PORT HEDLAND INDUSTRIES COUNCIL

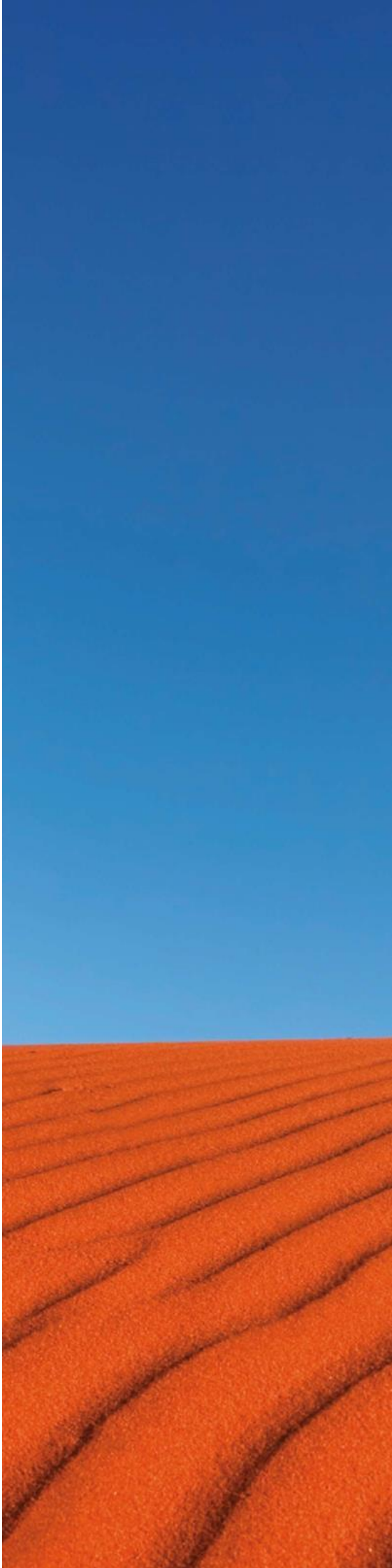
Annual Report – FY 2019/20 Port Hedland Ambient Air Quality Monitoring Program

FINAL

Port Hedland Industries Council

October 2020

Prepared by Katestone Environmental Pty Ltd



DOCUMENT CONTORL	
Deliverable Number:	D19037-17
Status:	Final
Document reference:	D19037-17 FY2019-20 Annual Monitoring Report v1.0 - Final.docx
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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 2019/20. This is the eighth annual performance report of its kind and the fourth annual report prepared by Katestone.

On 23 January 2020, following a series of investigations, PHIC confirmed inconsistent PM_{10} readings had occurred from the Taplin monitoring station PM_{10} instrument and affected the data from April 2018 to December 2019. The inconsistent Taplin PM_{10} data from 1 July 2019 to 31 December 2019 has been removed from this FY 2019/20 report. Following the finding of instrument inconsistencies with the Taplin PM_{10} monitor, PHIC conducted validation studies on all PHIC network PM_{10} instruments to ensure integrity of the network. Validation studies occurred between February 2020 and June 2020 and showed that all PM_{10} instruments were providing acceptable data. Further information on the PHIC Taplin PM_{10} instrument investigation can be found at the following link (PHIC Media Release, August 14, 2020).

A summary of the PHIC ambient air quality monitoring network in FY 2019/20 is provided in the table below.

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

This annual report presents a summary of the Port Hedland ambient air quality monitoring network performance for FY 2019/20. 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 – interim guideline for PM_{10} of 70 µg/m³ (24-hour average) with ten allowable exceedances at Taplin.
  - *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:

- During the period of available data (1 January 2020 to 30 June 2020), the Taplin monitoring station recorded three days above the 24-hour average interim guideline for PM_{10} of 70 µg/m³.
- The exceedances of the 24-hour average interim guideline for PM_{10} of 70 µg/m³ on 9 and 10 January 2020 were attributed to regional events.
- The exceedance of the 24-hour average interim guideline for PM_{10} of 70 µg/m³ on 18 May 2020 was attributed to a local industry source.
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites in FY 2019/20. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 10 days at Taplin (1 January 2020 to 30 June 2020 only) to 173 days at Richardson.
- The number of days per year above the AAQ NEPM standard for PM_{10} at each monitoring station have been compared for the last eight years, which shows the following:
    - The number of 24-hour average concentrations above the AAQ NEPM standard during FY 2019/20 dropped slightly compared to the year prior at Kingsmill, Neptune, Wedgefield and Yule monitoring stations.
    - The number of 24-hour average concentrations above the AAQ NEPM standard during FY 2019/20 increased slightly compared to the year prior at BoM, South Hedland and Richardson monitoring stations.
    - The Richardson site has recorded a gradual increase in the number of days above the AAQ NEPM standard over the 4 years from FY 2016/17, with the 173 event days recorded during the FY 2019/2020. This increase, may be in part, due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.
    - It is difficult to establish the trend at Taplin over the past two years from July 2018 to June 2020 due to the large period of insufficient data.
- The annual average concentration of PM_{10} was above the AAQ NEPM standard of 25 µg/m³ at BoM, Kingsmill, Neptune, Richardson, South Hedland, Taplin and Wedgefield.
- The annual average concentration of PM_{10} was below the AAQ NEPM standard of 25 µg/m³ at Yule.
- Annual average concentrations of PM_{10} over the past five years (FY 2015/16 to FY 2019/20) show that:
    - Neptune, South Hedland and Wedgefield monitoring stations have a slight decreasing trend to FY 2017/18, before increasing during FY 2018/19. Neptune and Wedgefield have a slight decreasing trend to FY 2019/20, while South Hedland shows a small increase.
    - BoM, Kingsmill and Yule have a relatively steady trends to FY 2017/18, before increasing during FY 2018/19. Kingsmill and Yule show a slight decreasing trend to FY 2019/20, while BoM shows a small increase.
    - The annual average trend at Taplin monitoring station from FY 2017/18 is difficult to determine due to the large period of insufficient data.
    - Richardson monitoring station shows an increasing trend through to FY 2019/20. This increase, may be in part, be due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.

$PM_{2.5}$

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

- The 24-hour average concentrations of $PM_{2.5}$ were above the AAQ NEPM standard of 25 µg/m³ on 9, 4, 5 and 2 days at the BoM (background), Richardson, Taplin and Yule (background) monitoring stations, respectively.
- The annual average concentration of $PM_{2.5}$ were below the AAQ NEPM standards at BoM (background), Richardson, Taplin and Yule (background).

NO_2

Analysis of the NO_2 data found that the concentrations of NO_2 measured at Taplin in FY 2019/20 were low and well below the AAQ NEPM standards. Concentrations were consistent with the NO_2 concentrations measured in previous years.

Data Capture

With the exception of Taplin PM_{10}, the annual data capture criterion of 75% was met for each pollutant at all monitoring stations during FY 2019/20.

The quarterly data capture criterion of 75% was met for each pollutant and at all monitoring stations with the exception of:

- PM_{10} in Q1 and Q2 at Taplin (inconsistent data removed)
- $PM_{2.5}$ in Q3 at Taplin (due to instrument being switched to PM_{10} as part of the data accuracy investigation
- PM_{10} and $PM_{2.5}$ in Q3 at Yule (due to Cyclone Damien and other cyclone warnings that resulted in power shutdown periods).

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). At the time of writing this annual report, the transfer of the network to DWER has not been finalised.

In accordance with the Taskforce requirements, PHIC has commissioned Katestone Environmental Pty Ltd (Katestone) to prepare this annual performance report on the Port Hedland ambient air quality monitoring network for FY 2019/20. This is the eighth annual performance report of its kind and the fourth annual report prepared by Katestone.

This annual performance report for the FY 2019/20 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**).

1.2. Taplin PM10

On 23 January 2020, following a series of investigations, PHIC confirmed inconsistent readings had occurred from the PM_{10} instrument at Taplin monitoring station that affected the data from April 2018 to December 2019. The FY 2018/19 Annual Report was re-issued in April 2020 with the inconsistent Taplin PM_{10} data removed. Similarly, the inconsistent Taplin PM_{10} data from 1 July 2019 to 31 December 2019 has been removed from this report.

Further information on the investigation into the Taplin PM_{10} instrument can be found at the following link (**PHIC Media Release, August 14, 2020**).

1.3. PHIC Network Instrument Validation

Following the finding of instrument inconsistencies with the Taplin PM_{10} monitor, PHIC conducted validation studies on all PM_{10} instruments to ensure integrity of the network (Ecotech, 2020). PM_{10} validation studies occurred

between February 2020 and June 2020. A high volume air sampler (HiVol) with a PM_{10} inlet was co-located at each PHIC site for a period of two weeks in accordance with Australian Standard 3580.9.6-2015 - *Methods for sampling and analysis of ambient air. Method 9.6 Determination of suspended particulate matter – PM_{10} high volume sampler with size selective inlet*.

The results of the paired HiVol and PHIC BAM 1020 24-hour average PM_{10} concentrations at each site were validated by calculating a normalised error score. The results showed that 96 of the 98 paired HiVol / BAM 1020 PM_{10} concentrations (98% of the samples) were within the acceptable criteria range using the normalised error score. The remaining two paired concentrations (one at Richardson and one at Kingsmill) were marginally outside the acceptable criteria range. Overall, the PHIC BAM 1020 PM_{10} insturment measuremetns were found to be acceptable.

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 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}, $PM_{2.5}$, meteorological conditions (wind speed, wind direction and temperature) and oxides of nitrogen (NO_x).

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 Wedgefield monitoring station is within a light industrial area that includes some residences and is located between the South Hedland and Port Hedland townships.

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 30 km from Port Hedland and serves as a rural background location.

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
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	✓	✓	✓	✓
Wedgefield	-20.370454°	118.584820	Industrial	✓			✓
Yule	-20.595167°	118.296311	Rural Background	✓	✓		✓

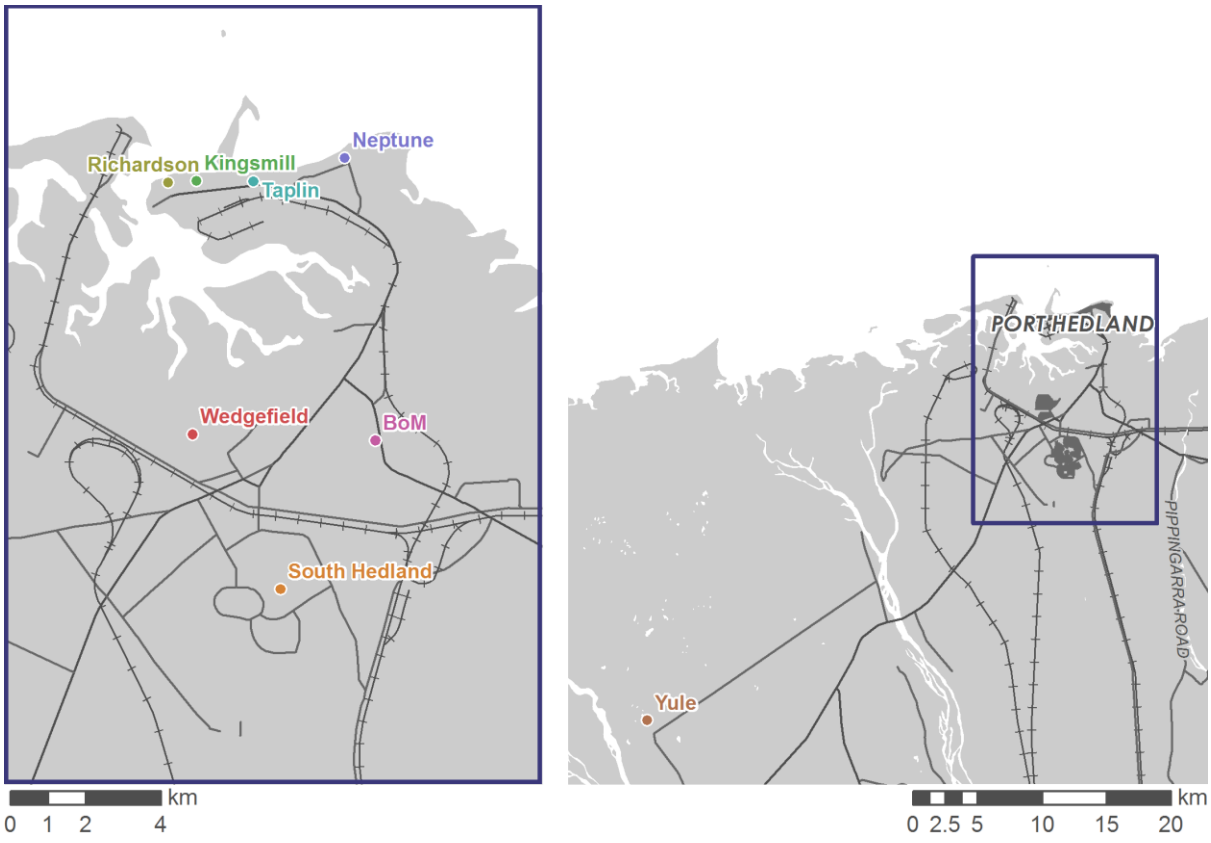


Figure 2-1: Port Hedland Ambient Air Quality Monitoring Network

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. Katestone produced a 1-hour average dataset from each BAM 5-minute or 10-minute average dataset. 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.

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 2019/20 Activities

The Port Hedland ambient air quality monitoring network activities for FY 2019/20 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 Tropical Cyclone Damien that affected the entire Port Hedland area between 7 February and 12 February 2020. The data loss at the Yule monitoring station continued up to 22 February 2020 due to the remote location of the site, which prevented access to restart. The Yule monitoring station also had a shut-down period between 5 January and 16 January due to a cyclone warning.
- The investigation of PM_{10} levels at Taplin was carried out during January 2020 into whether inconsistent data was being recorded. The investigation involved the $PM_{2.5}$ BAM inlet at Taplin being changed to a PM_{10} inlet for direct comparison with the existing PM_{10} instrument on 1 January 2020. Consequently, there was no $PM_{2.5}$ data recorded at the Taplin monitoring station during this period.
- As previously discussed, the Taplin PM_{10} instrument was found to have recorded inconsistent data between July 2019 and December 2019 and so the dataset has been removed.
- Intermittent power failures resulting from low solar charge at Kingsmill during July 2019.
- Ongoing intermittent data transmission errors for the meteorological station at South Hedland.
- Intermittent data losses across all stations during the period due to yearly maintenance, background tests and zero-tests.
- Power failure at Kingsmill during March 2020.
- Power failure and instrument fault/station shutdown due to a faulty air conditioner at Yule during April 2020.
- Extended background check performed at Yule during April 2020 and Kingsmill during May 2020.

Table 2-3: FY 2019/20 Port Hedland ambient air quality monitoring network activities

Station	Parameter	Averaging time [A]	Q1			Q2			Q3			Q4		
			July 19	August 19	September 19	October 19	November 19	December 19	January 20	February 20	March 20	April 20	May 20	June 20
BoM	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓	✓[B]	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
Kingsmill	PM_{10}	10-min / 1-hr	✓[C]	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓[M]	
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
Neptune	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓[I]	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
Richardson	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
South Hedland	PM_{10}	5-min / 1-hr	✓[D]	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
	Meteorology	5-min	✓[E]	✓ [E]	✓ [E]	✓ [E]	✓ [E]	✓ [E]	✓ [E]	- [B,E]	✓ [E]	✓ [E]	✓ [E]	✓ [E]
Taplin	PM_{10}	10-min / 1-hr	-[F]	- [F]	- [F]	- [F]	- [F]	- [F]	✓	✓ [B]	✓	✓	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	-[G]	-[B,G]	✓ [G]	✓	✓	✓
	NO_x	5-min	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	✓	✓ [B]	✓	✓	✓	✓
Wedgefield	PM_{10}	5-min / 1-hr	✓[H]	✓	✓	✓	✓	✓	✓	✓ [B]	✓[J]	✓	✓	✓
	Meteorology	10-min	- [H]	✓	✓	✓	- [H]	✓ [H]	✓	✓ [B]	✓	✓	✓	✓
Yule	PM_{10}	10-min / 1-hr	✓	✓	✓	✓	✓	✓	-[B]	-[B,L]	✓	✓ [K]	✓	✓
	$PM_{2.5}$		✓	✓	✓	✓	✓	✓	-[B]	-[B,L]	✓ [L]	✓ [K]	✓	✓
	Meteorology	10-min	✓	✓	✓	✓	✓	✓	-[B]	-[B,L]	✓	✓	✓	✓

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 tropical Cyclone Damien that affected the entire Port Hedland area between 7 February and 12 February 2020. The data loss occurred up to 22 February 2020 at the Yule monitoring station due to the remote location of the site which prevented access to restart. The Yule monitoring station also had a shut-down period between 5 January and 16 January 2020 due to a cyclone warning.

[C] Reduced data capture at Kingsmill during July due to intermittent power failures resulting from low solar charge.

[D] Reduced data capture at South Hedland due to a zero-test performed as part of yearly maintenance

[E] Reduced data capture for meteorological parameters at South Headland due to ongoing intermittent data transmission errors and power interruptions.

[F] PM_{10} monitor at Taplin found to be operating incorrectly and was decommissioned in January 2020. All PM_{10} data recorded at this site during July to December 2020 was subsequently removed from all analysis.

[G] Due to the investigation of PM_{10} levels at Taplin monitoring station, the $PM_{2.5}$ BAM inlet at Taplin was changed to a PM_{10} inlet for direct comparison with the existing PM_{10} instrument. Subsequently there was no $PM_{2.5}$ data recorded at the Taplin monitoring station during this three-month (January to March 2020) investigation period.

[H] Reduced data capture at Wedgefield due to yearly maintenance zero-test as well as intermittent power interruptions

[I] Reduced data capture at Neptune due to background test performed during March 2020.

[J] Reduced data capture at Wedgefield due to yearly maintenance and extended zero check during March 2020.

[K] Reduced data capture at Yule due to background test performed during April

[L] Reduced data capture at Yue due to power failure as well as instrument fault/shutdown due to faulty AC.

[M] Reduced data capture at Kingsmill due to background test performed during May

2.5. Data Processing

The FY 2019/20 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 2019/20 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 interim PM_{10} guideline 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 three days during period of available data at the Taplin monitoring station during the FY 2019/20 (January to June 2020) when the Taplin monitoring station recorded 24-hour average concentrations of PM_{10} above the interim guideline of 70 µg/m³. Further analysis of these event days 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 2019/20 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). The interim guideline for PM_{10} is defined as follows:

- Maximum concentration of 70 µg/m³ for a 24-hour average
- Ten exceedance events per calendar year due to industry (using a background station as a reference)
- Applies to residential areas east of Taplin Street

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 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 246 µg/m³ for 24-hour average concentration of NO_2 with maximum allowable exceedances of 1 day a year
- Maximum concentration of 62 µg/m³ for annual average concentration of NO_2.

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]	Interim Guideline
	24-hour	50	AAQ NEPM 2016
	Annual	25	
$PM_{2.5}$	24-hour	25	AAQ NEPM 2016
	Annual	8	
NO_2	1-hour	246[C]	AAQ NEPM 2016
	Annual	62	

Table note:
[A] Ten exceedance days allowed per year due to industry (using background station as a reference)
[B] Applies to residential areas east of Taplin Street
[C] Maximum allowable exceedances of 1 day a year

3. SUMMARY OF FY2019/20 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.

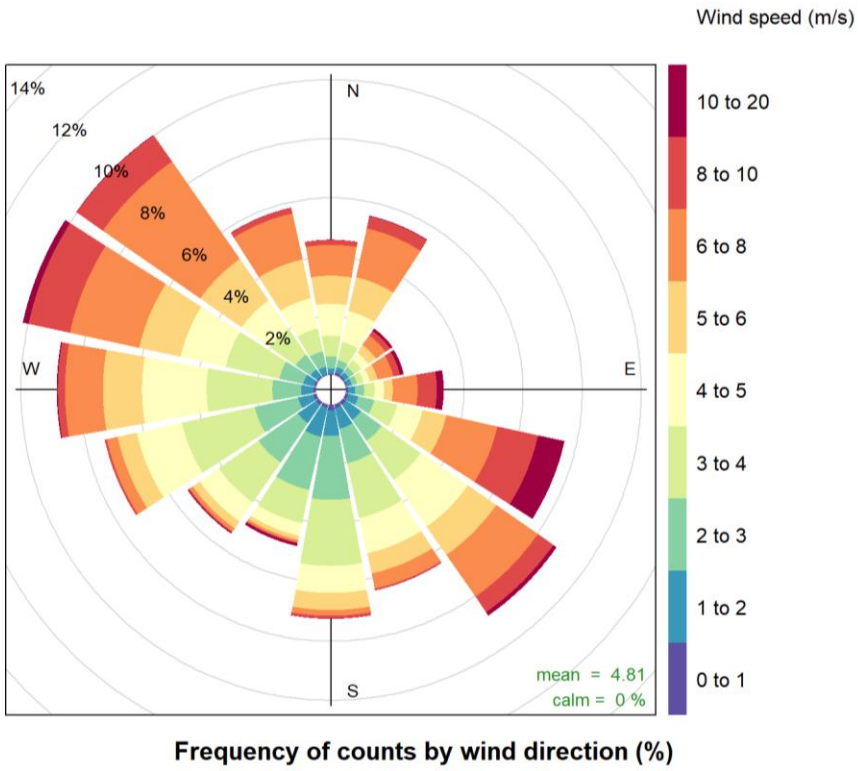
Exposed dust sources (be it from industry sources, other anthropogenic sources or natural sources), will have higher dust emissions during dry conditions and strong winds. The dust emissions will also have a greater radius of impact during periods of stronger wind speeds due to dust remaining suspended 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 2019/20 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 direction at all three sites is the northwest quadrant (west to northwest).
- All three sites also show frequent winds from the southeast quadrant.
- 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 2019/20 annual average wind speeds of 4.8 m/s, 2.3 m/s and 2.4 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.



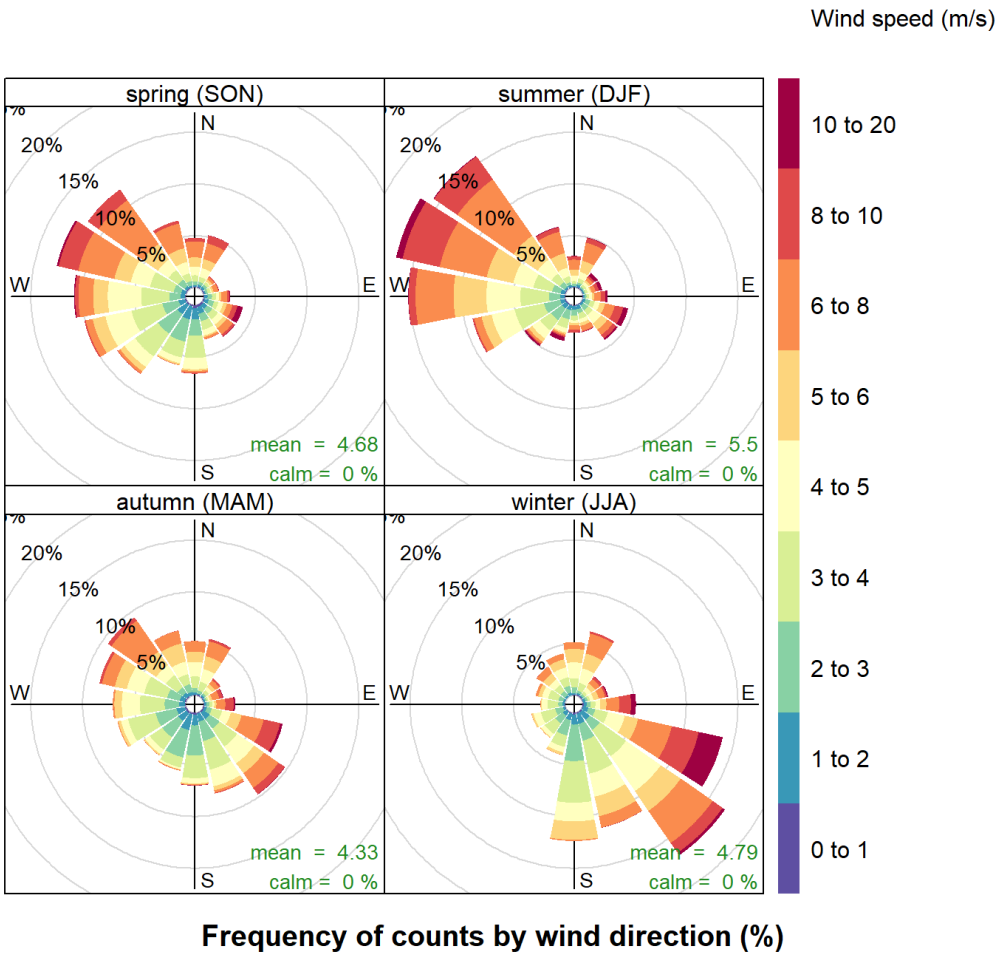
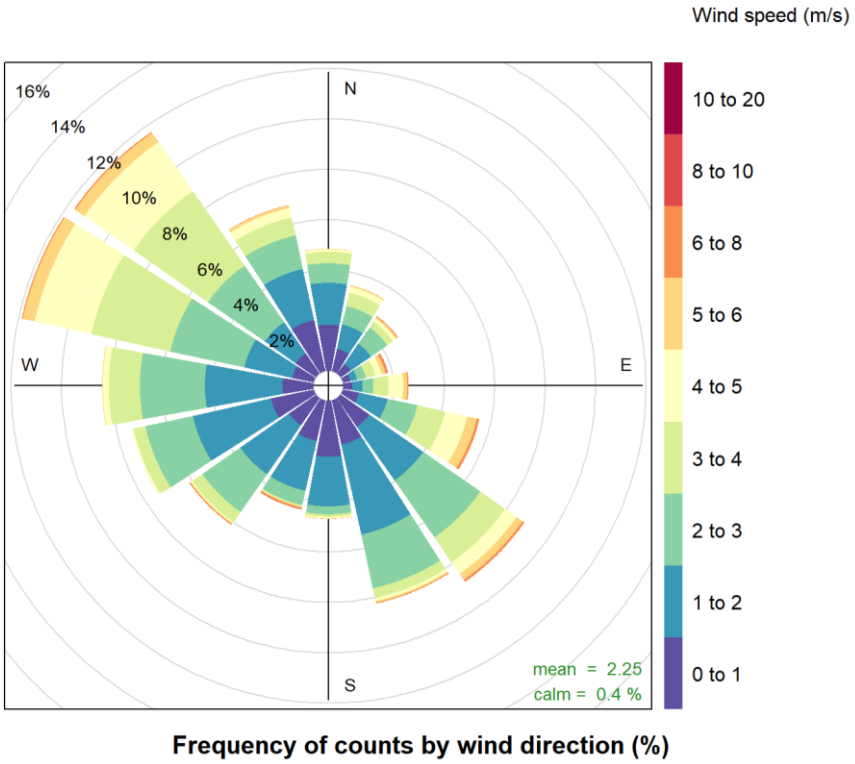


Figure 3-1: FY 2019/20 wind roses for BoM annual (top) seasonal (bottom)



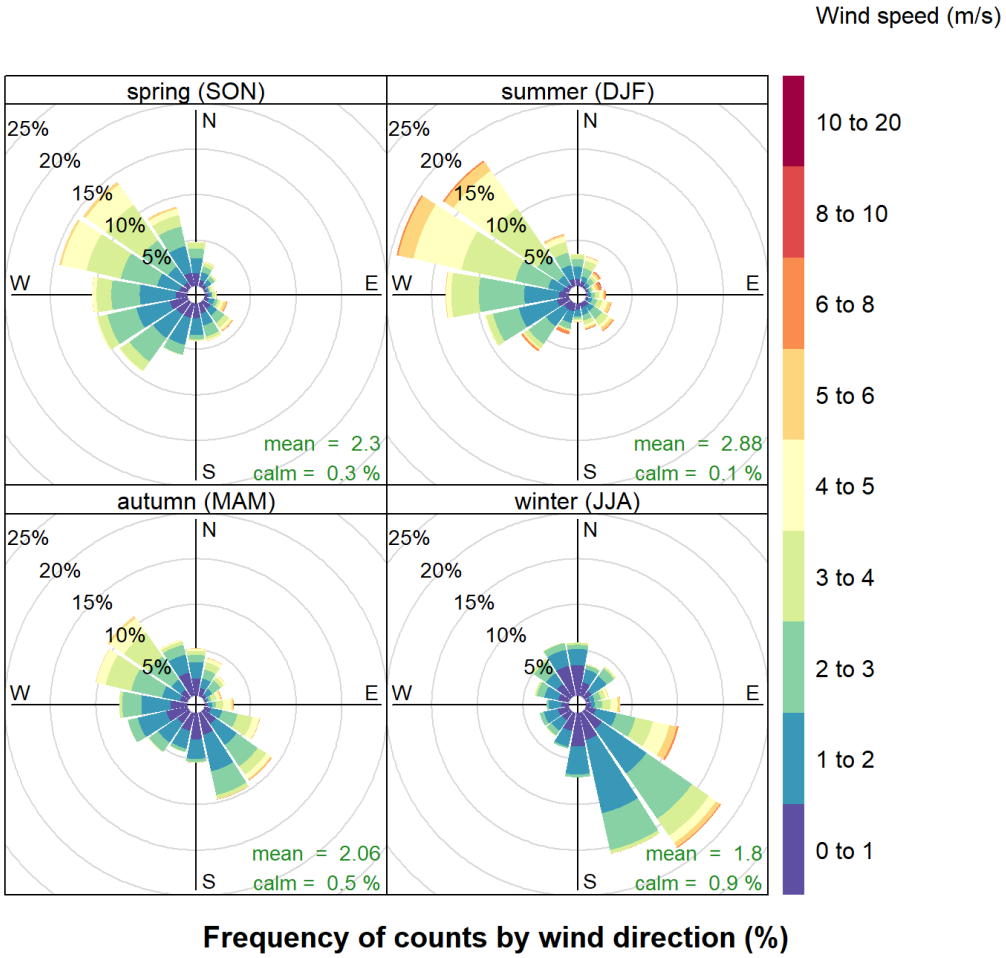
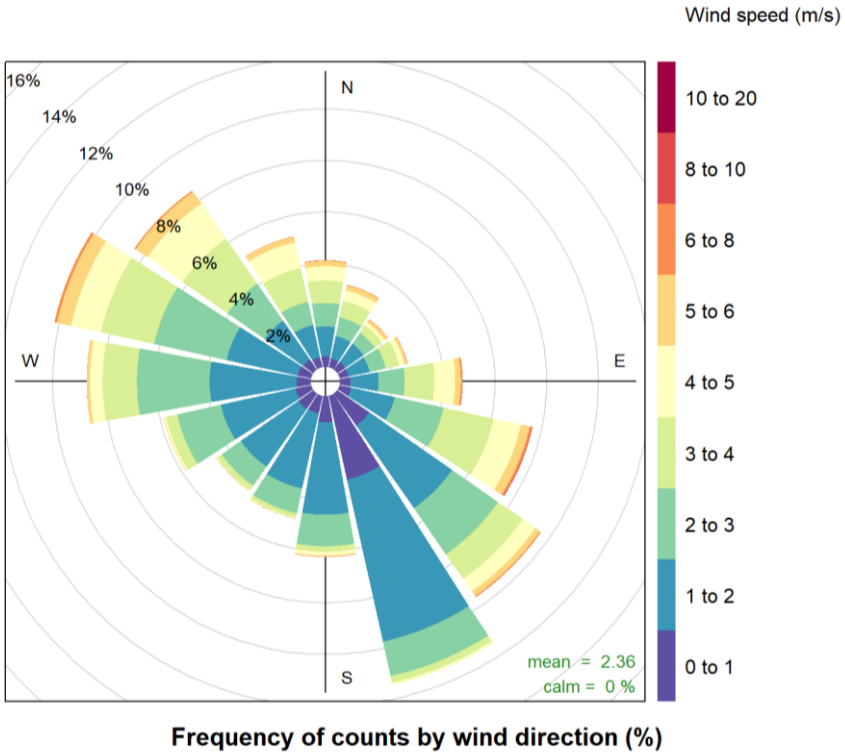


Figure 3-2: FY 2019/20 wind roses for Taplin annual (top) seasonal (bottom)



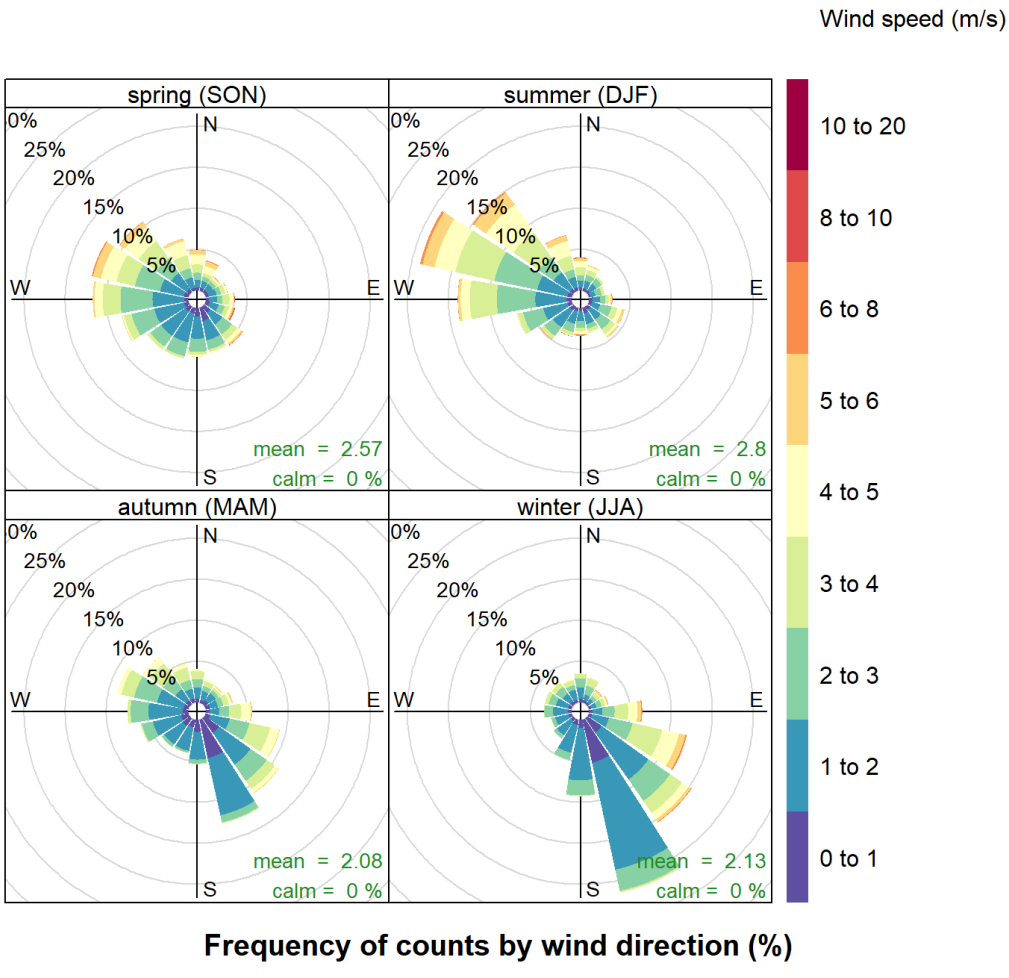


Figure 3-3: FY 2019/20 wind roses for Yule annual (top) seasonal (bottom)

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. PM10

PM_{10} was measured at all eight (8) monitoring stations during FY 2019/20.

4.1.1. Data Capture

Data capture rates for 1-hour average concentrations of PM_{10} for each monitoring station in FY 2019/20 are detailed in Table 4-1. The reduced period of available data at the Taplin site due to the inconsistent data recorded prior to the replacement BAM being installed on 1 January 2020 resulted in an annual data capture of less than 50%. However, following installation of the replacement BAM, the data capture was greater than 96% for Q3 and Q4, satisfying the PHIC criterion of 75%.

All other stations achieved an annual capture rate for PM_{10} of greater than 90%, meeting the PHIC criterion of 75% data capture. With the exception of Q3 at Yule, all sites also achieved quarterly capture rates greater than 87%, satisfying the PHIC criterion of 75% data capture. Data capture at Yule during Q3 was reduced to 71% due to Tropical Cyclone Damien that affected the entire Port Hedland area between 7 February and 12 February 2020.

The data loss occurred across all sites during the cyclone due to PHIC cyclone protcols, which require instruments to be intentionally shutdown; however, the data loss at the Yule monitoring station continued up to 22 February 2020 due to the remote location of the site which prevented access to restart. The Yule monitoring station also had a shut-down period between 5 January 2020 and 16 January 2020 due to another cyclone warning.

Table 4-1: FY 2019/20 Data Capture Summary 1-hour average concentration of PM_{10}

Monitoring Station	2019/20 PM_{10} Data Capture Rate (%)					Performance
	Q1	Q2	Q3	Q4	Annual	
BoM	99.8	99.6	93.8	98.5	97.9	Met
Kingsmill	95.0	99.5	91.7	96.3	95.7	Met
Neptune	99.8	99.8	90.2	99.2	97.3	Met
Richardson	98.6	99.8	95.3	99.8	98.4	Met
South Hedland	96.4	99.8	94.9	99.0	97.5	Met
Taplin	0	0	96.1	99.1	48.5	Not Met [A]
Wedgefield	95.2	97.0	87.2	95.4	93.7	Met
Yule	98.0	97.4	71.0	93.5	90.0	Not Met [B]

Table note:
[A] Data not available at Taplin during Q1 and Q2 due to inconsistent data being removed from analysis. Data capture during available period (January to June 2020) following installation of replacement BAM was above the PHIC criterion of 75%.
[B] Data capture rate in Q3 at Yule was less than 75%.

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 interim guideline for each station are detailed in Table 4-2. The average concentration of PM_{10} for FY 2019/20 for each station is detailed in Table 4-3.

The measurements of PM_{10} show that for FY 2019/20:

- The Taplin monitoring station recorded three days above the 24-hour average interim guideline for PM_{10} of 70 µg/m³ (1 January 2020 to 30 June 2020 only).
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on one or more days at all sites in FY 2019/20. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 10 days at Taplin (1 January 2020 to 30 June 2020 only) to 173 days at Richardson.

- With the exception of Yule, the annual average concentration of PM_{10} was above the AAQ NEPM standard of 25 µg/m³ at all sites during FY 2019/20.

Table 4-2: FY 2019/20 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 (Taskforce)	Performance (Taskforce)
BoM	293.2	33	Not met	-	-
Kingsmill	303.7	148	Not met		
Neptune	306.3	66	Not met		
Richardson	325.3	173	Not met		
South Hedland	264.7	22	Not met		
Taplin	134.8	10	Not demonstrated [A]	3	Not demonstrated [A]
Wedgefield	349.3	159	Not met	-	-
Yule	265.4	13	Not demonstrated [B]		

Table note:
[A] Data not available at Taplin during Q1 and Q2 due to inconsistent data being removed from analysis.
[B] Data capture rate in Q3 at Yule was less than 75%

Table 4-3: FY 2019/20 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	32.1	Not met
Kingsmill	50.3	Not met
Neptune	36.6	Not met
Richardson	54.1	Not met
South Hedland	27.9	Not met
Taplin	31.1	Not demonstrated [A]
Wedgefield	54.6	Not met
Yule	21.0	Not demonstrated [B]

Table note:
[A] Data not available at Taplin during Q1 and Q2 due to inconsistent data being removed from analysis.
[B] Data capture rate in Q3 at Yule was less than 75%

4.1.3. PM10 Timeseries Analysis

Timeseries plots of the 24-hour average concentrations of PM_{10} for FY 2019/20 for each monitoring station are shown in Figure 4-1.

The timeseries plot for Taplin monitoring station shows that the 24-hour average concentrations of PM_{10} were above the interim guideline of 70 µg/m³ on three occasions during the period of available data. Two of the occasions above the interim guideline occurred on 9 January and 10 January 2020, during Tropical Cyclone Blake, with all sites experiencing elevated levels.

Other notable events include significant regional dust storms on 30 November and 10-12 December 2019 that resulted in elevated 24-hour average PM_{10} concentrations at all PHIC sites.

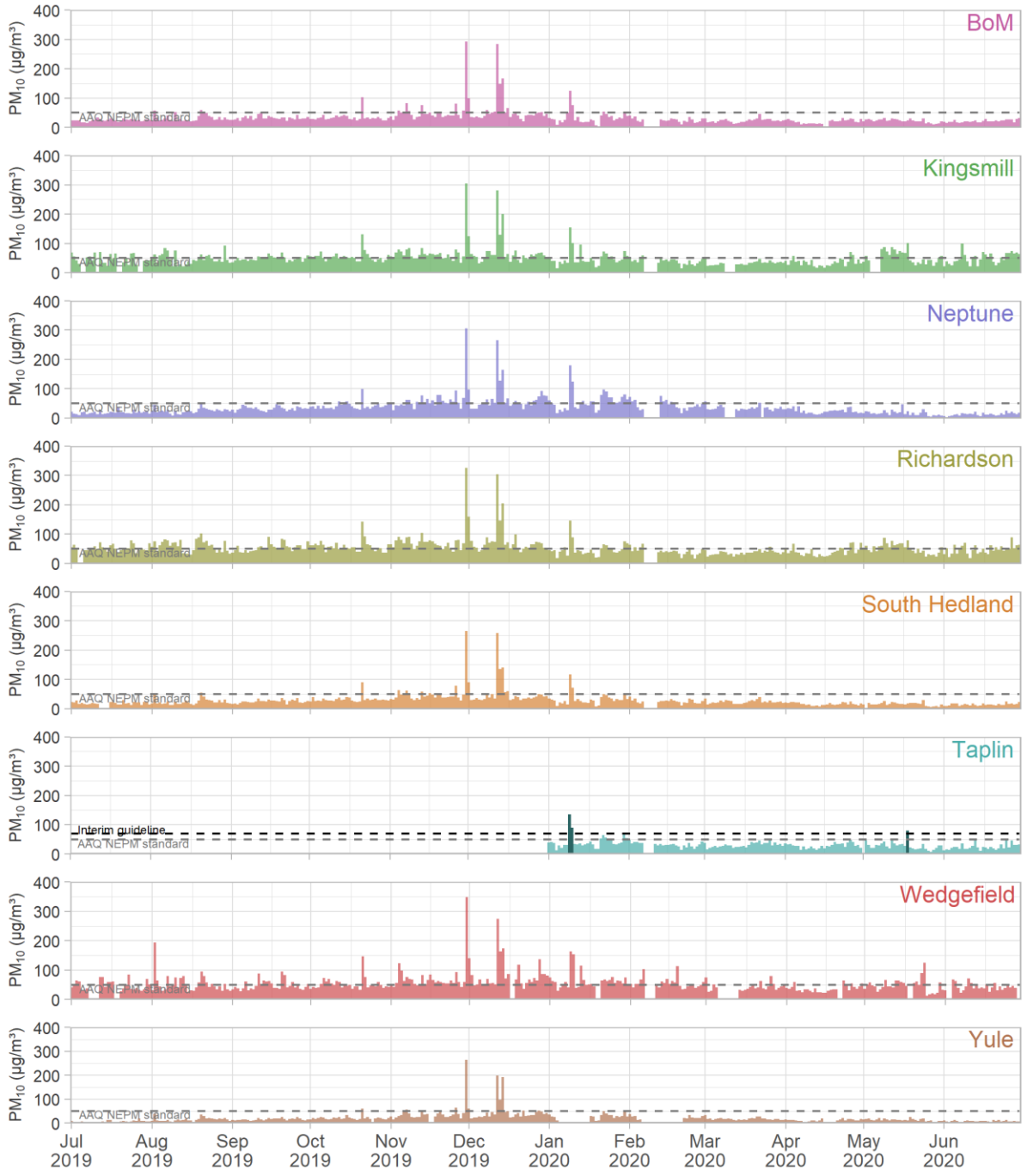


Figure 4-1: FY 2019/20 time series plots of 24-hour average concentrations of PM_{10}

4.2. PM2.5

$PM_{2.5}$ was measured at four (4) monitoring stations (BoM, Richardson, Taplin and Yule) during FY 2019/20.

4.2.1. Data Capture

Data capture rates for 1-hour average concentrations of $PM_{2.5}$ for each monitoring station in FY 2019/20 are detailed in Table 4-4. All stations achieved an annual capture rate for $PM_{2.5}$ of greater than 80%, satisfying the PHIC annual criterion of 75% data capture. The BoM and Richardson monitoring stations achieved quarterly capture rates greater than 94%, satisfying the PHIC quarterly criterion of 75% data capture.

Data capture at Taplin during Q3 was reduced to 22% due to the investigation of PM_{10} levels that involved changing the $PM_{2.5}$ BAM inlet to a PM_{10} inlet for comparison with the existing PM_{10} instrument, resulting in no $PM_{2.5}$ data at Taplin for the period 1 January 2020 to 11 March 2020. Data capture at Taplin was above 99% for all remaining quarters.

Data capture at Yule during Q3 was reduced to 65% due to Tropical Cyclone Damien that affected the entire Port Hedland area between 7 February and 12 February 2020. The data loss occurred across all sites during the cyclone due to PHIC cyclone protcols, which require instruments to be intentionally shutdown; however, the data loss at the Yule monitoring station continued up to 22 February 2020 due to the remote location of the site which prevented access to restart. The Yule monitoring station also had a shut-down period between 5 January and 16 January 2020 due to a cyclone warning.

Table 4-4: FY 2019/20 data capture summary 1-hour average concentrations of $PM_{2.5}$

Monitoring Station ID	2019/20 $PM_{2.5}$ Data Capture Rate (%)					Performance
	Q1	Q2	Q3	Q4	Annual	
BoM	99.8	99.5	94.4	98.7	98.1	Met
Richardson	98.5	99.8	94.2	99.8	98.1	Met
Taplin	99.5	99.5	22.4	99.5	80.4	Not met [A]
Yule	97.7	97.1	65.2	93.2	88.4	Not Met [B]

Table note:
[A] Due the investigation of PM_{10} levels at Taplin, the $PM_{2.5}$ BAM inlet at Taplin was changed to a PM_{10} inlet for comparison with the existing PM_{10} instrument between 1 January 2020 and 11 March 2020. Subsequently, data capture rate in Q3 at Taplin was less than 75%.
[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 2019/20:

- The 24-hour average concentration of $PM_{2.5}$ was above the AAQ NEPM standard of 25 µg/m³ on 9, 4, 5 and 2 days at BoM (background), Richardson, Taplin and Yule (background) monitoring stations, respectively.
- 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 2019/20 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	55.3	9	Not met	7.9	Met
Richardson	54.7	4	Not met	7.1	Met
Taplin	58.3	5	Not demonstrated [A]	7.7	Not demonstrated [A]
Yule	41.1	2	Not demonstrated [B]	4.1	Not demonstrated [B]

Table note:
[A] Data capture rate in Q3 at Taplin was less than 75%.
[B] Data capture rate in Q3 at Yule was less than 75%.

4.2.3. PM2.5 Timeseries Analysis

A timeseries plot of the 24-hour average concentration of $PM_{2.5}$ for FY 2019/20 for each monitoring station is shown in Figure 4-2.

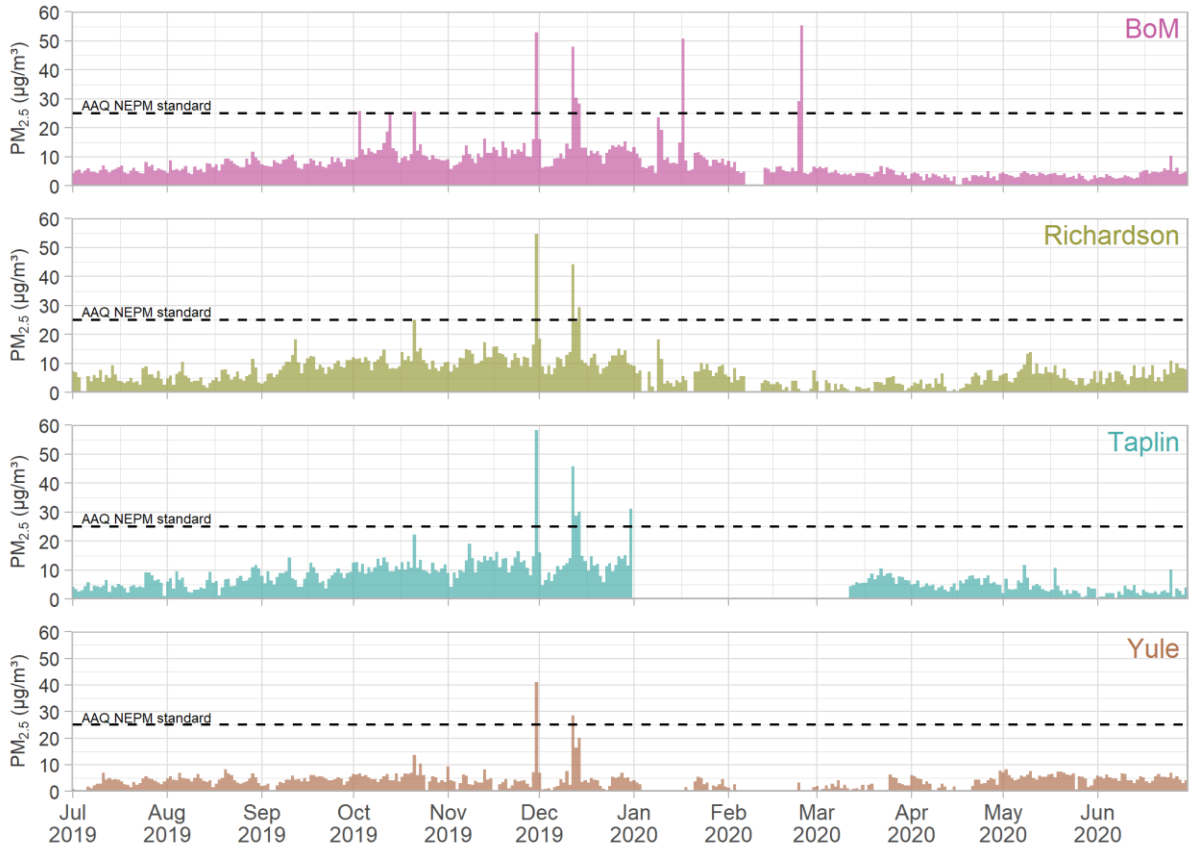


Figure 4-2: FY 2019/20 time series plots of 24-hour average concentrations of $PM_{2.5}$

4.3. Oxides of Nitrogen

NO_x was measured at the Taplin monitoring station during FY 2019/20. 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 94%, which meets the PHIC annual criterion of 75% data capture.

Table 4-6: FY 2019/20 data capture summary 1-hour average concentrations of NO_x

Monitoring Station ID	2019/20 NO_x Data Capture Rate (%)					Performance
	Q1	Q2	Q3	Q4	Annual	
Taplin	99.7	99.5	94.7	97.9	98.0	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 2019/20:

- The 1-hour average concentrations of NO_2 were below the AAQ NEPM standard of 246 µg/m³.
- The highest 1-hour average concentration of NO_2 corresponds to 30% of the AAQ NEPM standard.
- The annual average concentration of NO_2 was below the AAQ NEPM standard of 62 µg/m³.
- The annual average concentration of NO_2 corresponds to 22% 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 2019/20 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 246 µg/m³)	Annual average NO_2 concentration (µg/m³)	Performance (AAQ NEPM of 62 µg/m³)
Taplin	72.9	Met	13.6	Met

4.3.3. NO2 Time Series Analysis

A timeseries plot of the 1-hour average concentrations of NO_2 for FY 2019/20 at Taplin monitoring station is shown in Figure 4-3. Note that the AAQ NEPM standard is 246 µg/m³ and is not shown on Figure 4-3 due to the low levels measured at the station.

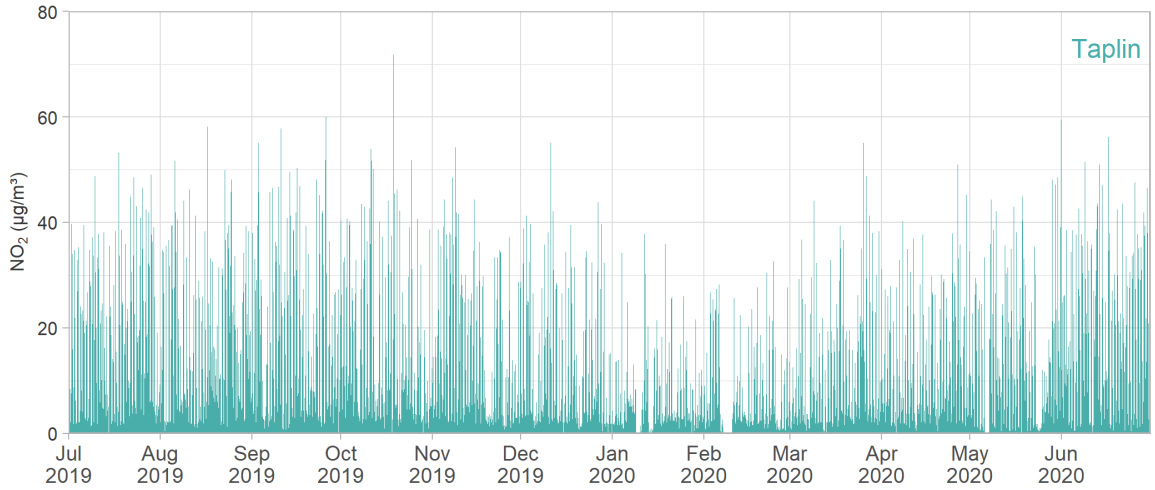


Figure 4-3: FY 2019/20 time series plot of 1-hour average concentrations of NO_2 for Taplin

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 2019/20.

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 and wind direction.

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 Taskforce's interim guideline for PM_{10}.

As previously discussed, PM_{10} data recorded at this site between July 2019 and December 2019 has been removed.

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	Interim Guideline / Standard		Number of instances above the Interim Guideline / Standard	Performance against Interim Guideline / Standard
		Concentration (µg/m³)	Averaging Period		
PM_{10}	Not met [A]	70	24-hour	3	Not demonstrated [A]
		50	24-hour	10	Not demonstrated [A]
		25	Annual	1	Not demonstrated [A]
$PM_{2.5}$	Not met [B]	25	24-hour	5	Not demonstrated [B]
		8	Annual	0	Not demonstrated [B]
NO_2	Met	246	1-hour	0	Met
		62	Annual	0	Met

Table note:
[A] PM_{10} data capture rate in Q1 and Q2 at Taplin was less than 75%.
[B] $PM_{2.5}$ data capture rate in Q3 at Taplin was less than 75%.

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	33	Not met
		25	Annual	1	Not met
$PM_{2.5}$	Met	25	24-hour	9	Not 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	148	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	66	Not met
		25	Annual	1	Not 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	173	Not met
		25	Annual	1	Not met
$PM_{2.5}$	Met	25	24-hour	4	Not 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	22	Not met
		25	Annual	1	Not 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}	Not Met	50	24-hour	159	Not met
		25	Annual	1	Not met

5.8. Yule

The Yule monitoring station is located 30 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}	Not Met [A]	50	24-hour	13	Not demonstrated [A]
		25	Annual	0	Not demonstrated [A]
$PM_{2.5}$	Not Met [B]	25	24-hour	2	Not demonstrated [B]
		8	Annual	0	Not demonstrated [B]

Table note:
[A] PM_{10} data capture rate in Q3 at Yule was less than 75%.
[B] $PM_{2.5}$ 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 2019/20.

6.1. 24-hour average concentrations of PM10 - Interim Guideline

The number of days that the 24-hour average concentration of PM_{10} at Taplin was above the interim guideline of 70 µg/m³ for the past eight years is presented in Table 6-1.

The data shows the following:

- The number of days above the interim guideline at the Taplin monitoring station showed a gradual downward trend over the six years between July 2012 and June 2018.
- It is difficult to establish a trend over the past two years from July 2018 to June 2020 due to the large period of insufficient data up to the replacement of the BAM monitor on 1 January 2020.

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

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

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 PM10 - 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:

- The number of 24-hour average concentrations above the AAQ NEPM standard decreased compared to the year prior at Kingsmill, Neptune, Wedgefield and Yule monitoring stations.
- The number of 24-hour average concentrations above the AAQ NEPM standard increased compared to the year prior at BoM, South Hedland and Richardson monitoring stations.
- The Richardson site has 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, with the 173 event days recorded during the FY 2019/2020. This increase, may be in part, be due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.
- It is difficult to establish the trend at Taplin over the past two years from July 2018 to June 2020 due to the large period of insufficient data up to the replacement of the BAM monitor on 1 January 2020.

Table 6-2: Summary of 24-hour average concentrations of PM_{10} above the AAQ NEPM standard for the last seven 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
BoM	50	24	10	17	12	7	4	25	33
Kingsmill		89	98	156	112	83	103	155	148
Neptune		25	25	67	43	29	15	102	66
Richardson		74	50	79	39	90	143	167	173
South Hedland		23	13	19	12	8	0	11	22
Taplin		48	48	55	48	27	65	No data [A]	10 [B]
Wedgefield		157	148	169	150	99	88	165	159
Yule		24	8	18	5	1	8	15	13

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)

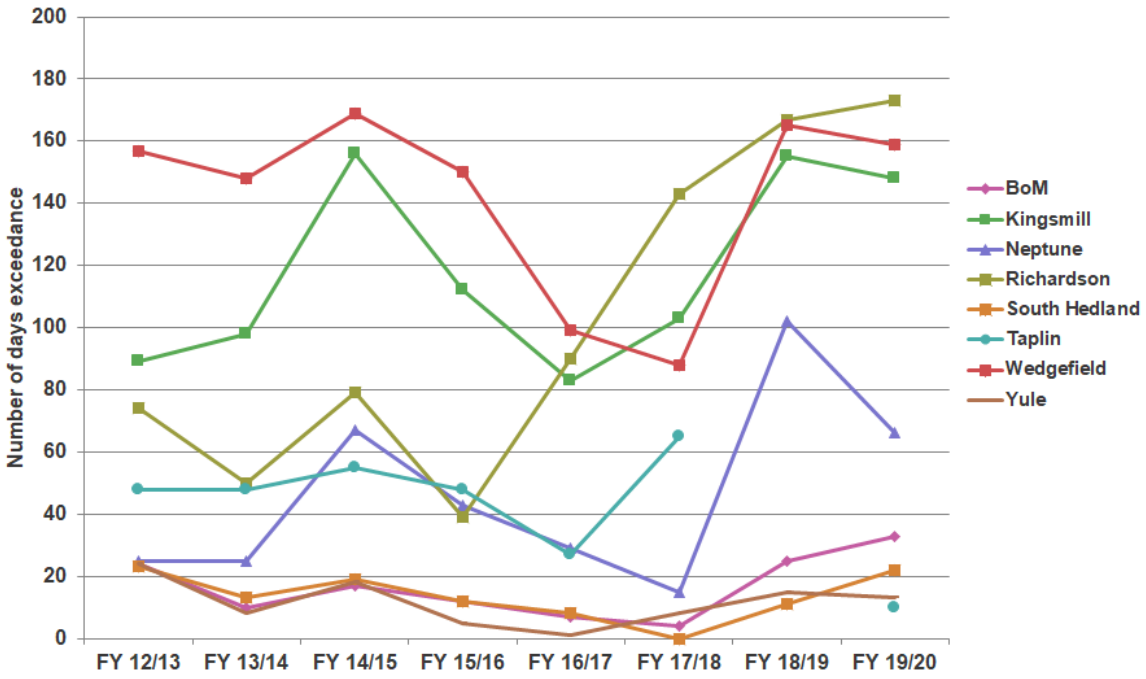


Figure 6-1: Number of the 24-hour average concentration of PM_{10} above the AAQ NEPM standard for each reporting year

6.3. Annual average concentration of PM10 – 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 five reporting years (FY 2015/16 to FY 2018/19) have been compared with the standard in Table 6-3 and Figure 6-2.

The data shows the following:

- Neptune, South Hedland and Wedgefield monitoring stations show a slight decreasing trend to FY 2017/18, before increasing during FY 2018/19. Neptune and Wedgefield also show a slight decrease to FY 2019/20, while South Hedland shows a small increase.

- BoM, Kingsmill and Yule show a relatively steady trend to FY 2017/18, before increasing during FY 2018/19. Kingsmill and Yule show a slight decrease to FY 2019/20, while BoM shows a small increase.
- The annual average trend at Taplin monitoring station from FY 2017/18 is difficult to determine due to the large period of insufficient show at this site.
- Richardson monitoring station shows an increasing trend through to FY 2019/20. This increase may be, in part, due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.

Table 6-3: Summary of annual average concentrations of PM_{10} for the last five 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
BoM	25	Not required to be reported			25.4	21.4	23.8	31.5	32.1
Kingsmill					44.7	40.4	43.7	51.0	50.3
Neptune					32.3	27.4	26.4	40.2	36.6
Richardson					35.2	40.0	47.3	51.4	54.1
South Hedland					26.5	22.2	16.1	24.4	27.9
Taplin					35.6	31.3	34.4	No data [B]	31.1 [C]
Wedgefield					51.1	43.1	42.2	55.0	54.6
Yule					18.5	15.4	17.9	22.2	21.0

Table note:
[A] AAQ NEPM annual average standard for PM_{10} was introduced in 2016
[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)

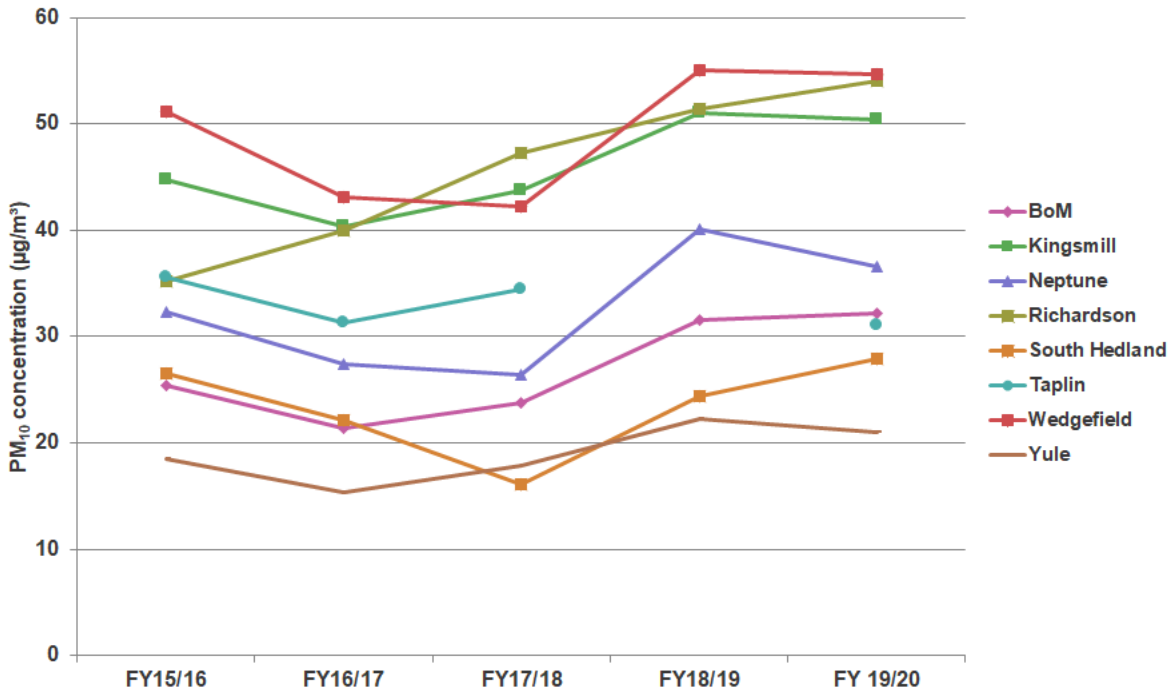


Figure 6-2: Annual average concentrations of PM_{10} for the last five years

6.4. PM10 Statistics

The following summary statistics for 24-hour average concentrations of PM_{10} are displayed graphically in Appendix A for the past eight 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, and a significant increase in FY 2019/20.
- 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, with a slight increase during FY 2018/19 and FY 2019/20.
- 50th percentile 24-hour average concentration of PM_{10} exhibit a generally stable trend at all monitoring stations over the eight reporting years, with a slight increase during FY 2018/19 and then a slight drop in FY 2019/20.

7. INVESTIGATION OF PM_{10} EVENTS

7.1. Investigation methodology

The Taskforce interim guideline for 24-hour average concentrations of PM_{10} allows for ten days above 70 µg/m³ at Taplin monitoring station as a result of industry. During periods exceeding the 24-hour Taskforce interim guideline, 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 Taskforce interim guideline 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 Taskforce interim guideline. 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.

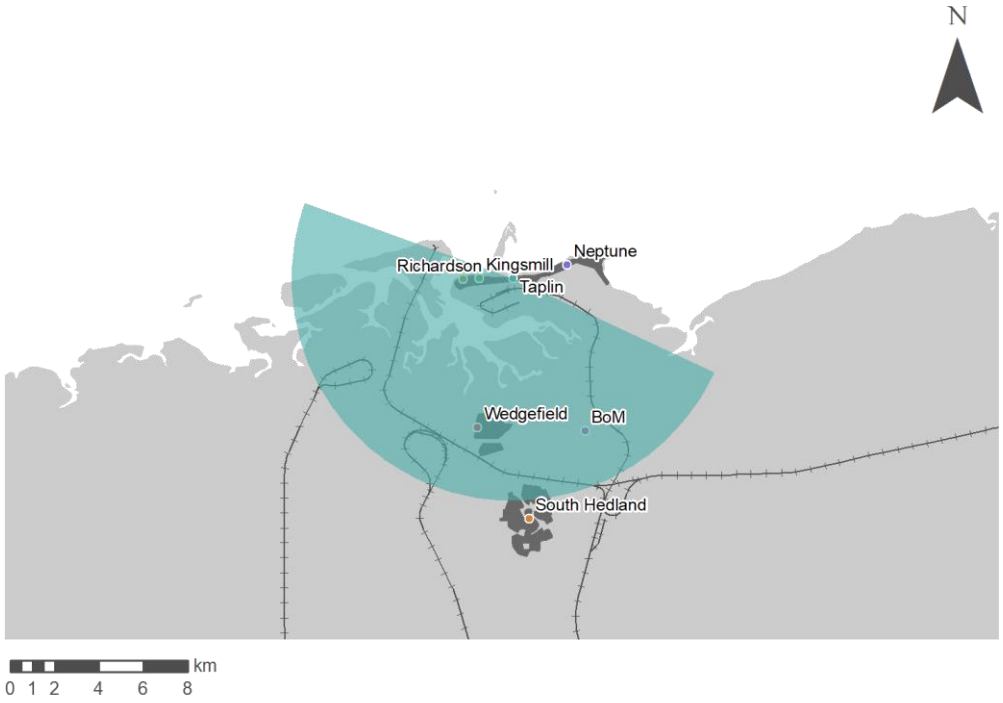


Figure 7-1: Port Hedland industry arc of influence (shaded area) at Taplin monitoring station

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 three days when the 24-hour average concentration of PM_{10} was above 70 µg/m³ at Taplin during between 1 January 2020 to 30 June 2020. 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 exceedances at Taplin on 9 and 10 January 2020 were the result of a regional event
- The exceedance at Taplin site on 18 May 2020 was the result of a local industry source

Table 7-1: Summary of 24-hour average concentrations of PM_{10} above 70 µg/m³ at Taplin, BoM and Yule between 1 January 2020 and 30 June 2020

Date	24-hour average PM_{10} (µg/m³)			Likely cause (as determined by methodology presented in Section 7)
	Taplin	BoM	Yule	
9 January 2020	**134.8**	**123.9**	No data [A]	Regional
10 January 2020	**89.5**	**76.0**	No data [A]	Regional
18 May 2020	**80.3**	23.6	10.7	Local (industry)

Table note:
[A] No data recorded at Yule due to cyclone warning and subsequent power shutdown.

7.3. Detailed analysis of exceedances

7.3.1. 9 January 2020

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
9 January 2020	**134.8**	**123.9**	No data [A]	Regional

Table note:
[A] No data recorded at Yule due to cyclone warning and subsequent power shutdown.

On the 9 January 2020, the 24-hour average concentration of PM_{10} was 134.8 µg/m³ at Taplin and 123.9 µg/m³ at BoM, both above the interim guideline of 70 µg/m³. These high values indicate a significant regional event occurring. Data was not available at Yule due to a cyclone warning and subsequent power shut down.

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 and BoM 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 7 m/s,) and from the west-northwest to northwest. A small proportion of these winds (those from the west-northwest) are from within the industry arc of influence.
- The PM_{10} polar frequency plot indicates that the highest 10-minute average concentrations of PM_{10} (dark red and orange areas) occurred during moderate (3 to 5 m/s) winds from the west to northwest. While a proportion of those higher concentrations were during winds from within the industry arc of influence, the time-series plot shows that the trend and level of PM_{10} concentrations during this period were similar at the Taplin and BoM monitoring stations, including the peak between 5am and 11am. This indicates a regional event.

Overall, on 9 January 2020, concentrations of PM_{10} were significantly elevated across the Taplin and BoM sites, indicating a regional event.

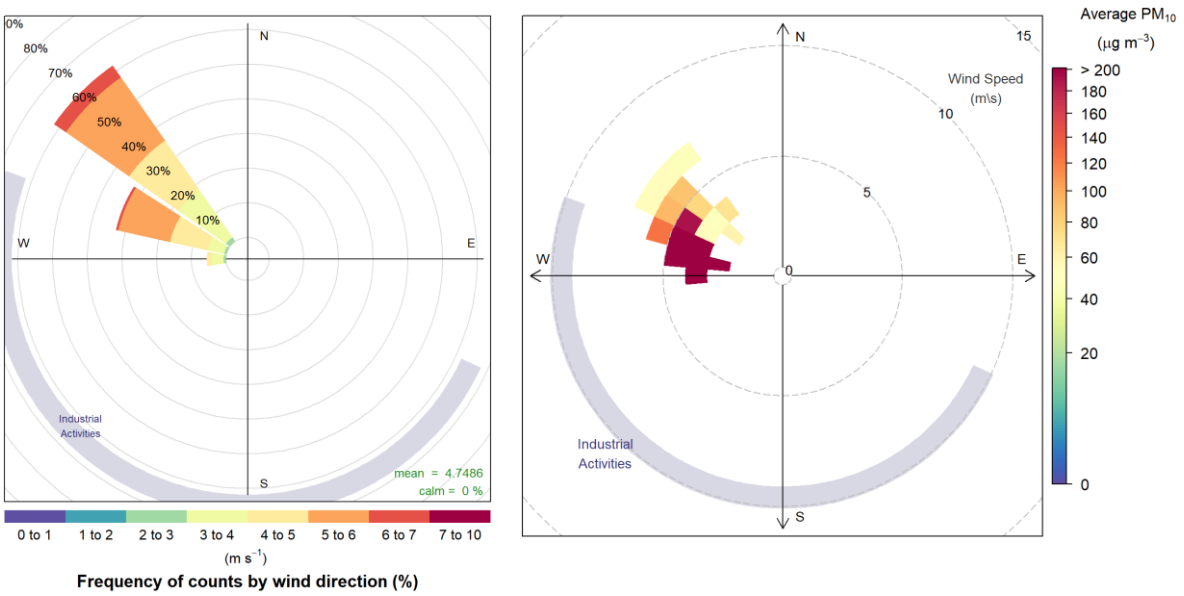


Figure 7-2: **Wind rose (left) and PM_{10} polar plot (right) on 9 January 2020 at Taplin**

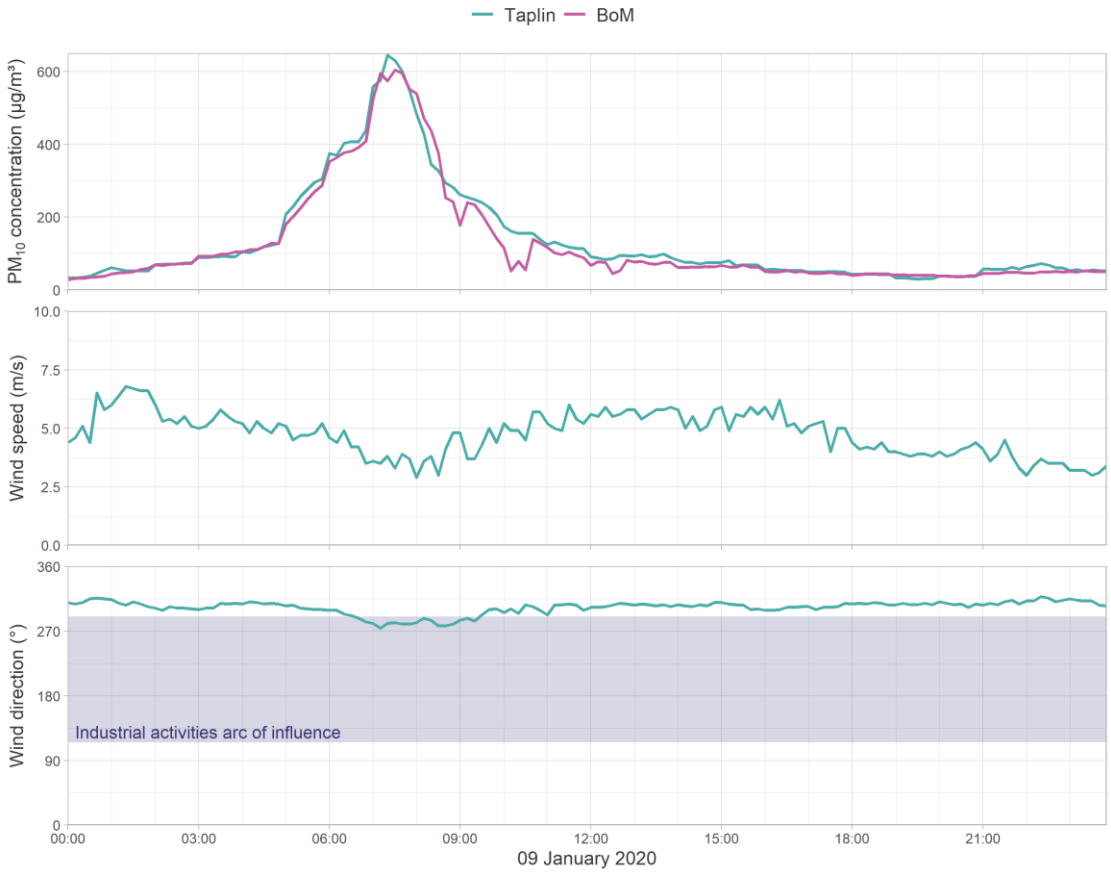


Figure 7-3: **Time series of concentrations of PM_{10} at Taplin and BoM (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 9 January 2020**

7.3.2. 10 January 2020

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
10 January 2020	**89.5**	**76.0**	No data [A]	Regional

Table note:
[A] No data recorded at Yule due to cyclone warning and subsequent power shutdown.

On the 10 January 2020, the 24-hour average concentration of PM_{10} was 89.5 µg/m³ at Taplin and 76.0 µg/m³ at BoM, both above the interim guideline of 70 µg/m³. These high values indicate a possible regional event occurring. Data was not available at Yule due to a cyclone warning and subsequent power shut down.

A wind rose and PM_{10} polar frequency plot for Taplin is shown in Figure 7-4 and a time series plot of concentrations of PM_{10} at Taplin and BoM and wind speed and wind direction at Taplin is shown in Figure 7-5.

The figures indicate the following:

- Winds were generally light to moderate (up to 5 m/s) and predominantly from the northeast and northwest sectors. A lower frequency of winds occurred from the southeast sector, while minimal winds occurred from the southwest sector. Winds were strongest from the northwest to north-northeast.
- The PM_{10} polar frequency plot indicates that the highest 10-minute average concentrations of PM_{10} (darker orange areas) occurred during winds from the northeast sector, outside the industry arc of influence. Elevated concentrations (orange areas) also occurred during winds from the southeast and northwest sectors, with a portion of these within the industry arc of influence.
- The time series plots show that concentrations of PM_{10} at Taplin and BoM were elevated (greater than 70 µg/m³) throughout most of the 24-hour period, with a slight peak at the Taplin site between 10am and midday. The elevated concentrations appear to be reasonably independent of any changes in wind speed and wind direction at both sites during this period, indicating a regional event. Notwithstanding this, it is noted that the peak at the Taplin site was not recorded at the BoM site and occurred during winds from outside the industry arc of influence.

Overall, on 10 January 2020, concentrations of PM_{10} were elevated across Taplin and BoM sites, indicating a regional event occurring.

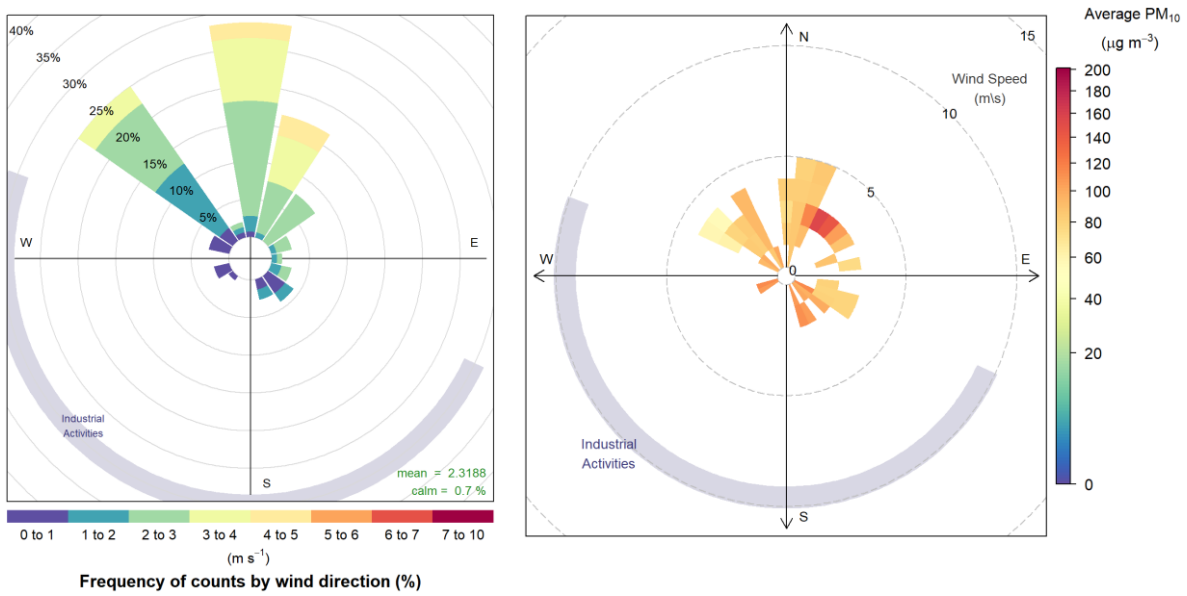


Figure 7-4: **Wind rose (left) and PM_{10} polar plot (right) on 10 January 2020 at Taplin**

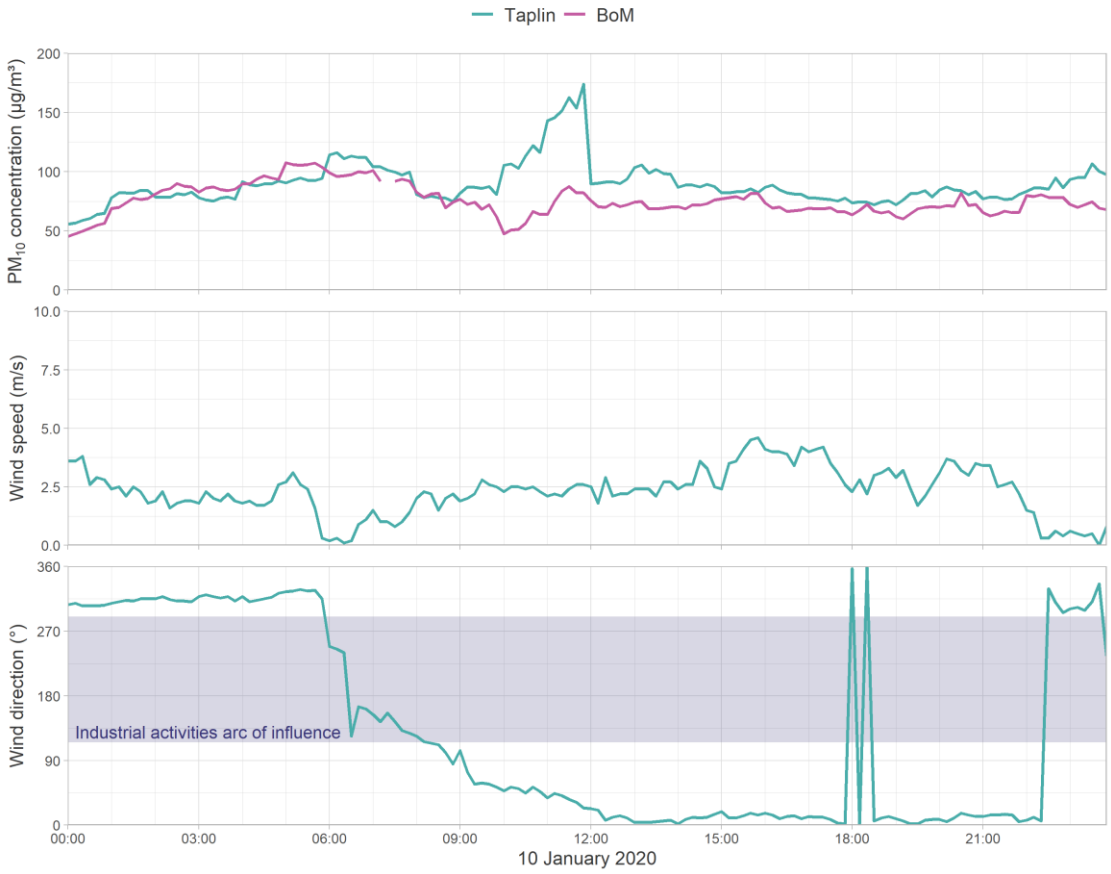


Figure 7-5: **Time series of concentrations of PM_{10} at Taplin and BoM (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 10 January 2020**

7.3.3. 18 May 2020

Date	24-hour average PM_{10} (µg/m³)			Likely cause
	Taplin	BoM	Yule	
18 May 2020	**80.3**	23.6	10.7	Local (industry)

On the 18 May 2020, the 24-hour average concentration of PM_{10} was 80.3 µg/m³ at Taplin, above the interim guideline of 70 µg/m³. Significantly lower corresponding concentrations of 23.6 µg/m³ and 10.7 µg/m at BoM and Yule, respectively, indicate that the exceedance at Taplin was likely due to a local event.

A wind rose and PM_{10} polar frequency plot for Taplin is shown in Figure 7-6 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 7-7.

The figures indicate the following:

- Winds were generally light (up to 4 to 5 m/s) and predominantly from the south-southeast to southwest direction. The remaining winds were predominantly from the northwest through to southeast, with minimal winds directly from the west. Winds were slightly stronger from the northeast through to south, particularly directly from the east.
- The PM_{10} polar frequency plot indicates that the highest 10-minute average concentrations of PM_{10} (dark red areas) occurred during light winds from the south to southwest, within the industry arc of influence. Slightly elevated concentrations (yellow areas) also occurred during winds from the south through to the west, also within the industry arc of influence.
- The time series plots show that concentrations of PM_{10} at Taplin were relatively low and at similar levels to BoM and Yule for most of the 24-hour period, from midnight through to around 5pm. From 5pm concentrations at Taplin increased significantly up to a peak of 658 µg/m³ around 10pm, before decreasing through to midnight. These elevated concentrations occurred during light winds from within the industry arc of influence and while concentrations remained low at BoM and Yule.

Overall, on 18 May 2020, concentrations of PM_{10} were elevated at Taplin while winds were from within the industry arc of influence and relatively low concentrations were recorded at BoM and Yule, indicating a local industry source contributing to the event at Taplin.

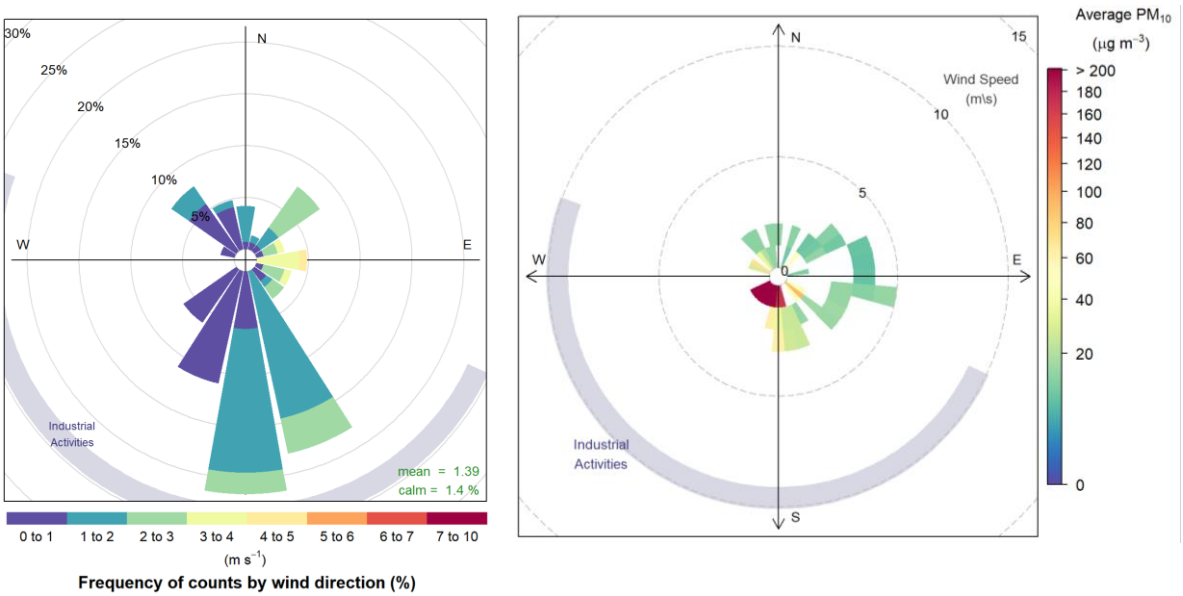


Figure 7-6: Wind rose (left) and PM_{10} polar plot (right) on 18 May 2020 at Taplin

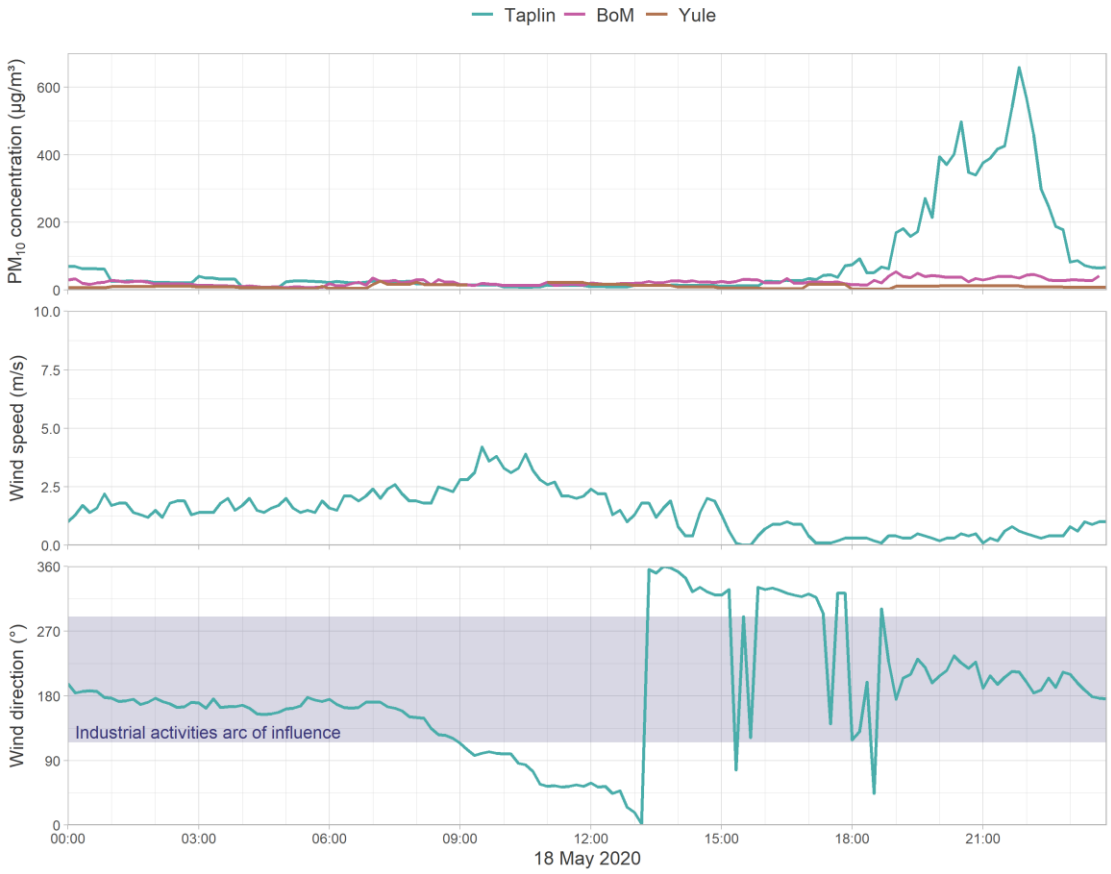


Figure 7-7: Time series of concentrations of PM_{10} at Taplin, BoM and Yule (top) and wind speed at Taplin (middle) and wind direction at Taplin (bottom) on 18 May 2020

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 2019/20. This is the eighth annual performance report of its kind and the fourth annual report prepared by Katestone.

On 23 January 2020, following a series of investigations, PHIC confirmed inconsistent PM_{10} readings had occurred from the Taplin monitoring station PM_{10} instrument and affected the data from April 2018 to December 2019. The inconsistent Taplin PM_{10} data from 1 July 2019 to 31 December 2019 has been removed from this FY 2019/20 report. Notwithstanding this, the annual report findings are summarised below.

8.1. PM10

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

- During the period of available data (1 January 2020 to 30 June 2020), the Taplin monitoring station recorded three days above the 24-hour average interim guideline for PM_{10} of 70 µg/m³.
- The exceedances of the 24-hour average interim guideline for PM_{10} of 70 µg/m³ on 9 and 10 January 2020 were attributed to regional events.
- The exceedance of the 24-hour average interim guideline for PM_{10} of 70 µg/m³ on 18 May 2020 was attributed to a local industry source.
- 24-hour average concentrations of PM_{10} were above the AAQ NEPM standard on multiple occasions at all sites in FY 2019/20. The number of days above the AAQ NEPM standard of 50 µg/m³ ranged from 10 days at Taplin (1 January 2020 to 30 June 2020 only) to 173 days at Richardson.
- The number of days per year above the AAQ NEPM standard for PM_{10} at each monitoring station have been compared for the last eight years, which shows the following:
    - The number of 24-hour average concentrations above the AAQ NEPM standard during FY 2019/20 dropped slightly compared to the year prior at Kingsmill, Neptune, Wedgefield and Yule monitoring stations.
    - The number of 24-hour average concentrations above the AAQ NEPM standard during FY 2019/20 increased slightly compared to the year prior at BoM, South Hedland and Richardson monitoring stations.
    - The Richardson site has recorded a gradual increase in the number of days above the AAQ NEPM standard over the 4 years from FY 2016/17, with the 173 event days recorded during the FY 2019/2020. This increase, may be in part, due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.
    - It is difficult to establish the trend at Taplin over the past two years from July 2018 to June 2020 due to the large period of insufficient data.
- The annual average concentration of PM_{10} was above the AAQ NEPM standard of 25 µg/m³ at BoM, Kingsmill, Neptune, Richardson, South Hedland, Taplin and Wedgefield.
- The annual average concentration of PM_{10} was below the AAQ NEPM standard of 25 µg/m³ at Yule.
- Annual average concentrations of PM_{10} over the past five years (FY 2015/16 to FY 2019/20) show that:
    - Neptune, South Hedland and Wedgefield monitoring stations have a slight decreasing trend to FY 2017/18, before increasing during FY 2018/19. Neptune and Wedgefield have a slight decreasing trend to FY 2019/20, while South Hedland shows a small increase.
    - BoM, Kingsmill and Yule have a relatively steady trends to FY 2017/18, before increasing during FY 2018/19. Kingsmill and Yule show a slight decreasing trend to FY 2019/20, while BoM shows a small increase.
    - The annual average trend at Taplin monitoring station from FY 2017/18 is difficult to determine due to the large period of insufficient data.
    - Richardson monitoring station shows an increasing trend through to FY 2019/20. This increase, may be in part, be due to site changes that have occurred in the past few years, including the operation of a boat repair business since 2017.

8.2. PM2.5

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

- The 24-hour average concentrations of $PM_{2.5}$ were above the AAQ NEPM standard of 25 µg/m³ on 9, 4, 5 and 2 days at the BoM, Richardson, Taplin and Yule monitoring stations, respectively.
- The annual average concentration of $PM_{2.5}$ were below the AAQ NEPM standards at BoM, Richardson, Taplin and Yule.

8.3. NO2

Analysis of the NO_2 data found that the concentrations of NO_2 measured at Taplin in FY 2019/20 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

With the exception of Taplin PM_{10}, the annual data capture criterion of 75% was met for each pollutant at all monitoring stations during FY 2019/20. The quarterly data capture criterion of 75% was met for each pollutant and at all monitoring stations with the exception of:

- PM_{10} in Q1 and Q2 at Taplin (inconsistent data removed)
- $PM_{2.5}$ in Q3 at Taplin (due to instrument being switched to PM_{10})
- PM_{10} and $PM_{2.5}$ in Q3 at Yule (due to Cyclone Damien and other cyclone warnings that resulted in power shutdown periods).

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Appendix A PM_{10} TREND SUMMARY GRAPHS

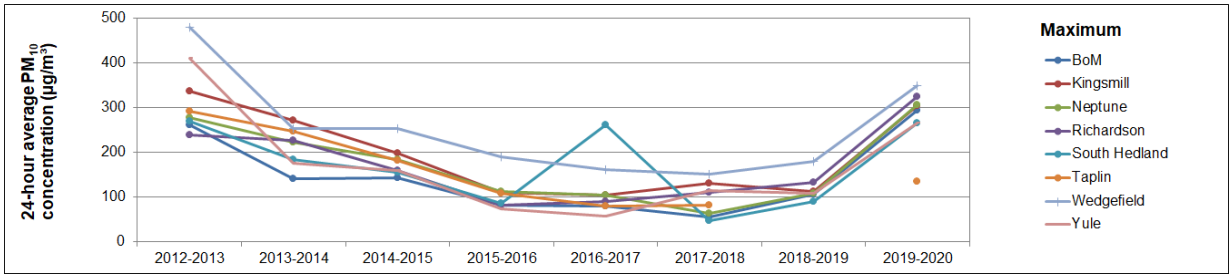

Figure A-1: Maximum 24-hour average PM_{10} Trends

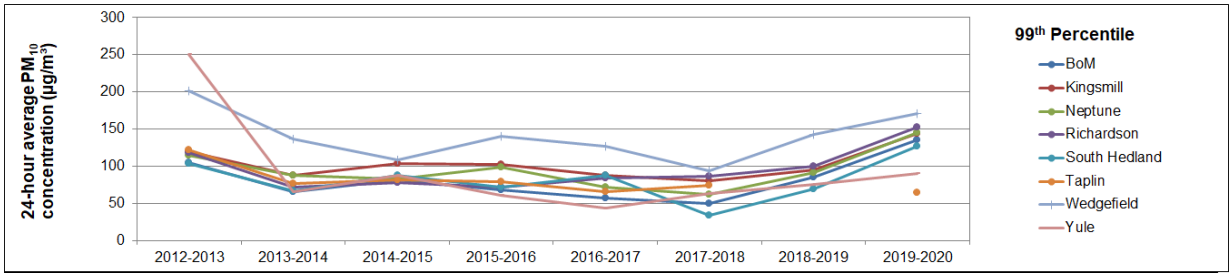

Figure A-2: 99th percentile 24-hour average PM_{10} Trends

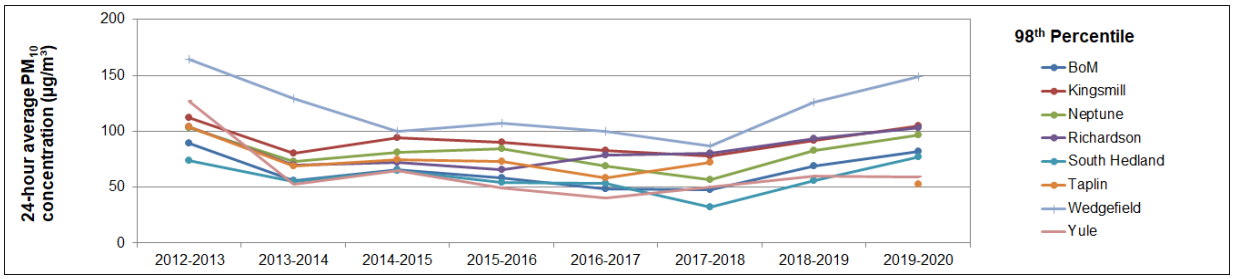

Figure A-3: 98th percentile 24-hour average PM_{10} Trends

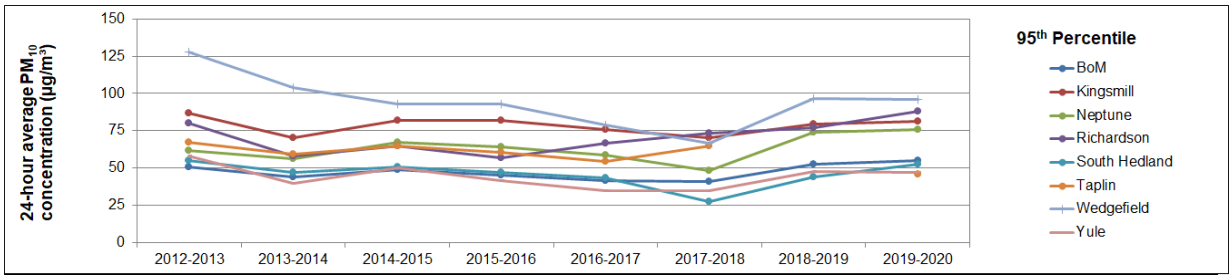

Figure A-4: 95th percentile 24-hour average PM_{10} Trends

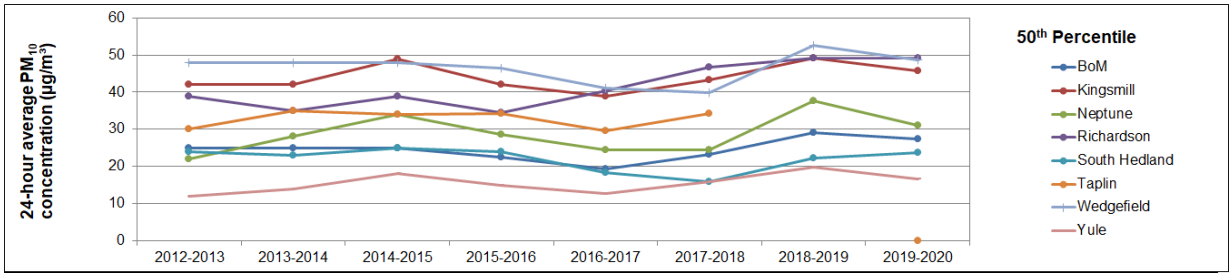

Figure A-5: 50th percentile 24-hour average PM_{10} Trends