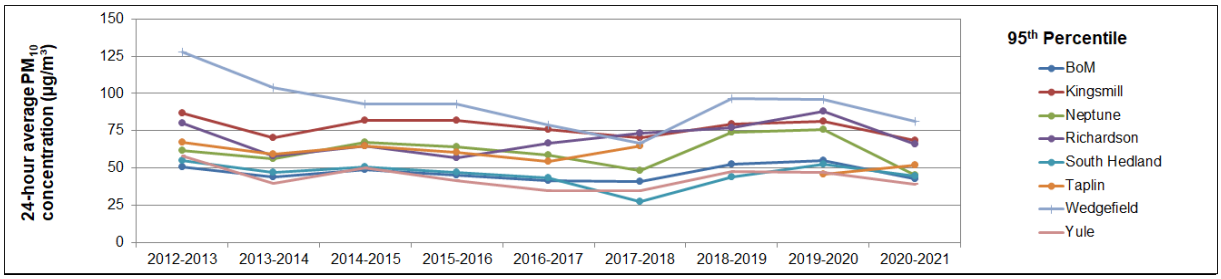

Figure A-4: 95th percentile 24-hour average PM_{10} Trends

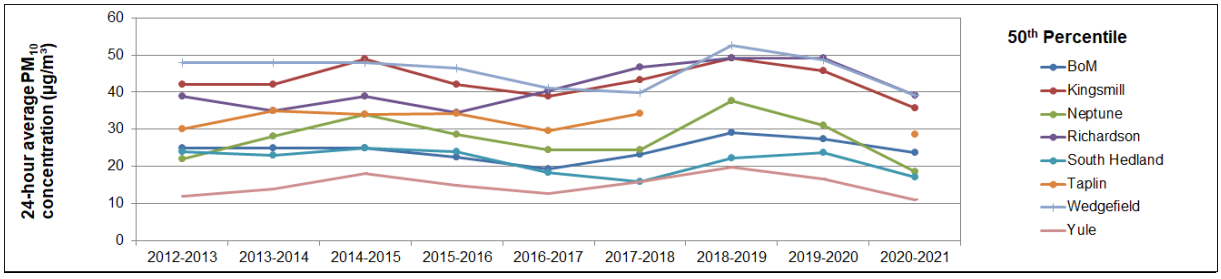

Figure A-5: 50th percentile 24-hour average PM_{10} Trends