Station Pier Air Quality Monitoring Program

Air Quality Monitoring Report – Annual Report

Ports Victoria

23 April 2025

→ The Power of Commitment

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GHD Pty Ltd | ABN 39 008 488 373
Contact: Pri Pandey, Senior Engineer | Service Line Leader, Air & Noise, APAC | GHD
133 Castlereagh Street, Level 15
Sydney, New South Wales 2000, Australia
T +61 2 9239 7100 | **F** +61 2 9239 7199 | **E** sydmail@ghd.com | **ghd.com**

Executive summary

Ports Victoria have implemented an air quality monitoring program at Station Pier, Port Melbourne, Victoria for a period of 12 months from December 2023 to December 2024. Station Pier is the premier cruise ship terminal in Melbourne, with around 100 cruise ship visits every cruise season. The primary objective of this air quality monitoring program was to provide Ports Victoria, EPA Victoria and the local community with a greater understanding of local air quality from Station Pier operations by:

– Undertaking near-real time air quality monitoring during Station Pier operations.
– Determining the significance of the levels relative to the Environmental Reference Standards (ERS).
– Assessing the relative contribution of Station Pier activities to the local air shed by comparison (correlation) with existing EPA monitoring stations.
– Reviewing against Air Quality Monitoring results from the monitoring program conducted in 2016 and 2017.
– Engaging with stakeholders including EPA Victoria and local neighbours.

In addition to the primary objectives of the program, an opportunity was also identified to undertake a trial of portable air monitoring units (Kunaks). The trial was undertaken in collaboration with local residents between 1 May 2024 and 31 December 2024. Discussion on the outcome of this trial is presented in Section 6.

This air quality monitoring report presents the analysis of data collected between 1 December 2023 to 31 December 2024. The monitoring data observed at Station Pier air quality monitoring station (AQMS) during this monitoring period has been presented and, where relevant, compared against observations from the local EPA Stations and the adopted Air Pollution Assessment Criteria (APACs) from the EPA Publication 1961.

The parameters measured as part of the air quality monitoring program included wind speed, wind direction, temperature, relative humidity, sigma, PM_{10}, $PM_{2.5}$, NO_2, and SO_2 concentrations. Data collected by the AQMS has undergone a NATA accreditation procedure undertaken by ACOEM to ensure all analysed data is valid. AQMS observations were processed into averaging periods defined by the relevant APACs. The processed data is also overlayed with vessel presence at the port.

A summary of the AQMS data is provided in Table 1.1.

Table 1.1 Summary of AQMS data

Pollutant	Annual average	Exceedances	Correlation with EPA Stations	Correlation with port activity
PM_{10}	– When a vessel was present: 23.5 µg/m^3 – When no vessels were present: 21.5 µg/m^3 – 2024 average: 22.1 µg/m^3	Exceedances of the 24-hour criterion were observed on two days, both likely due to regional emissions sources rather than a localised source. Annual average concentration was above the criterion by 11%. The average concentrations both while a vessel was in port and when no vessel was in port were both above the criterion, indicating that port activity was likely not the key driver of PM_{10} concentrations in the area.	Positive correlation (>0.75) with all EPA Stations	Minimal correlation (0.08) with vessel presence
$PM_{2.5}$	– When a vessel was present: 6.8 µg/m^3 – When no vessels were present: 6.1 µg/m^3 – 2024 average: 6.3 µg/m^3	Exceedances of the 24-hour criterion were observed on two days, both likely due to regional emissions sources rather than a localised source.	Positive correlation (>0.75) with all EPA Stations	Minimal correlation (0.05) with vessel presence

Pollutant	Annual average	Exceedances	Correlation with EPA Stations	Correlation with port activity
NO_2	– When a vessel was present: 9.0 ppb – When no vessels were present: 9.4 ppb – 2024 average: 9.5 ppb	No exceedances of the adopted 1-hour or annual NO_2 criteria were observed.	Positive correlation (0.83) with the Altona North EPA Station	Minimal correlation (-0.03) with vessel presence
SO_2	– When a vessel was present: 1.4 ppb – When no vessels were present: 1.2 ppb	No exceedances of the adopted 1-hour or annual SO_2 criteria were observed	Minimal correlation with the Altona North EPA Station	Minimal correlation (0.11) with vessel presence

In general, analysis of the AQMS data indicated that the observed concentrations at the AQMS had high correlation with the nearby EPA Stations (for all pollutants except for SO_2), and low correlation with port activity. Occasional exceedances of the PM_{10} and $PM_{2.5}$ 24-hour average criteria were observed, which were both identified to be likely due to regional emissions rather than a localised source. The annual average PM_{10} concentration was above the criterion by 11%. The average PM_{10} concentrations measured while a vessel was in port and when no vessel was in port were both above the criterion, indicating that port activity was likely not the key driver of PM_{10} concentrations in the area. No exceedances of the NO_2 or SO_2 criteria were observed.

A previous air quality monitoring program was undertaken at Station Pier in 2016-17. Since the study undertaken in 2016-17, two significant events have occurred which have the potential to reduce sulphur dioxide emissions, and vessel emissions more broadly. These include the introduction of low-sulphur marine fuels in 2020 and the relocation of the TT line from Station Pier to Geelong in 2020. Comparison of the data collected in 2023-24 with the 2016-17 data indicated the following:

– PM_{10} and NO_2 monthly average concentrations were very similar between the monitoring periods
– $PM_{2.5}$ concentrations were slightly reduced during 2023-24 for all months except February
– SO_2 concentrations were reduced during 2023-24 for all months, with a more significant decrease during the cruise season (November to March), which indicates that Station Pier shipping activities are no longer a key contributor to SO_2 concentrations in the local air shed.

The air quality monitoring program undertaken at Station Pier generally indicates that ambient air quality has improved since the 2016-17 study. Where exceedances of the criteria were observed, based on an analysis of broader events such as bushfires, port activity is considered to be an unlikely driver for these exceedances.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

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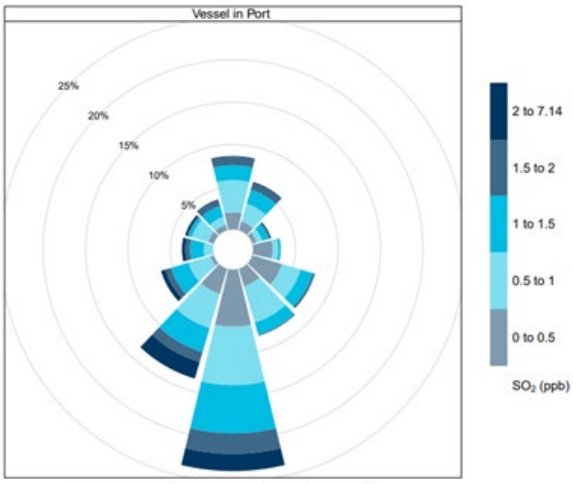
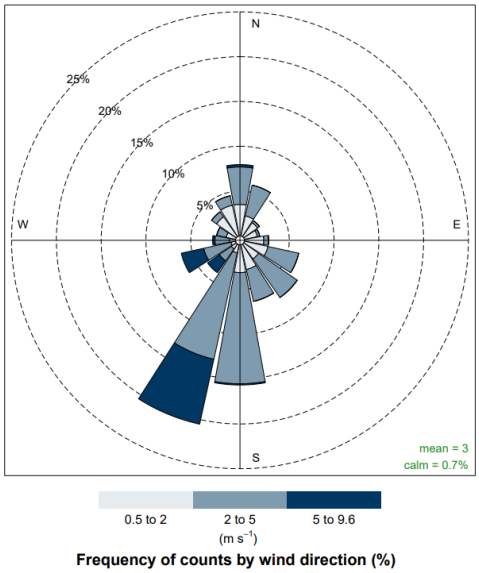
Glossary of terms

Term	Description
ACOEM	Acoem Australasia (EcoTech) Pty Ltd
APACs	Air Pollution Assessment Criteria
API	Application Programming Interface
AQMP	Air Quality Monitoring Program
AQMS	Air Quality Monitoring Station
Australian Standard measuring methods	A set of Australian Standards which detail the type of equipment required to measure pollutants and meteorological parameters and the correct siting of the monitoring equipment.
AWS	Automatic Weather Station
BAM	Beta Attenuation Monitoring
BoM	Bureau of Meteorology
Calm	Wind speeds below 0.5 m/s.
Correlation	Correlation measures the linear relation between two variables. A strong positive correlation (close to 1) indicates that when one variable increases, the other also increases. A strong negative correlation (close to -1) indicates that when one variable increases, the other decreases.
EP Act	Environment Protection Amendment Act 2018
EPA Victoria	Environment Protection Authority Victoria
EPA Stations	EPA Victoria air quality monitoring stations. More information can be found on https://www.epa.vic.gov.au/for-community/airwatch.
ERS	Environment Reference Standard
GED	General Environmental Duty
GHD	GHD Pty Ltd
Interquartile range	The interquartile range is a measure of spread from the median of a dataset.
Kunak sensors	Kunak™ Air Pro, portable real-time air quality sensors
NATA	National Association of Testing Authorities
NEPM AAQ	National Environment Protection Measure (Ambient Air Quality)
NO_2	Nitrogen dioxide
Normalised concentration	Normalised concentration refers to the concentration series divided by the maximum concentration (of each pollutant) to reduce the concentration range to between 0 and 1. This is useful when assessing pollutants measured in different units.
OHS	Occupational Health and Safety
PM_{10}	Particulate matter with diameter less than 10 micrometres (10 µm).
$PM_{2.5}$	Particulate matter with diameter less than 2.5 micrometres (2.5 µm).
Point-Biserial correlation	The Point-Biserial correlation is the correlation between a continuous variable and a binary variable. In this case, the continuous variable used was the concentration of each pollutant and the binary variable was the presence or absence of a vessel.
Ports Victoria	Ports Melbourne Victoria
Pollution rose	A pollution rose illustrates the frequency of occurrence of various pollutant concentrations in each wind direction for a given month.

Term	Description
	The length of 'petal' in a direction corresponds to the frequency of occurrence of a pollutant when wind is blowing from that direction. The colour within each 'petal' corresponds to the level of concentration of the measured pollutant. For example, in the pollution rose below, winds from the South occur for approximately 23% of the time. Of that 23%, 7% of the pollutant concentrations are between 0 to 0.5 ppb, 7% of the pollutant concentrations are between 0.5 to 1 ppb and so on. This is indicated by the length of the shading on the petals.  **Frequency of counts by wind direction (%)**
Sigma	Standard deviation of wind direction, can be used to calculate atmospheric stability
SEPP AQM	State Environment Protect Policy for Air Quality Management (replaced by ERS)
SO_2	Sulphur dioxide
Vessel in port	Vessel berthed at Station Pier. Does not include vessels approaching or departing Station Pier.
Windrose	A wind rose illustrates the frequency of occurrence of winds of various speeds in each wind direction for a given month. The length of 'petal' in a direction corresponds to the frequency of wind blowing from that direction, while the colour within each 'petal' corresponds to the wind speeds. For example, in the wind rose below, winds from the South occur for approximately 16% of the time. Of that 16%, 3% of the wind speeds are between 0.5 to 2 m/s, 12% of the wind speeds are between 2 to 5 m/s and less than 1% of the wind speeds are between 5 to 9.6 m/s. This is indicated by the length of the shading on the petals.  **Frequency of counts by wind direction (%)**

1. Introduction

Ports Victoria implemented an air quality monitoring program at Station Pier, Port Melbourne, Victoria for a period of 12 months from December 2023 to December 2024. Station Pier is the premier cruise ship terminal in Melbourne, with around 100 cruise ship visits every cruise season. The primary objective of this air quality monitoring program was to provide Ports Victoria, Environment Protection Authority (EPA) Victoria and the local community with a greater understanding of local air quality from Station Pier operations by undertaking an air quality monitoring program for a period of twelve months to cover the cruise and non-cruise ship visit seasons, and seasonal weather variation. Development of the monitoring program took into account the results of a previous air quality monitoring program which was undertaken in the period 2016-17.

The monitoring program activities included:

– Undertaking near-real time air quality monitoring during Station Pier operations
– Determining the significance of the levels relative to the Environmental Reference Standards (ERS)
– Assessing the relative contribution of Station Pier activities to the local air shed by comparison (correlation) with existing EPA monitoring stations
– Reviewing against Air Quality Monitoring results from the monitoring program conducted in 2016 and 2017
– Engaging with stakeholders including the EPA Victoria and local neighbours

In addition to the primary objectives of the program, an opportunity was also identified to undertake a trial of portable air monitoring units (Kunaks). The trial was undertaken in collaboration with local residents.

Ports Victoria engaged GHD Pty Ltd (GHD) to undertake this air quality monitoring program, including monthly technical reporting and data analysis. Acoem Australasia (EcoTech Pty Ltd) (ACOEM) was engaged as the monitoring equipment supplier. ACOEM is an Australia National Association of Testing Authorities (NATA) accredited company and conducts all required maintenance and calibration of the monitoring equipment as well as validation of the collected data.

This air quality monitoring report presents the analysis of all data collected by the Air Quality Monitoring Station (AQMS) located at Station Pier, 6 Waterfront Place, Port Melbourne Victoria, between 1 December 2023 and 31 December 2024. Discussion on the outcome of the trial of the two portable real-time Kunak sensors carried out between 1 May 2024 and 31 December 2024 is presented in Section 6. .

The location of the project is shown in Figure 1.1.

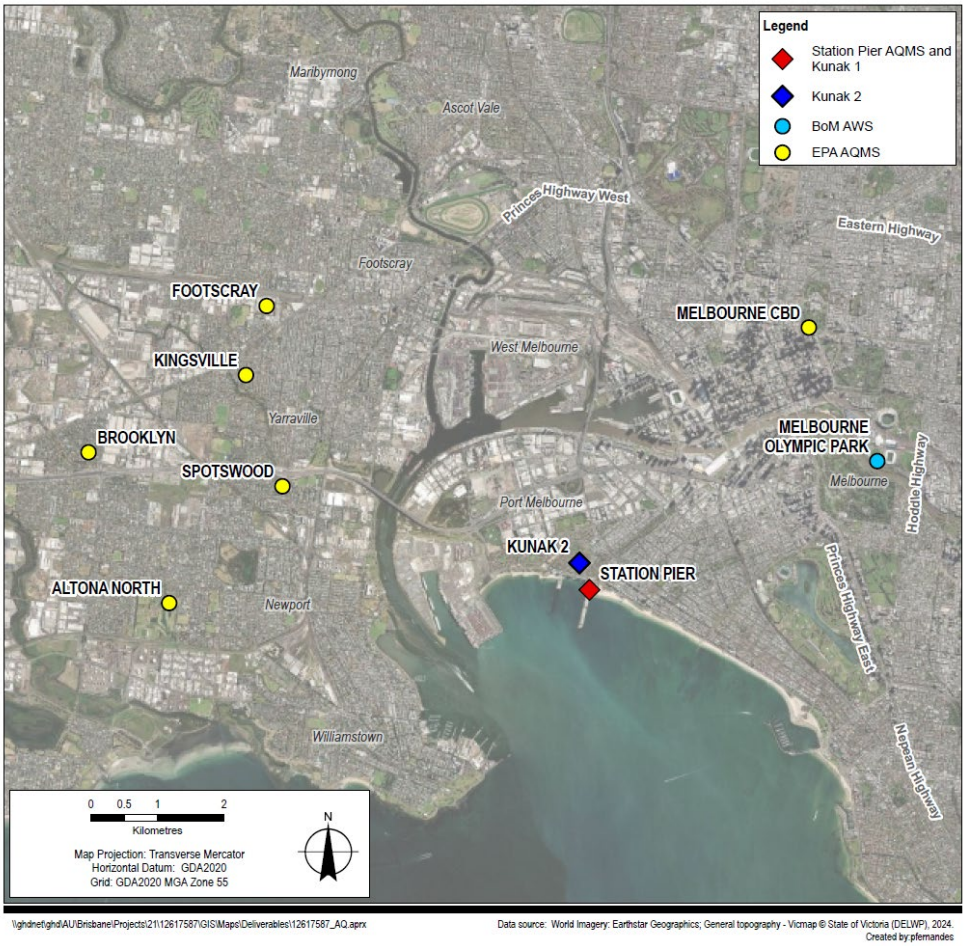


Figure 1.1 Air quality monitoring program location

1.1 Scope of work

The scope of this annual report is summarised in Table 1.1.

Table 1.1 Scope of air quality monitoring program (AQMP)

Scope of work	Description	Report section
Monitoring overview	An overview of the air quality monitoring report	Section 2
Legislative context	Environmental values, air quality indicators and objectives that set the benchmark for the quality of the air environment needed to protect environmental values in Victoria.	Section 3
Methodology summary	– Summary of monitoring equipment in the AQMS and the parameters and pollutants measured. – Review of data during the period. – Data availability and quality during the period.	Section 4
Data analysis	Summary of monitoring findings: – Direct comparison of measurement data to the assessment criteria summarised in Section 3 – Assessment of regional air quality data in comparison to measurements undertaken at Station Pier AQMS and the nearby EPA stations. – Detailed analysis of data for the entire monitoring period, between 4 December 2023 and 31 December 2024. – Other impacts to air quality in the region.	Section 5

Scope of work	Description	Report section
Kunak monitoring overview	Discussion of Kunak monitoring equipment, trial and outcome.	Section 6
Previous Station Pier Air Quality Monitoring Program	Review of previous air quality monitoring program undertaken in 2016-2017 and comparison of results with the 2023-2024 monitoring program	Section 7
Conclusion	Discussion and summary of findings from the air quality monitoring program	Section 8
NATA accredited data	Validated AQMS and Kunak monitoring data provided by ACOEM	This data can be requested from Ports Victoria: information@ports.vic.gov.au

1.2 Limitations

This report: has been prepared by GHD for Ports Victoria and may only be used and relied on by Ports Victoria for the purpose agreed between GHD and Ports Victoria as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Ports Victoria arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

1.3 Assumptions

The content of this report is subject to the following assumptions:

– Data provided by ACOEM has been validated and is NATA accredited.
– Data provided by the EPA is as uploaded via the EPA developer portal API.

2. Monitoring overview

What is presented in this report

This air quality monitoring report presents the analysis of data collected between 1 December 2023 to 31 December 2024. The monitoring data observed at Station Pier AQMS during this monitoring period have been presented and, where relevant, compared against observations from the local Environment Protection Authority (EPA) Victoria air quality monitoring stations (EPA Stations) and the adopted Air Pollution Assessment Criteria (APACs) from the EPA Publication 1961.

Two portable real-time Kunak sensors were installed in April 2024 as a trial with the aim to understand the air quality in the community north of Station Pier. Discussion on the outcome of this trial is presented in Section 6.

Monitoring equipment and locations

This air quality monitoring data is collected from the AQMS located at Station Pier, 6 Waterfront Place, Port Melbourne Victoria.

The validated monitoring data was provided by ACOEM, a NATA accredited company.

What is an AQMS

The AQMS measures pollutant concentrations and meteorological data using Australian Standard measuring methods, providing accurate measurements.

The parameters measured as part of the air quality monitoring program include wind speed, wind direction, temperature, relative humidity, sigma, PM_{10}, $PM_{2.5}$, NO_2, and SO_2 concentrations. Further details on the monitoring methodology for each parameter is provided in Section 4.

What is a Kunak Air Pro sensor

A Kunak Air Pro sensor, or Kunak sensor, is a portable real-time sensor which estimates the concentrations of pollutants in the air, providing indicative concentrations of localised pollutants. Two Kunak sensors were installed in April 2024 with the aim to understand the air quality in the community north of Station Pier.

What are EPA Stations and how is the data used

EPA Victoria operate air quality monitoring sites across Victoria to monitor air quality. The EPA Stations data is publicly available on the EPA website [1].

In this report, the Station Pier AQMS observations are compared against the regional air quality observed at selected EPA Stations – Altona North, Spotswood, Kingsville, Footscray, Brooklyn and Melbourne CBD stations. The selected EPA Stations also measure pollutants using Australian Standard measuring methods, providing accurate measurements. Detailed data analysis is provided in Section 5.

[1] https://www.epa.vic.gov.au/for-community/airwatch

3. Legislative and policy context

3.1 Environment Protection Act 2018 (amendment to Environment Protection Act 2017)

Environment Protection Authority (EPA) Victoria implemented a new legal framework with the intention for this framework to drive environmental improvements in industrial operations. The cornerstone of the Environment Protection Amendment Act 2018 (the EP Act) is the general environmental duty (GED), which requires all Victorians to understand and minimise their risks of harm to human health and the environment, from pollution and waste. This means the approach to the protection of human health and the environment has changed from 'compliance-based' regulation to 'outcomes-based' regulation. The expectation is that individuals will manage their activities to avoid the risk of environmental damage. There is also a requirement to quickly and appropriately respond if pollution does occur.

This legal framework came into force on 1 July 2021. For businesses already managing their environmental risks, the GED generally means little to no change in how they operate. Most businesses already follow good management practices. This will make complying with the GED easier. EPA Victoria have committed to working with industry to help them understand how to fulfil their obligations, by providing guidance, advice and other support. Complying with the GED is about taking reasonable proactive steps and employing good environmental work practices. Compliance with the GED can be through following responsibilities under occupational health and safety (OHS) laws, meeting industry standards, adopting industry better management practices, and following other relevant legislation related to the environment. In effect, the GED makes it clear that it is the individual businesses' responsibility to reduce risk to the environment and to protect it.

3.2 Environment Reference Standard

The EP Act's environment protection framework includes the Environment Reference Standard (ERS). This identifies environmental values, air indicators and objectives that set the benchmark for the quality of the air environment needed to protect environmental values. The environmental values identified include:

– Life, health and wellbeing of humans
– Life, health and well-being of other forms of life, including the protection of ecosystems and biodiversity
– Local amenity and aesthetic enjoyment
– Visibility
– The useful life and aesthetic appearance of buildings, structures, property and materials
– Climate systems that are consistent with human development, the life, health and well-being of humans, and the protection of ecosystems and biodiversity

The ERS is a reference standard, not a 'compliance standard' for businesses i.e. it relates to ambient air and not any individual facility. The ERS replaces State Environment Protect Policy for Air Quality Management (SEPP AQM) and generally adopts the objectives in the National Environment Protection Measure (Ambient Air Quality) (NEPM AAQ) with some modifications.

The following air quality indicators, and respective objectives, relevant to this assessment are outlined below in Figure 3.1.

Column 1 Indicators	Column 2 Objectives	Column 3 Averaging period
Carbon monoxide (maximum concentration)	9.0 ppm	8 hours
Nitrogen dioxide (maximum concentration)	0.08 ppm	1 hour
	0.015 ppm	1 year
Photochemical oxidants (as ozone) (maximum concentration)		
	0.06 ppm	8 hours
Sulfur dioxide (maximum concentration)	0.075 ppm	1 hour
	0.02 ppm	1 day
Lead (maximum concentration)	0.50 µg/m^3	1 year
Particles as PM_{10} (maximum concentration)	50 µg/m^3	1 day
	20 µg/m^3	1 year
Particles as $PM_{2.5}$ (maximum concentration)	25 µg/m^3	1 day
	8 µg/m3	1 year
Visibility reducing particles (minimum visual distance)	20 km	1 hour
Odour	An air environment that is free from offensive odours from commercial, industrial, trade and domestic activities	N/A

Figure 3.1 Table 2.2 from the ERS No. S245 Gazette 26 May 2021, as amended by ERS No S158 Gazette 29 March 2022

3.3 EPA Publication 1961 Guideline for assessing and minimising air pollution in Victoria

As part of the Victorian Environment Protection Act 2017 (EP Act), EPA Victoria has produced an air quality guideline namely, Guideline for assessing and minimising air pollution in Victoria (EPA Publication 1961). This guideline forms part of Victoria's environmental protection framework that establishes the state of knowledge to protect the environmental values of the ambient air environment. The guideline describes the General Environmental Duty (GED) which requires anyone engaging in any activity that may give rise to risks of harm to human health or the environment from pollution or waste to minimise those risks, so far as reasonably practicable.

As such, emitters of pollution to air have a responsibility to put in proportionate controls to eliminate or minimise risks to human health or the environment. Being proportionate and preventative requires duty holders to:

– Understand their risks
– Actively seek out ways to eliminate or minimise these risks, so far as reasonably practicable
– Ensure any risks remaining after the implementation of all controls are within acceptable limits.

The purpose of the guideline is to provide a framework to assess and control risks associated with air pollution.

3.4 Air Pollution Assessment Criteria

The Air Pollution Assessment Criteria (APACs) are introduced in the EPA Publication 1961 as concentrations of pollutants in air that provide a benchmark to understand potential risks to human health or the environment. They are risk-based concentrations that can help identify when or if an activity is likely to pose an unacceptable risk to the receiving environment. They are not concentrations which one can 'pollute up to' and also not concentrations below which no action is required. The APACs for PM_{10}, $PM_{2.5}$, NO_2 and SO_2 are based on the ERS.

The APACs relevant to the Station Pier air quality monitoring program are outlined in Table 3.1. Concentrations of each pollutant recorded by the Station Pier AQMS have been compared against these criteria to identify risk to the receiving environment.

Table 3.1 APACs relevant to the monitoring plan

Substance	Assessment criteria	Averaging time	Classification [2]	Basis
PM_{10}	50 µg/m^3	24 hours	Class 1	ERS Objective
	20 µg/m^3	1 year		
$PM_{2.5}$	25 µg/m^3	24 hours	Class 2	ERS Objective
	8 µg/m^3	1 year		
NO_2 (maximum concentration)	80 ppb	1 hour	Class 1	ERS Objective
	15 ppb	1 year		
SO_2 (maximum concentration)	75 ppb	1 hour	Class 1	ERS Objective
	20 ppb	24 hours		

[2] Substances are classified as per Schedule 4 of the Environmental Protection Regulations 2021

4. Methodology summary

4.1 Parameters measured

The AQMS was installed at Station Pier on 4 December 2023. Table 4.1 summarises the equipment included in the AQMS and the pollutants measured. A photograph of the AQMS is provided in Figure 4.1.

Table 4.1 Summary of monitoring equipment and pollutants measured

Equipment and hardware supplied	Pollutant/parameter measured	Measurement method	Australian Standard	Location
Air Quality Monitoring System (AQMS)				
MetOne Spirant Beta Attenuation Monitoring	Particles as PM_{10}	Beta Attenuation Monitoring (BAM) technology	AS 3580.9.12.2022	Station Pier. Refer to Figure 1.1 for location of AQMS.
MetOne Spirant BAM	Particles as $PM_{2.5}$	BAM technology	AS 3580.9.11.2022	
Ecotech Model Serinus® 40	Nitrogen dioxide (NO_2)	Chemiluminescence technology	AS 3580.5.1.2011	
Ecotech Model Serinus® 50	Sulphur dioxide (SO_2)	Pulse UV Fluorescent Radiation technology	AS 3580.4.1.2008	
Ultrasonic anemometer at 10 m	Wind speed, wind direction Sigma (Standard deviation of wind direction. Can be used to calculate atmospheric stability)	Ultrasonic sensor	AS 3580.14:2014	
Vaisala HMP155 at 2 m	Temperature, relative humidity	Warmed probe technology	AS 3580.14:2014	

Figure 4.1 Photograph of AQMS

4.2 Monitoring period

The monitoring period for this report is 1 December 2023 to 31 December 2024.

4.3 Data analysis

Data collected by the AQMS has undergone a NATA accreditation procedure undertaken by ACOEM to ensure all analysed data is valid. AQMS observations of each parameter were processed and analysed and are presented in Section 5.

To understand if the port activity or regional emissions was the key driver of the monitored pollutants concentrations in the area, the processing and analysis of AQMS observations are undertaken as follows:

- AQMS observations were processed into averaging periods defined by the relevant APACs. The processed data is also overlayed with vessel presence at the port. Where it is indicated that a vessel is in port, a vessel is berthed at Station Pier. Vessels near the port (during approach and departure) are not included as vessels in port.
- AQMS observations of each parameter are then overlayed with vessel presence and the local EPA Stations, along with the relevant APACs. This analysis allows for comparison against ambient air quality across the local region, and identification of potential risk to the receiving environment. Any exceedances of the criteria have been discussed, taking into account the observations at the nearby EPA stations, vessel presence, and other potential impacts to air quality.
- A previous air quality monitoring program was undertaken at Station Pier during 2016-17. The previous results have been presented and compared against the results from this monitoring period to review the changes in ambient air quality over time.

4.4 Data information

Table 4.2 summarises the availability and quality of the data measured by the AQMS between 1 December 2023 to 31 December 2024.

ACOEM has conducted all required servicing and calibration for production of NATA accredited air quality data, and monthly data has been reviewed. Data presented in this report from the Station Pier AQMS is NATA accredited.

Table 4.2 AQMS data availability and quality

Parameters	Units	Data availability (%) between 1 December 2023 and 31 December 2024	Reason for missing data
PM_{10}	$\mu g/m^3$	92%	– Data between 4 and 20 December 2023 removed due to commissioning phase (zero filter inlet used) – Scheduled monthly maintenance – Non-scheduled maintenance – Station power interruption and instrument stabilisation – Instrument fault – instrument stalled (01/02/24 – 07/02/24) – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Other brief, intermittent interruptions (e.g. instrument faults, calibrations, etc.)
$PM_{2.5}$	$\mu g/m^3$	93%	– Data between 4 and 20 December 2023 removed due to commissioning phase (zero filter inlet used) – Scheduled monthly maintenance – Non-scheduled maintenance – Station power interruption and instrument stabilisation

Parameters	Units	Data availability (%) between 1 December 2023 and 31 December 2024	Reason for missing data
			– Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Other brief, intermittent interruptions (e.g. instrument faults, calibrations, etc.)
NO_2	ppb	93%	– Scheduled monthly maintenance – Non-scheduled maintenance – Station power interruption and instrument stabilisation – Automatic calibration checks occurring daily overnight – Intermittent unrealistic negative values – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Other brief, intermittent interruptions (e.g. power interruption, modem interruption, calibrations, etc.)
SO_2	ppb	93%	– Scheduled monthly maintenance – Non-scheduled maintenance – Station power interruption and instrument stabilisation – Automatic calibration checks occurring daily overnight – Static offsets applied intermittently as required to correct baseline – Intermittent unrealistic outlier data – Linear offset applied intermittently as required to correct baseline – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Other brief, intermittent interruptions (e.g. power interruption, modem interruption, calibrations, etc.)
Wind speed	m/s	95%	– Scheduled monthly maintenance – Non-scheduled maintenance – Station power interruption and instrument stabilisation – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Instrument fault – wind data flatlined (18/10/24 – 30/10/24, 06/11/24 – 07/11/24) – Other brief, intermittent interruptions (e.g. power interruption, logger error, etc.)
Wind direction	°	95%	– Scheduled monthly maintenance – Non-scheduled maintenance – Station power interruption and instrument stabilisation – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Instrument fault – wind data flatlined (18/10/24 – 30/10/24, 06/11/24 – 07/11/24) – Other brief, intermittent interruptions (e.g. power interruption, logger error, etc.)
Ambient temperature	°C	73%	– Instrument installed 13 March 2024 – Scheduled monthly maintenance – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Other brief, intermittent interruptions (e.g. power interruption, logger error, etc.)
Relative humidity	%	73%	– Instrument installed 13 March 2024 – Scheduled monthly maintenance

Parameters	Units	Data availability (%) between 1 December 2023 and 31 December 2024	Reason for missing data
			– Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Other brief, intermittent interruptions (e.g. power interruption, logger error, etc.)
Sigma	°	95%	– Scheduled monthly maintenance – Non-scheduled maintenance – Intermittent power interruption followed by instrument stabilisation (02/03/24-16/03/24) – Station power interruption and instrument stabilisation – Instrument fault – wind data flatlined (18/10/24 – 30/10/24, 06/11/24 – 07/11/24) – Other brief, intermittent interruptions (e.g. power interruption, logger error, etc.)

5. AQMS monitored data analysis

5.1 Meteorological parameters

5.1.1 Wind conditions

The effects of wind on dispersion patterns can be examined using the general wind climate and atmospheric stability class distributions. The general wind climate at a site is displayed by means of wind rose plots, giving the incidence of winds from different directions for various wind speed ranges.

Figure 5.1 shows the average wind rose and Figure 5.2 shows the average seasonal wind roses at Station Pier for the monitoring period. Figure 5.1 shows the following features:

- The predominant monthly average wind direction was from the south-southwest comprising 12.2% of all incident winds, followed by winds from the south (11.8%) and the north (10.8%).
- The average wind speed was 3.0 m/s.
- Calms (wind speeds less than 0.5 m/s) occurred 2.2% of the time.
- Winds from the north-northeast, south-southeast, southwest, west-southwest, west, and north-northwest each occurred between 5 and 10% of the time.
- Winds from the remaining directions each occurred for less than 5% of the time.

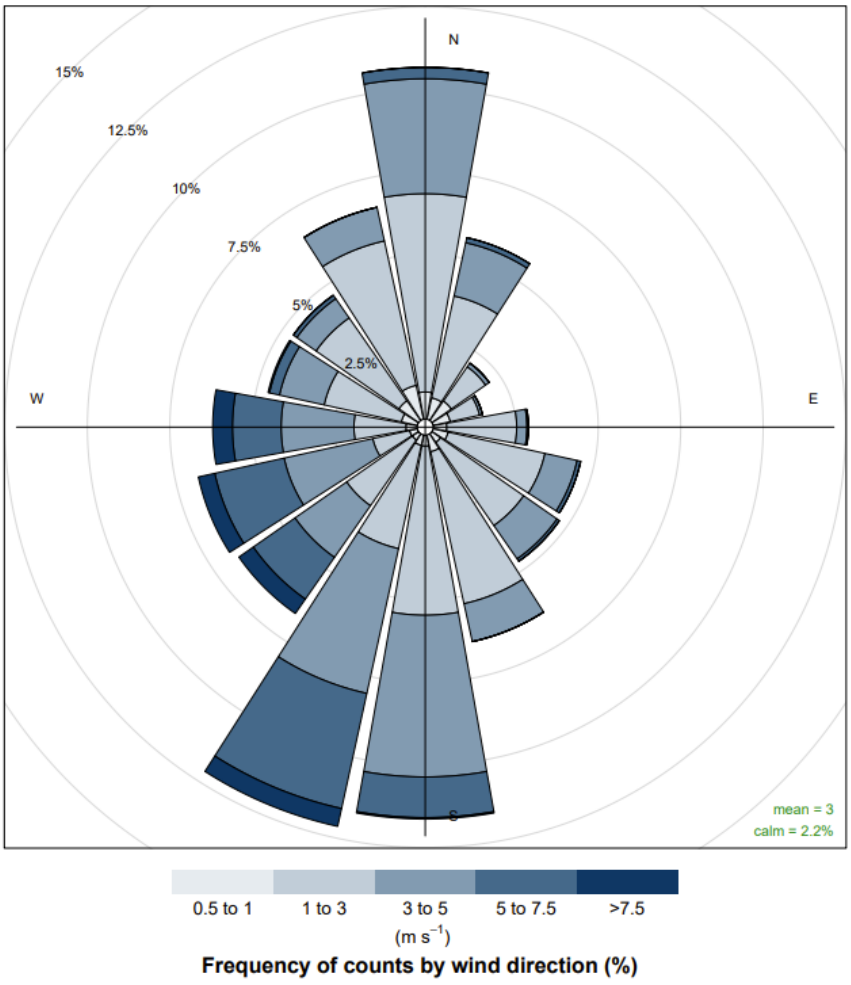


Figure 5.1 Average wind rose collected at Station Pier (Dec 2023 – Dec 2024)

Figure 5.2 extends these observations, showing that:

– The winds from the north mainly occurred during winter, while the winds from the south mainly occurred during spring and summer
– Autumn and winter had a slightly lower average wind speed than spring and summer
– Spring has the smallest proportion of calm conditions.

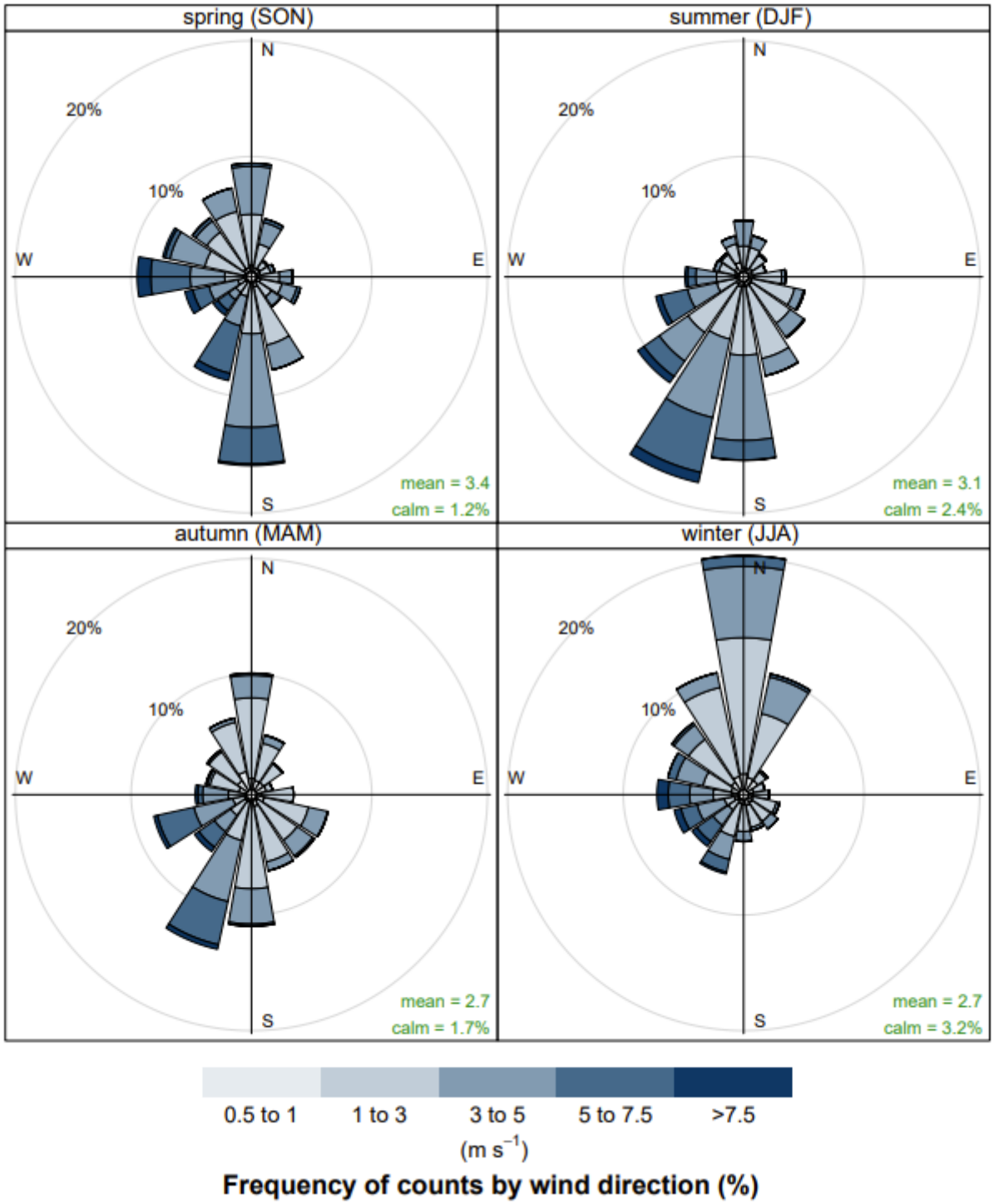


Figure 5.2 Average seasonal wind roses collected at Station Pier (Dec 2023 – Dec 2024)

5.1.2 Temperature and relative humidity

Figure 5.3 shows monthly mean temperature and relative humidity statistics for data measured at Station Pier for the monitoring period. The monthly maximum and minimum temperatures are used to show the typical temperature range for each month. These are shown along with the monthly average temperature and relative humidity.

Figure 5.4 shows the daily average temperature and relative humidity measured at Station Pier for the monitoring period.

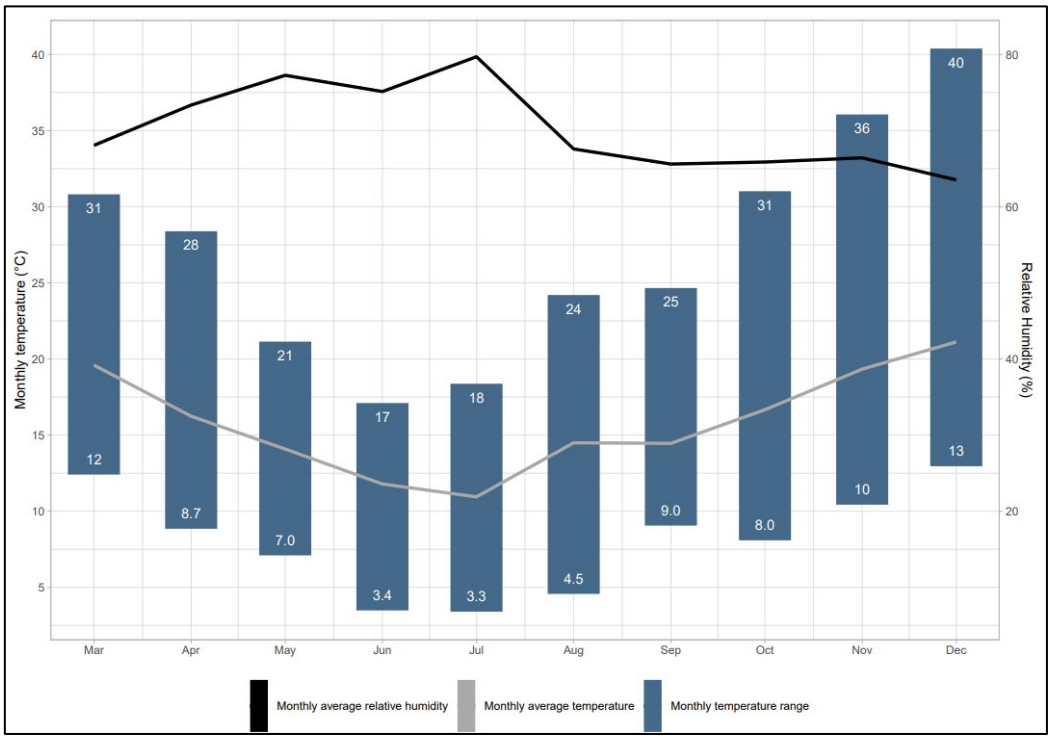


Figure 5.3 Monthly temperature and relative humidity at Station Pier

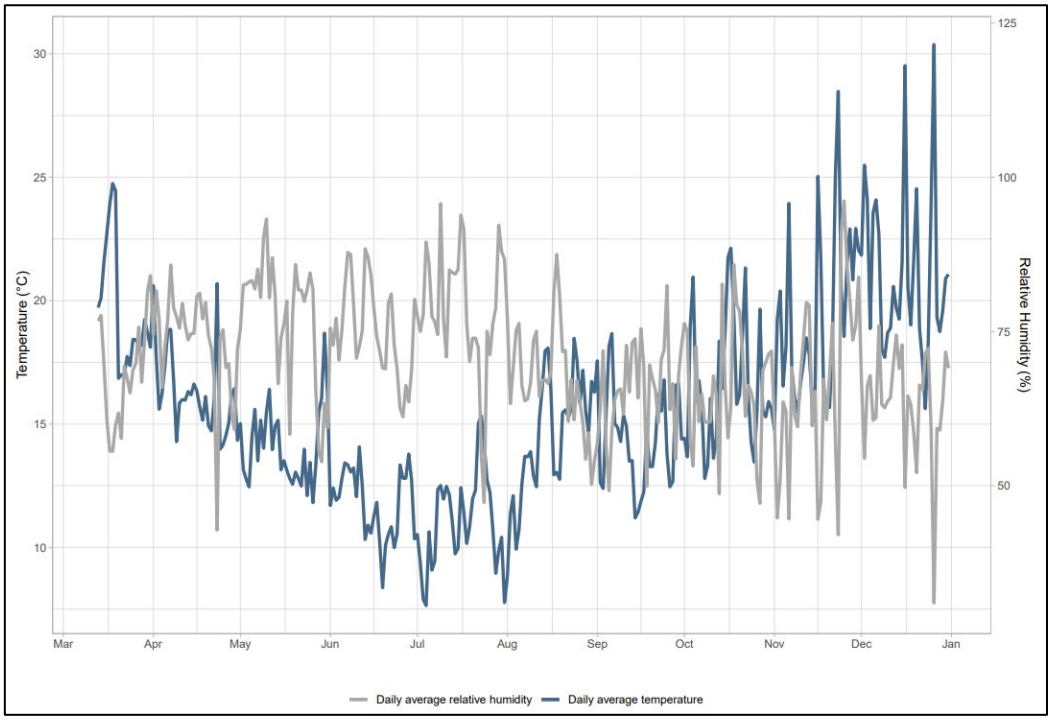


Figure 5.4 Daily temperature and relative humidity at Station Pier

5.2 PM_{10}

5.2.1 24-hour average results

The 24-hour average PM_{10} concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.5, with hours during which a vessel was present in the port highlighted.

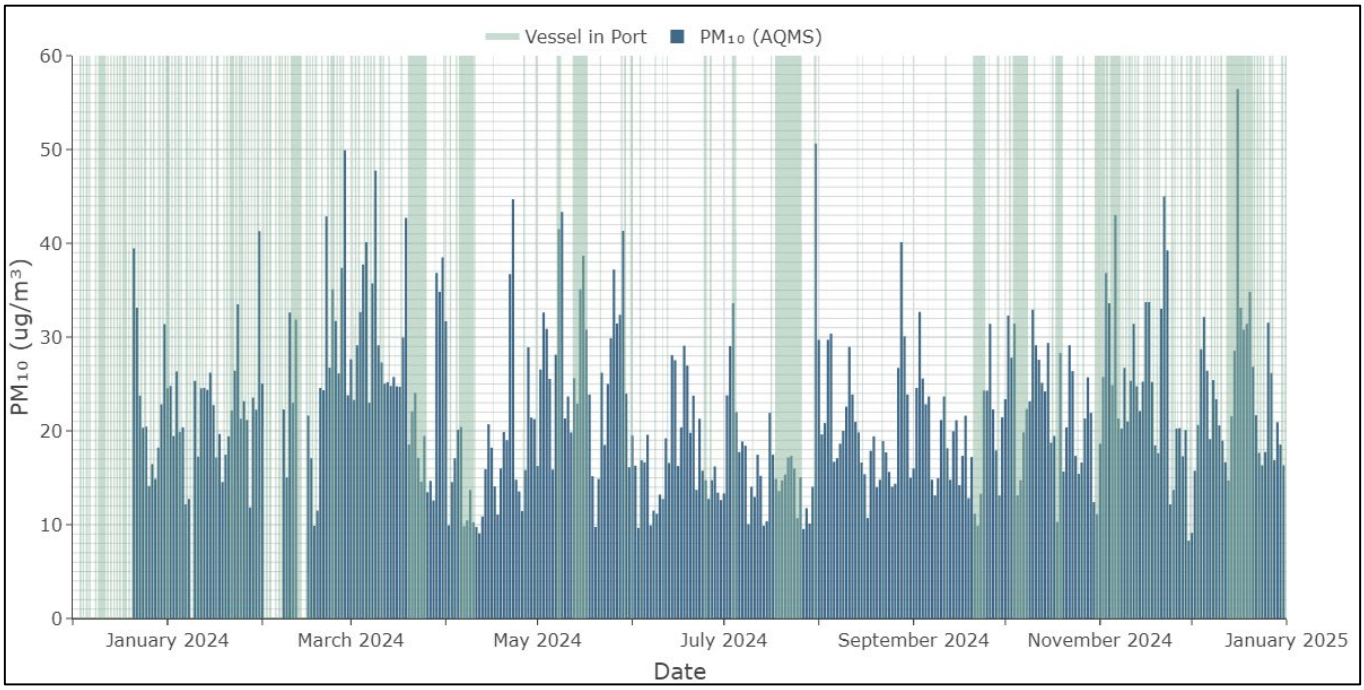


Figure 5.5 24-hour average PM_{10} concentrations (µg/m³) at Station Pier (criteria: 50 µg/m³)

5.2.2 Long term results

An annual average criterion of 20 µg/m³ is specified for PM_{10}. The annual average PM_{10} concentration for 2024 was 22.1 µg/m³ which is above the criterion by 11%.

The annual average concentrations observed at the Brooklyn EPA Station exceeded the adopted criterion by 19%, while concentrations at Kingsville and Footscray were below the criterion. Monthly average and overall average concentrations using all data available are presented in Table 5.1.

Table 5.1 Monthly average PM_{10} concentrations (µg/m³)

Month	Station Pier	Kingsville	Footscray	Brooklyn
December 2023	23.3	19.0	14.8	-
January 2024	22.1	18.3	12.6	-
February 2024	26.7	23.3	18.6	29.8
March 2024	27.2	23.7	21.0	30.9
April 2024	17.7	13.5	12.0	18.3
May 2024	26.6	24.5	20.6	28.7
June 2024	17.3	13.7	6.6	20.2
July 2024	17.5	14.2	12.0	20.6
August 2024	20.9	12.8	13.7	26.2
September 2024	19.3	11.6	-	19.9
October 2024	22.1	18.3	-	22.1

Month	Station Pier	Kingsville	Footscray	Brooklyn
November 2024	25.3	18.6	-	24.1
December 2024	23.8	14.8	-	22.4
2024 average	**22.1**	**17.0**	**14.8**	**23.8**
All available data	**22.2**	**17.2**	**14.8**	**23.8**

"-" indicates no data available
Note seasons are differentiated by shading

Seasonal pollution roses for PM_{10} area shown in Figure 5.6. These indicate the following:

– During spring, increased PM_{10} concentrations were observed during winds from the north
– During summer, increased PM_{10} concentrations were observed during winds from the northwest quadrant
– During autumn and winter, PM_{10} concentrations were similar during winds from all directions

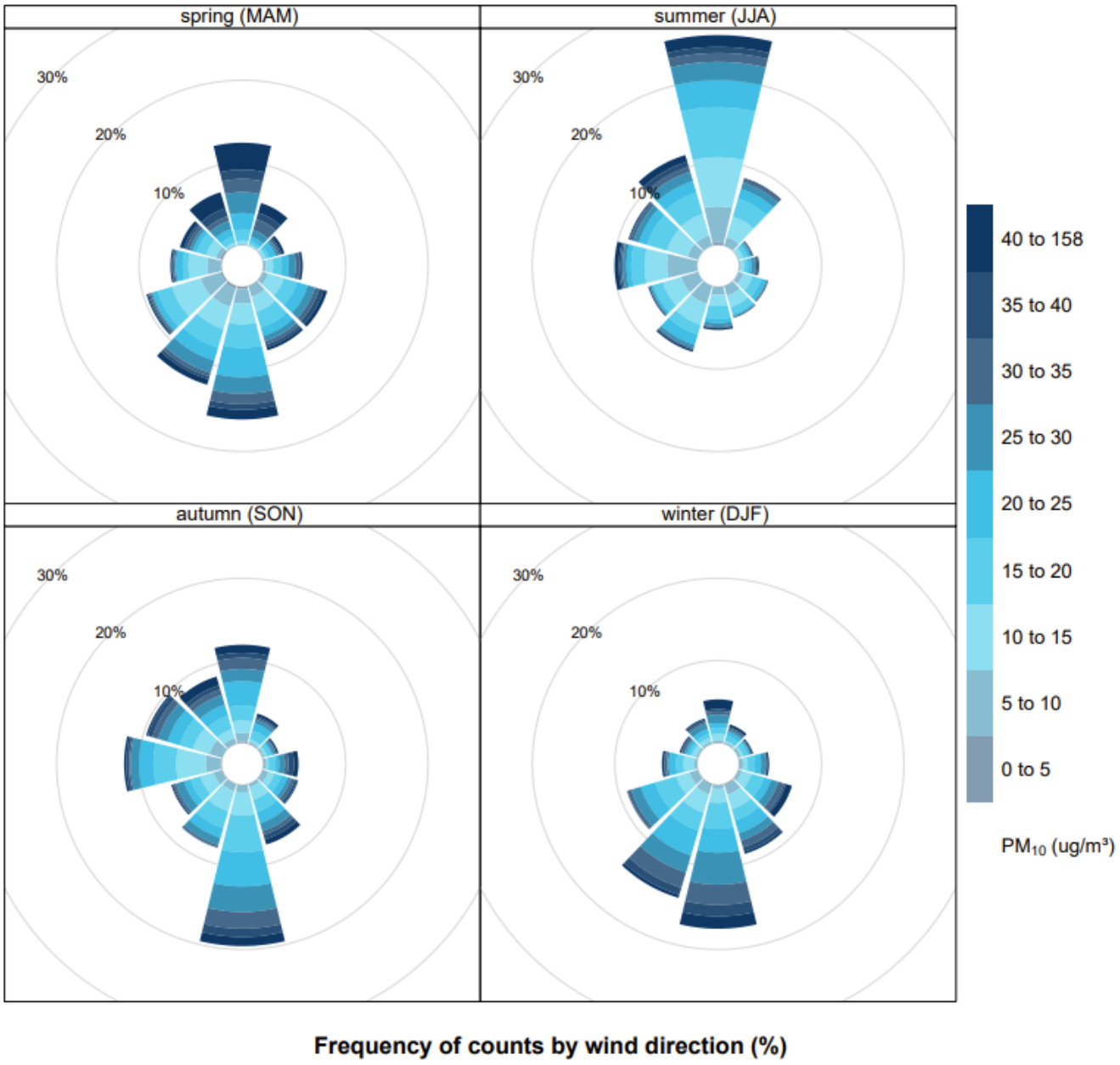


Figure 5.6 Seasonal PM_{10} concentration (µg/m³) pollution roses

5.2.3 Discussion

5.2.3.1 Data comparison with EPA Stations

The 24-hour average PM_{10} concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.7, alongside observations from the local EPA Stations and the adopted criterion. Hours during which a vessel was present in the port highlighted.

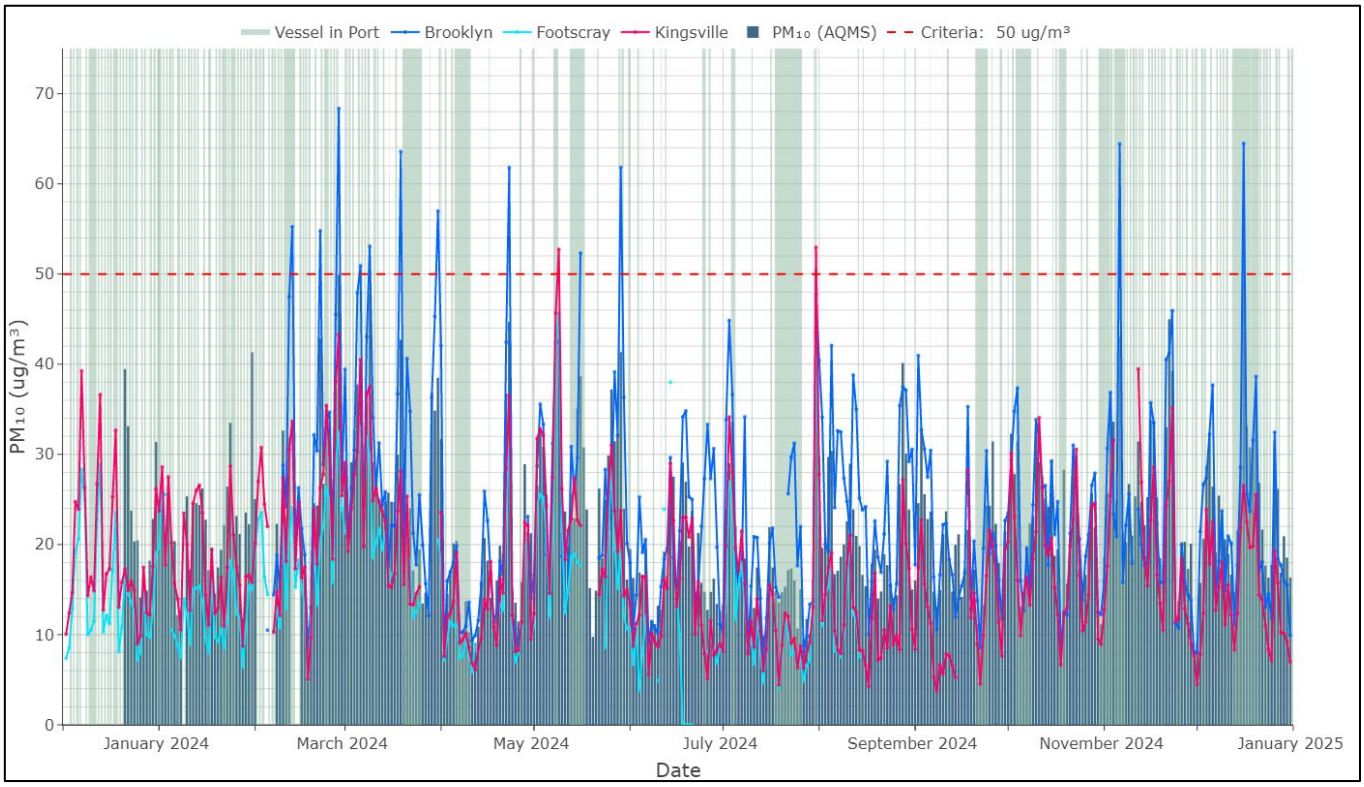


Figure 5.7 24-hour average PM_{10} concentrations ($\mu g/m^3$) at Station Pier and local EPA stations (criteria: 50 $\mu g/m^3$)

Correlation between the 24-hour average Station Pier observations and local EPA station observations is presented in Table 5.2. Positive correlation (>0.75) was observed between the Station Pier observations and the EPA station observations.

Table 5.2 Comparison between 24-hour average PM_{10} Station Pier observations and local EPA station observations

EPA Station	Correlation coefficient (r)
Kingsville	0.82
Footscray	0.77
Brooklyn	0.84

5.2.3.2 Port activity

The hourly average PM_{10} concentrations observed at Station Pier at the average wind direction for that hour are presented in Figure 5.8. Colouring indicates the presence or absence of a vessel in the port.

Pollution roses presenting data observed when there were no vessels in port, and when there were vessels in port are shown in Figure 5.9. The pollution rose presents the frequency of occurrence of hourly average PM_{10} concentrations in each wind direction for the month.

At least one vessel was present at the port for 34% of the time during the PM_{10} observation period. The following average concentrations were observed:

– When a vessel was in port: 23.5 µg/m^3
– When no vessels were in port: 21.5 µg/m^3

The Point-Biserial correlation coefficient between the hourly PM_{10} concentrations and vessel presence was 0.08, indicating minimal correlation between PM_{10} concentrations and port activity.

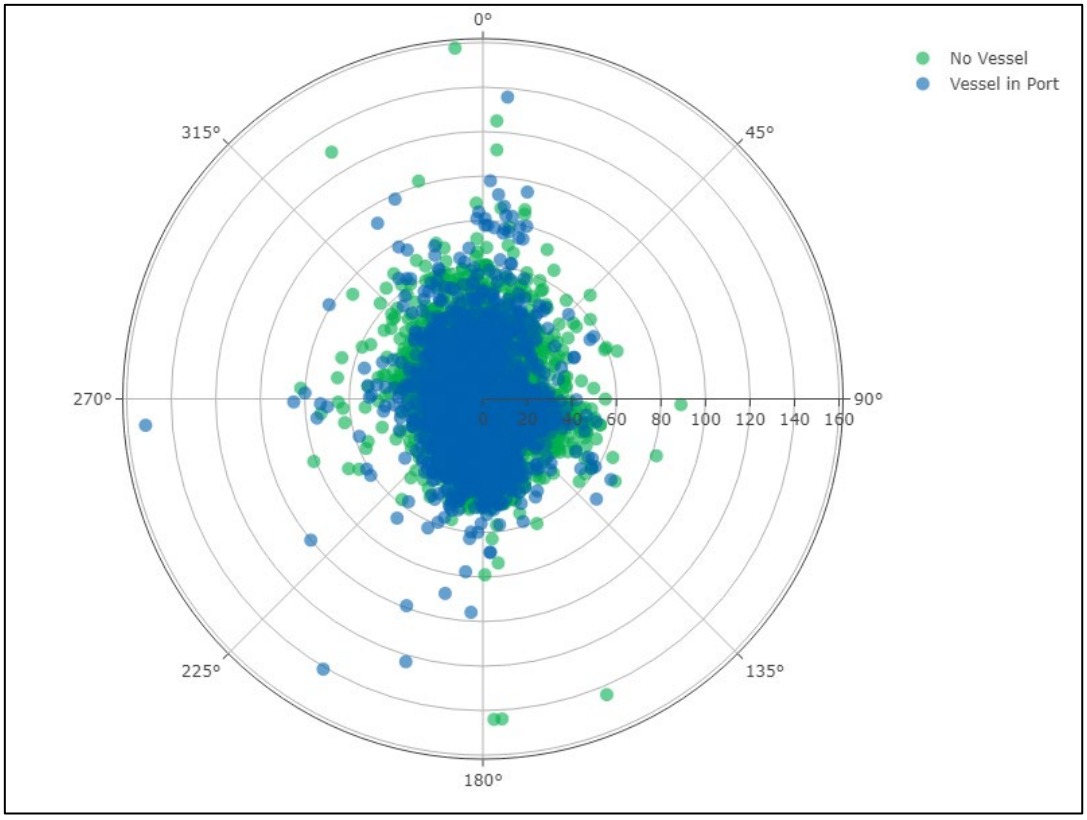


Figure 5.8 Hourly average PM_{10} concentration (µg/m^3) by wind direction at Station Pier

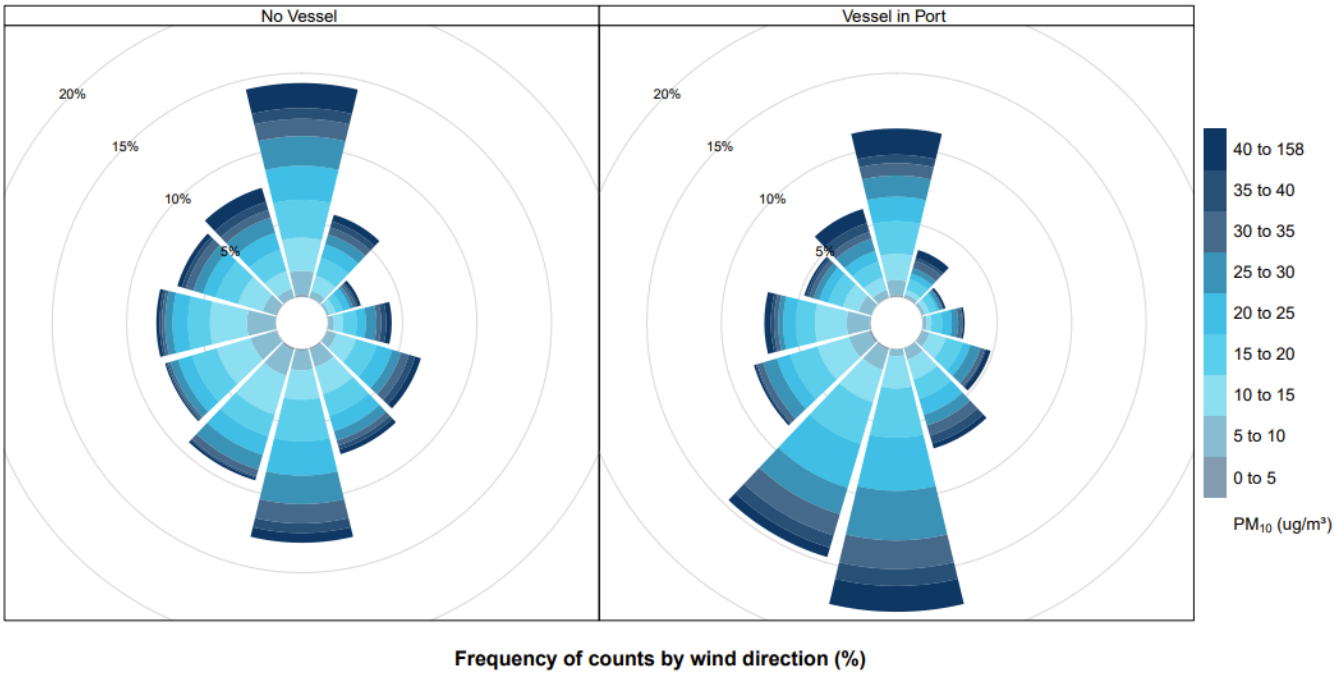


Figure 5.9 Hourly average PM_{10} concentration (µg/m^3) pollution roses

5.2.3.3 Exceedances of the criteria

PM_{10} concentrations were generally below the adopted criterion. Exceedances of the criterion were observed on two days, which are described in Table 5.3.

Table 5.3 Exceedances of the PM_{10} criterion

Date	24-hour average concentration (µg/m^3)	Percent above the adopted criterion (50 µg/m^3)	Increased observations at nearby EPA stations?	Vessel presence	Other impacts to air quality
31 July 2024	50.6 µg/m^3	1%	Yes – Brooklyn: 47.7 µg/m^3 – Footscray: 43.7 µg/m^3 – Kingsville: 53.0 µg/m^3	No vessels present. The ICS Allegiance left the port at midnight on 30 July.	Planned burns reported at Anglesea, Carlisle River and Gellibrand, approximately 90 km southwest, 160 km southwest and 150 km southwest of Station Pier respectively.
16 December 2024	56.5 µg/m^3	13%	Yes, only at Brooklyn – Brooklyn: 64.5 µg/m^3 – Kingsville: 26.5 µg/m^3	Two vessels were present at the port: – Victorian Reliance II was present for the entire day – Crown Princess (P) was present between 5am and 5:40pm	Bushfires were reported at Boisdale within the Avon-Mt Hedrick Scenic Reserve, located approximately 170 km east of Station Pier.

The higher concentrations of PM_{10} observed at both Station Pier AQMS and the EPA stations indicate that there were likely regional emission sources contributing to elevated levels, rather than a localised source.

As noted in Section 5.2.2, the annual average PM_{10} concentration for 2024 was 22.1 µg/m^3 which is above the criterion by 11%. Maximum monthly average concentrations occurred during February, March, May and November. This is likely due to planned burns during these months. Monthly average concentrations over summer were also above 20 µg/m^3, likely due to bushfires.

The annual average concentrations observed at the Brooklyn EPA Station exceeded the adopted criterion by 19%, while concentrations at Kingsville and Footscray were below the criterion. Similar trends were observed across all EPA Stations with the maximum monthly concentrations generally occurring during February, March and May.

The average concentrations both while a vessel was in port and when no vessel was in port were both above the criterion, indicating the port activity was likely not the key driver of PM_{10} concentrations in the area.

5.3 $PM_{2.5}$

5.3.1 24-hour average results

The 24-hour average $PM_{2.5}$ concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.10, with hours during which a vessel was present in the port highlighted.

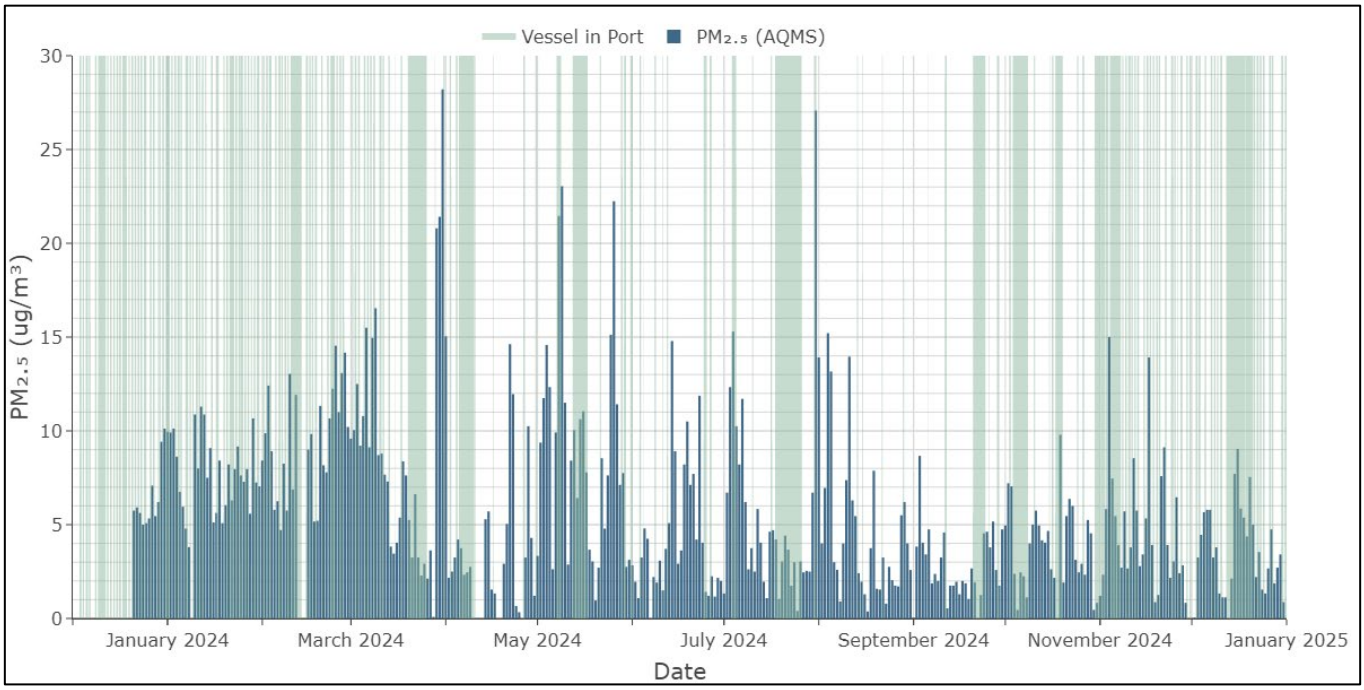


Figure 5.10 24-hour average $PM_{2.5}$ concentrations (µg/m³) at Station Pier (criteria: 25 µg/m³)

5.3.2 Long term results

An annual average criterion of 8 µg/m³ is specified for $PM_{2.5}$. The annual average $PM_{2.5}$ concentration for 2024 was 6.3 µg/m³ which is below the criterion by 21%. Monthly average and overall average concentrations using all data available are presented in Table 5.4.

Table 5.4 Monthly average $PM_{2.5}$ concentrations (µg/m³)

Month	Station Pier	Kingsville	Footscray	Brooklyn	Melbourne CBD	Spotswood	Altona North
December 2023	6.5	3.3	3.2	-	6.5	2.1	3.2
January 2024	7.8	3.4	3.0	6.1	6.8	3.0	3.3
February 2024	9.4	4.0	3.7	7.5	8.2	3.6	2.5
March 2024	9.2	4.2	4.1	8.6	8.4	3.7	-
April 2024	4.9	3.8	3.9	7.1	6.8	3.6	1.1
May 2024	9.4	11.7	11.5	12.1	13.6	12.0	11.5
June 2024	5.0	5.2	2.1	6.9	7.9	6.6	4.4
July 2024	6.0	5.9	5.5	6.9	8.3	5.6	5.4
August 2024	5.5	4.7	4.8	6.5	7.9	5.2	4.9
September 2024	3.5	2.4	2.7	4.3	6.2	2.5	2.5

Month	Station Pier	Kingsville	Footscray	Brooklyn	Melbourne CBD	Spotswood	Altona North
October 2024	4.3	2.9	2.5	5.3	8.2	2.8	3.1
November 2024	5.2	3.8	3.7	6.0	8.8	3.6	3.1
December 2024	4.2	2.3	2.5	4.6	7.6	2.4	2.7
2024 average	**6.3**	**4.5**	**4.2**	**6.8**	**8.1**	**4.3**	**4.3**
All available data	**6.3**	**4.4**	**4.1**	**6.8**	**8.0**	**4.2**	**4.2**
"-" indicates no data available Note seasons are differentiated by shading							

Seasonal pollution roses for $PM_{2.5}$ area shown in Figure 5.11. These indicate the following:

– During spring and summer, increased $PM_{2.5}$ concentrations were observed during winds from the north
– During winter, increased $PM_{2.5}$ concentrations were observed during winds from the south and southwest
– During autumn, $PM_{2.5}$ concentrations were similar during winds from all directions

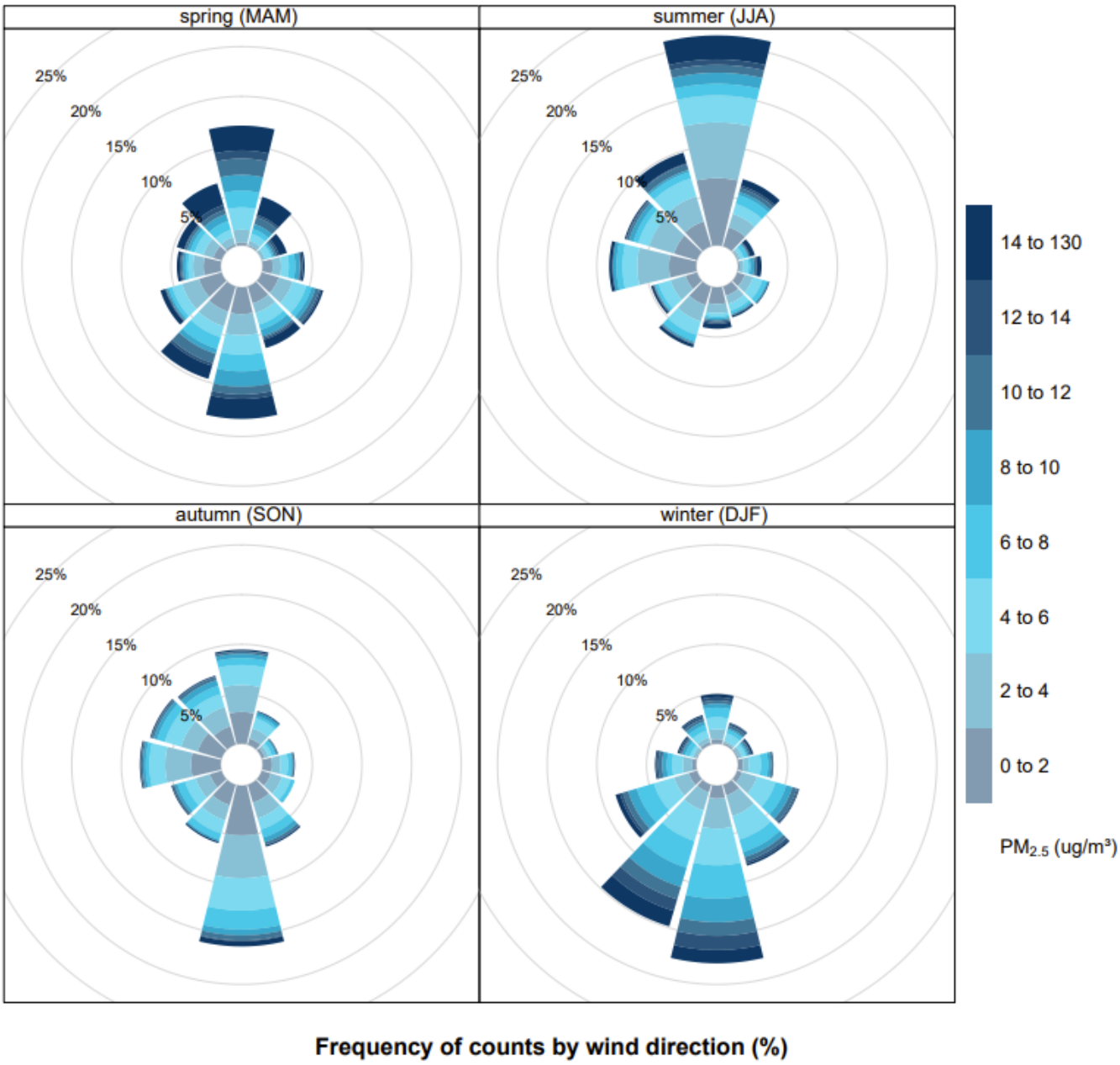


Figure 5.11 Seasonal $PM_{2.5}$ concentration (µg/m³) pollution roses

5.3.3 Discussion

5.3.3.1 Data comparison with EPA Stations

The 24-hour average $PM_{2.5}$ concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.12, alongside observations from the local EPA Stations and the adopted criterion. Hours during which a vessel was present in the port highlighted.

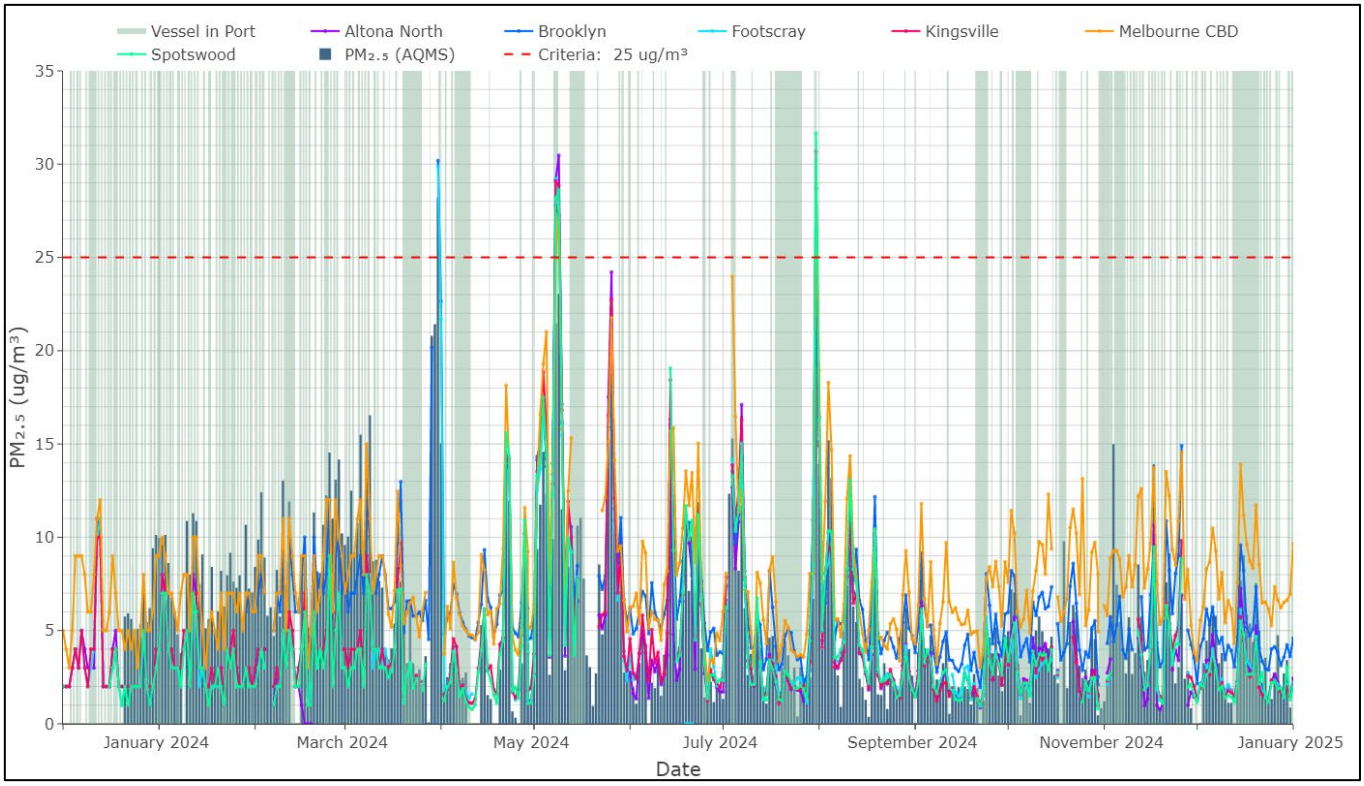


Figure 5.12 24-hour average $PM_{2.5}$ concentrations (µg/m³) at Station Pier and local EPA stations (criteria: 50 µg/m³)

Correlation between the 24-hour average Station Pier observations and local EPA station observations is presented in Table 5.5. Positive correlation (>0.75) was observed between the Station Pier observations and the EPA station observations.

Table 5.5 Comparison between 24-hour average $PM_{2.5}$ Station Pier observations and local EPA station observations

EPA Station	Correlation coefficient (r)
Altona North	0.82
Spotswood	0.75
Kingsville	0.77
Footscray	0.79
Brooklyn	0.85
Melbourne CBD	0.78

5.3.3.2 Port activity

The hourly average $PM_{2.5}$ concentrations observed at Station Pier at the average wind direction for that hour are presented in Figure 5.13. Colouring indicates the presence or absence of a vessel in the port.

Pollution roses presenting data observed when there were no vessels in port, and when there were vessels in port are shown in Figure 5.14. The pollution rose presents the frequency of occurrence of hourly average $PM_{2.5}$ concentrations in each wind direction for the month.

At least one vessel was present at the port for 34% of the time during the $PM_{2.5}$ observation period. The following average concentrations were observed:

– When a vessel was in port: 6.8 µg/m³
– When no vessels were in port: 6.1 µg/m³

The Point-Biserial correlation coefficient between the hourly $PM_{2.5}$ concentrations and vessel presence was 0.05, indicating minimal correlation between $PM_{2.5}$ concentrations and port activity.

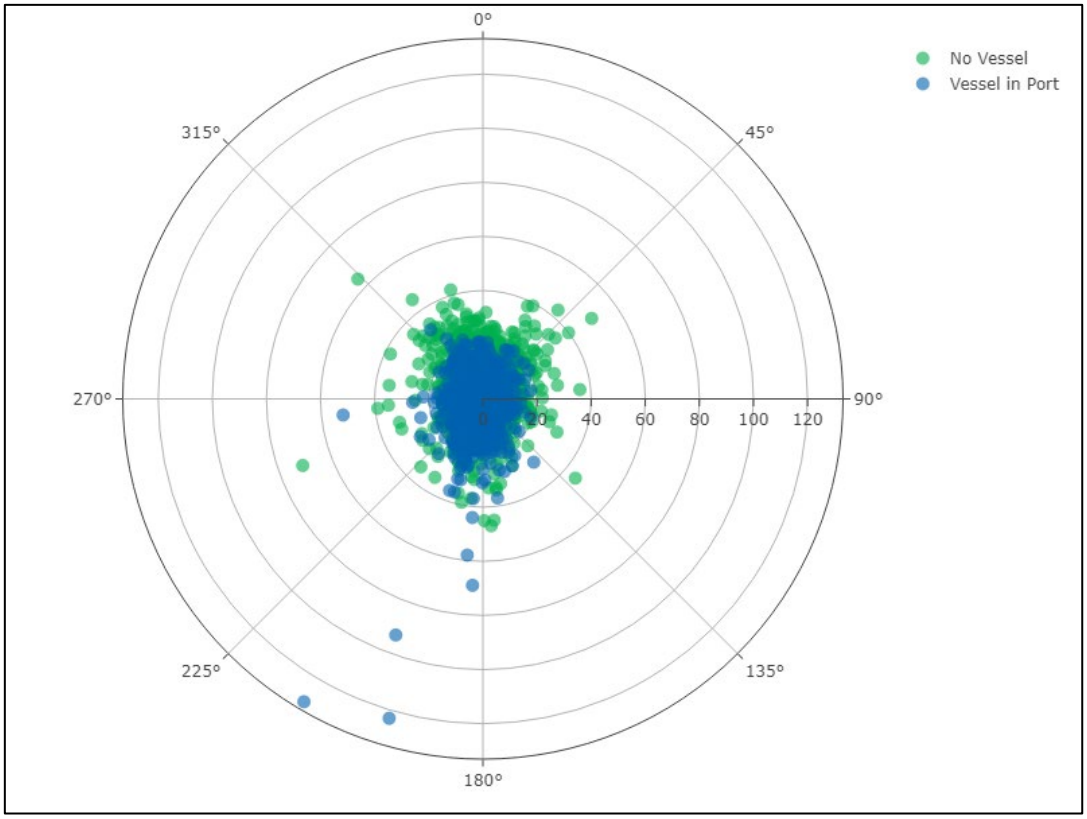


Figure 5.13 Hourly average $PM_{2.5}$ concentration (µg/m³) by wind direction at Station Pier

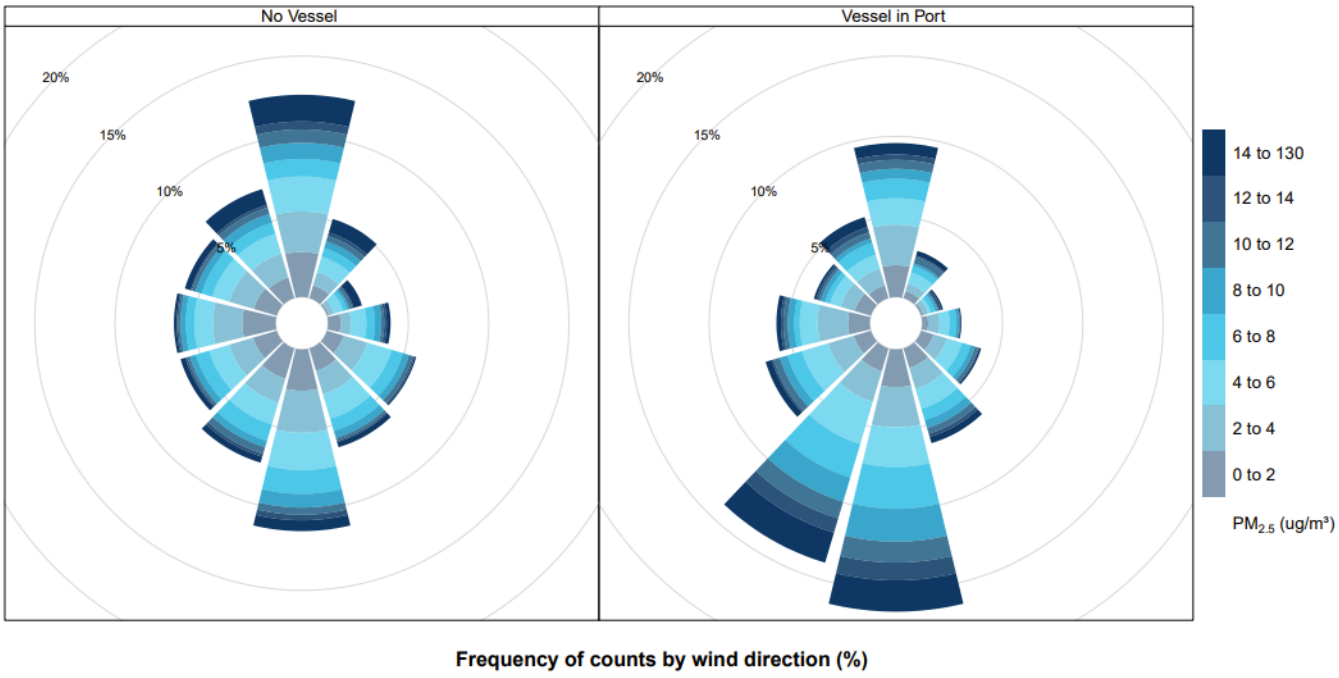


Figure 5.14 Hourly average $PM_{2.5}$ concentration (µg/m³) pollution roses

5.3.3.3 Exceedances of the criteria

$PM_{2.5}$ concentrations were generally below the adopted criterion. Exceedances of the criterion were observed on two days, which are described in Table 5.6.

Table 5.6 Exceedances of the $PM_{2.5}$ criterion

Date	24-hour average concentration (µg/m³)	Percent above the adopted criterion (50 µg/m³)	Increased observations at nearby EPA stations?	Vessel presence	Other impacts to air quality
31 March 2024	28.2 µg/m³	13%	Yes – Brooklyn: 30.2 µg/m³ – Spotswood: 29.9 µg/m³	The Grand Princess (P) was present at the port between 5:30 am to 6 pm.	Several planned burns were reported around Victoria over this weekend.
31 July 2024	27.1 µg/m³	8%	Yes – Altona North: 28.7 µg/m³ – Brooklyn: 25.9 µg/m³ – Footscray: 28.7 µg/m³ – Kingsville: 30.7 µg/m³ – Melbourne CBD: 29.0 µg/m³ – Spotswood: 31.7 µg/m³	No vessels present. The ICS Allegiance left the port at midnight on 30 July.	Planned burns reported at Anglesea, Carlisle River and Gellibrand, approximately 90 km southwest, 160 km southwest and 150 km southwest of Station Pier respectively.

The higher concentrations of $PM_{2.5}$ observed at both Station Pier AQMS and the EPA stations indicate that there were likely regional emission sources contributing to elevated levels, rather than a localised source.

The annual average $PM_{2.5}$ concentration observed at Station Pier was below the annual criterion.

5.4 NO_2

5.4.1 1-hour average results

The 1-hour average NO_2 concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.15, with hours during which a vessel was present in the port highlighted.

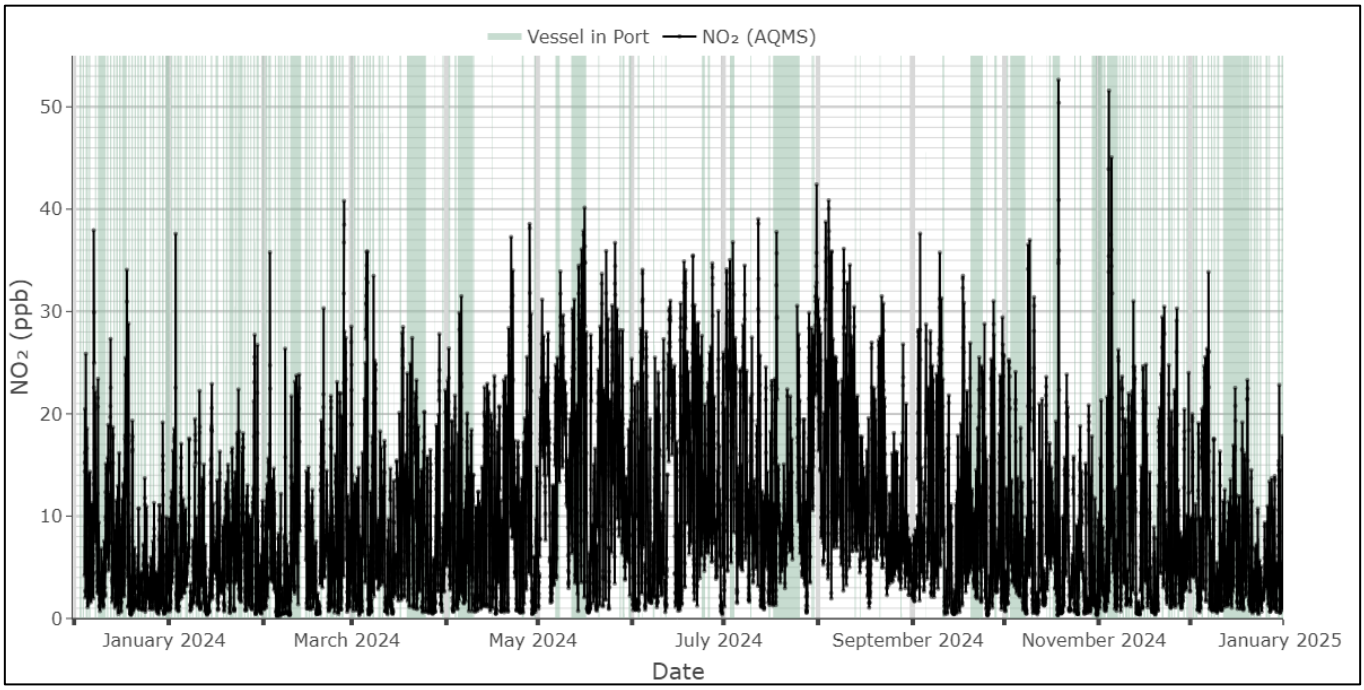


Figure 5.15 24-hour average NO_2 concentrations (ppb) at Station Pier (criteria: 80 ppb)

5.4.2 Long term results

An annual average criterion of 15 ppb is specified for NO_2. The annual average NO_2 concentration for 2024 was 9.5 ppb which is below the criterion by 37%. Monthly average and overall average concentrations using all data available are presented in Table 5.7.

Table 5.7 Monthly NO_2 concentrations (ppb)

Month	Station Pier	Altona North
December 2023	6.1	4.0
January 2024	6.3	4.2
February 2024	7.1	4.3
March 2024	7.9	5.9
April 2024	9.0	7.4
May 2024	14.7	13.3
June 2024	12.6	10.9
July 2024	13.2	10.7
August 2024	13.0	10.8
September 2024	8.9	6.8
October 2024	6.9	6.9
November 2024	8.0	6.1
December 2024	6.1	4.6

Month	Station Pier	Altona North
2024 average	**9.5**	**8.0**
All available data	**9.2**	**7.6**
Note seasons are differentiated by shading		

Seasonal pollution roses for NO_2 area shown in Figure 5.16. These indicate the following:

– During spring and summer, increased NO_2 concentrations were observed during winds from the north
– During autumn, increased NO_2 concentrations were observed during winds from the northwest quadrant
– During winter, NO_2 concentrations were similar during winds from all directions

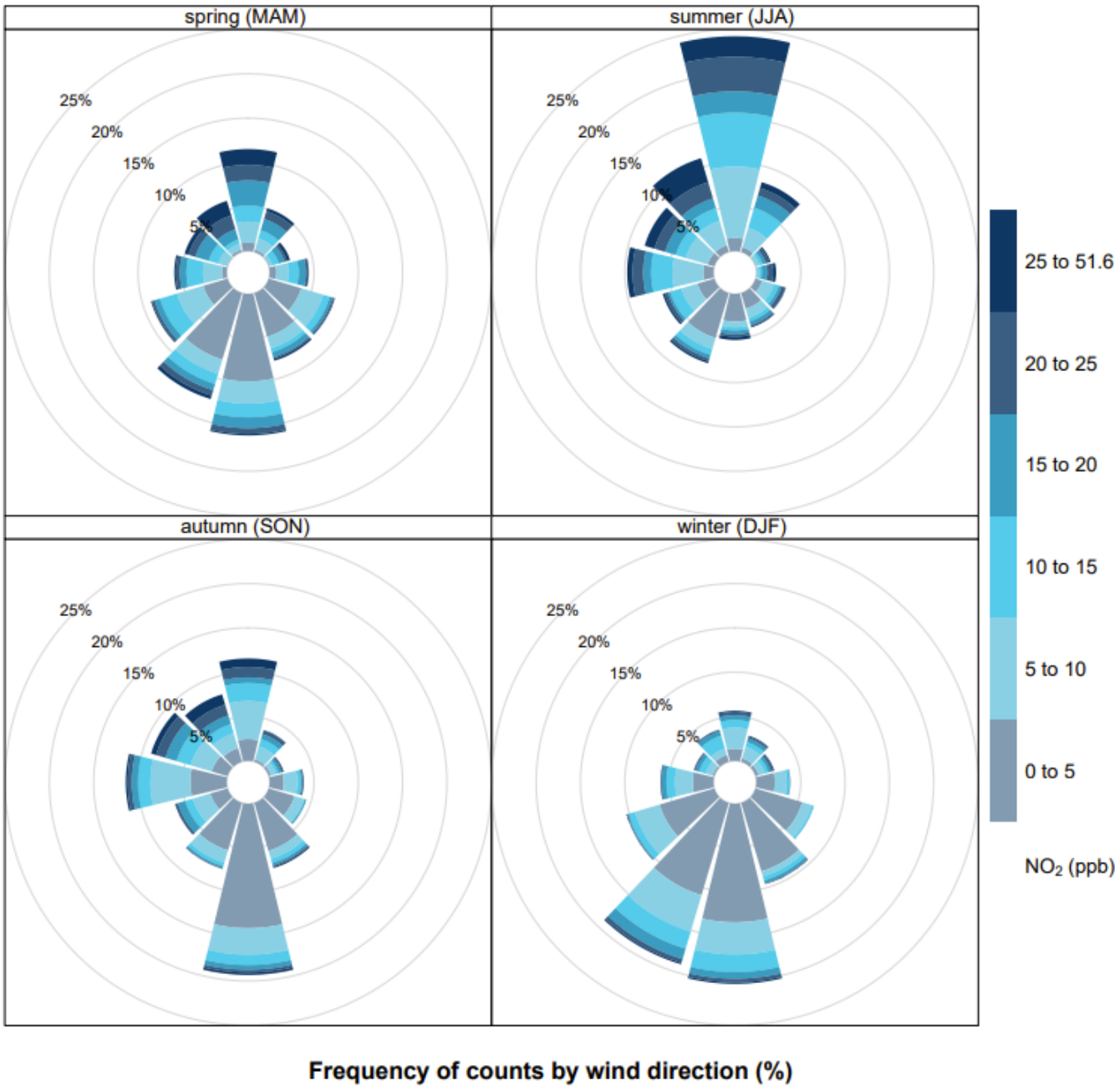


Figure 5.16 Seasonal NO_2 concentration (ppb) pollution roses

5.4.3 Discussion

5.4.3.1 Data comparison with EPA Stations

The 1-hour average NO_2 concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.17, alongside observations from the local EPA Stations and the adopted criterion. Hours during which a vessel was present in the port highlighted.

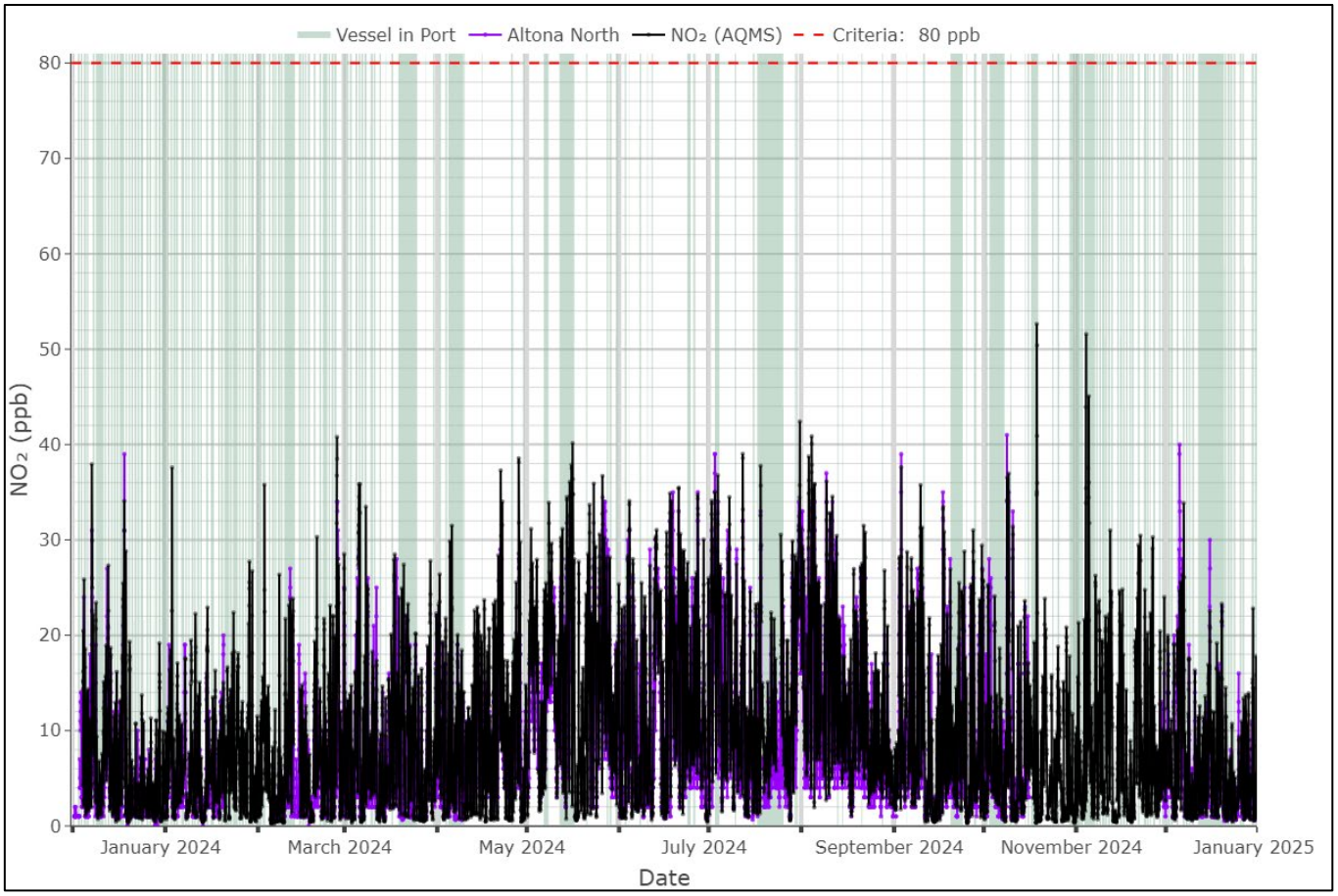


Figure 5.17 1-hour average NO_2 concentrations (µg/m^3) at Station Pier and local EPA stations (criteria: 80 ppb)

Positive correlation (0.83) was observed between the Station Pier observations and the Altona North EPA station observations.

5.4.3.2 Port activity

The hourly average NO_2 concentrations observed at Station Pier at the average wind direction for that hour are presented in Figure 5.18. Colouring indicates the presence or absence of a vessel in the port.

Pollution roses presenting data observed when there were no vessels in port, and when there were vessels in port are shown in Figure 5.19. The pollution rose presents the frequency of occurrence of hourly average NO_2 concentrations in each wind direction for the month.

At least one vessel was present at the port for 36% of the time during the NO_2 observation period. The following average concentrations were observed:

– When a vessel was in port: 9.0 ppb
– When no vessels were in port: 9.4 ppb

The Point-Biserial correlation coefficient between the hourly NO_2 concentrations and vessel presence was -0.03, indicating minimal correlation between NO_2 concentrations and port activity.

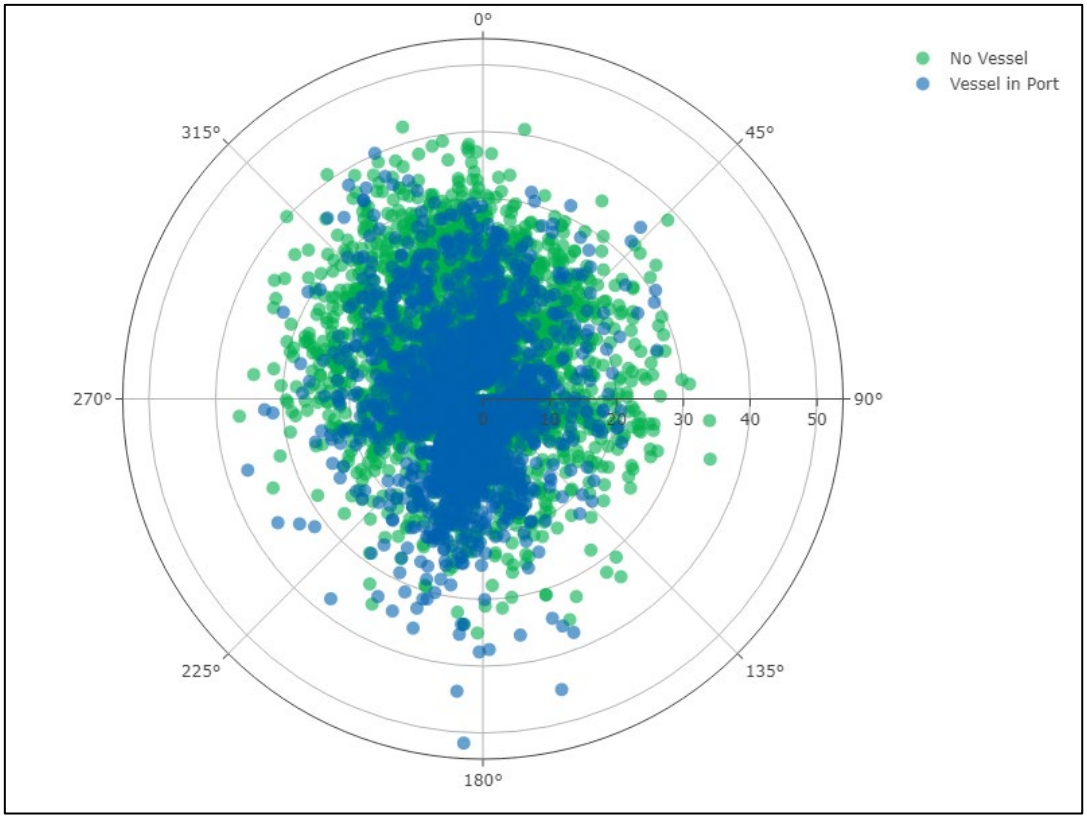


Figure 5.18 Hourly average NO_2 concentration (ppb) by wind direction at Station Pier

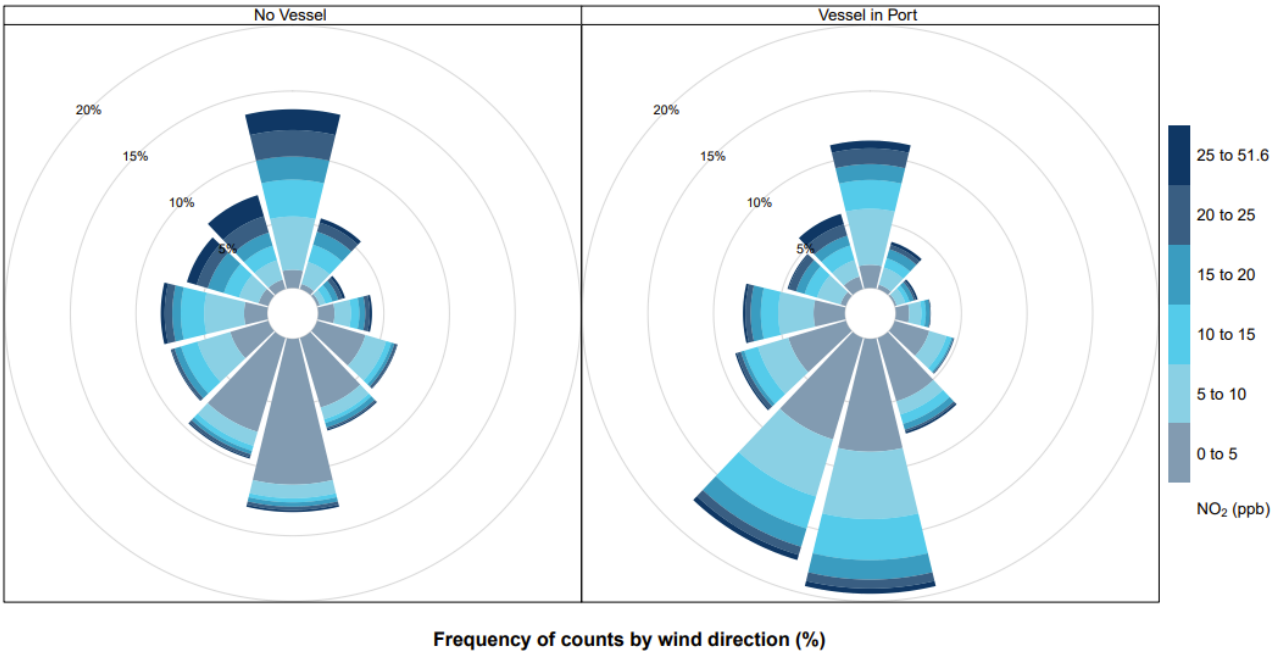


Figure 5.19 Hourly average NO_2 concentration (ppb) pollution roses

5.4.3.3 Exceedances of the criteria

No exceedances of the adopted 1-hour or annual NO_2 criteria were observed at the Station Pier AQMS during the monitoring period.

5.5 SO_2

5.5.1 1-hour average results

The 1-hour average SO_2 concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.20, with hours during which a vessel was present in the port highlighted.

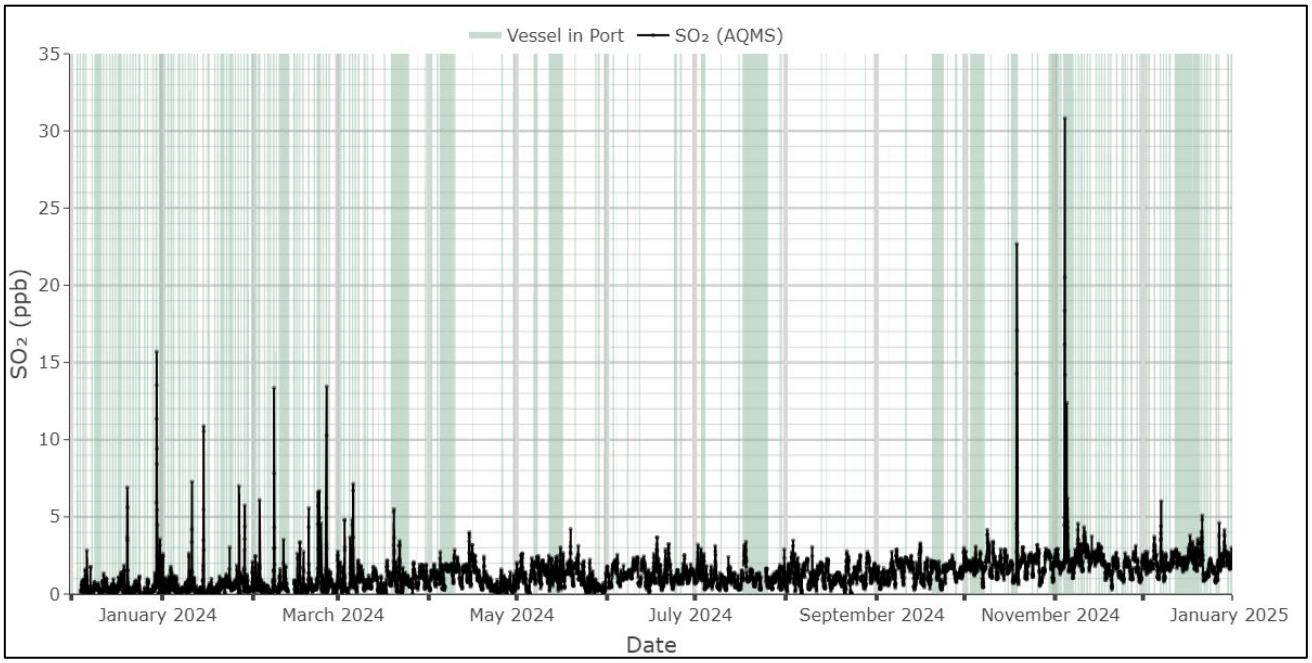


Figure 5.20 24-hour average SO_2 concentrations (ppb) at Station Pier (criteria: 75 ppb)

5.5.2 24-hour average results

The 24-hour average SO_2 concentrations observed at the Station Pier AQMS over the monitoring period is presented in Figure 5.21, with hours during which a vessel was present in the port highlighted.

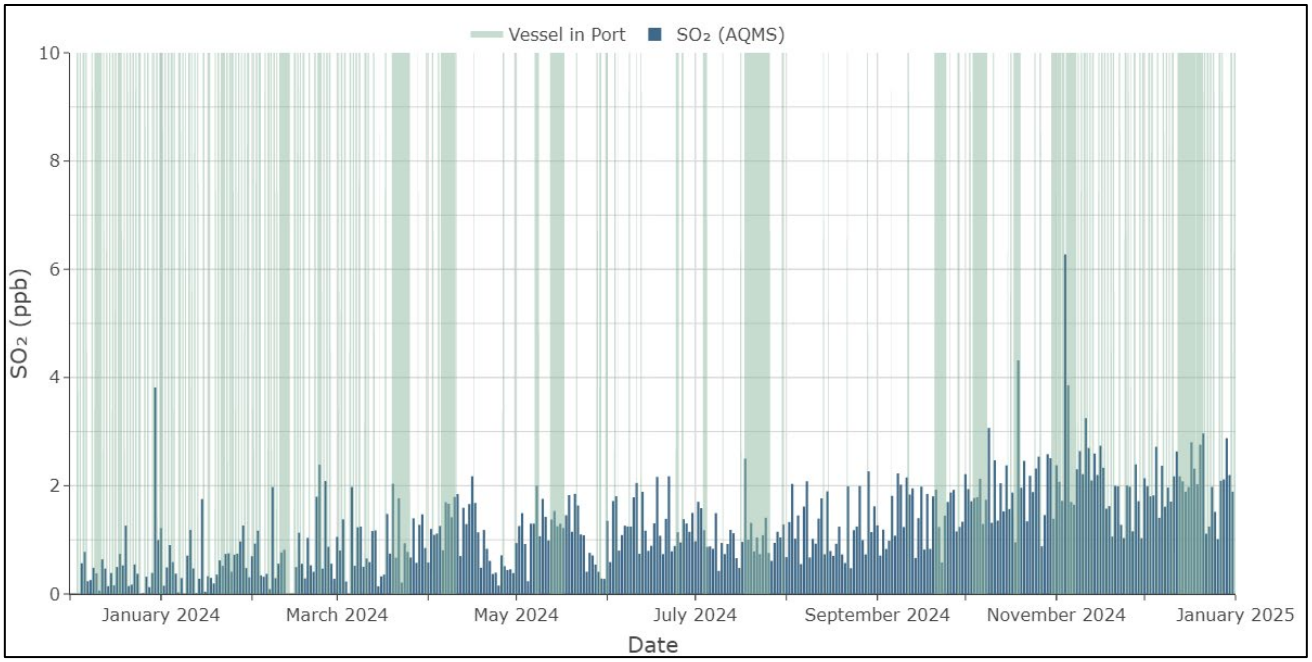


Figure 5.21 24-hour average SO_2 concentrations (µg/m^3) at Station Pier (criteria: 20 ppb)

Seasonal pollution roses for SO_2 area shown in Figure 5.22. These indicate the following:

– During spring, summer and autumn, and summer, SO_2 concentrations were similar during winds from all directions
– During winter, increased SO_2 concentrations were observed during winds from the south

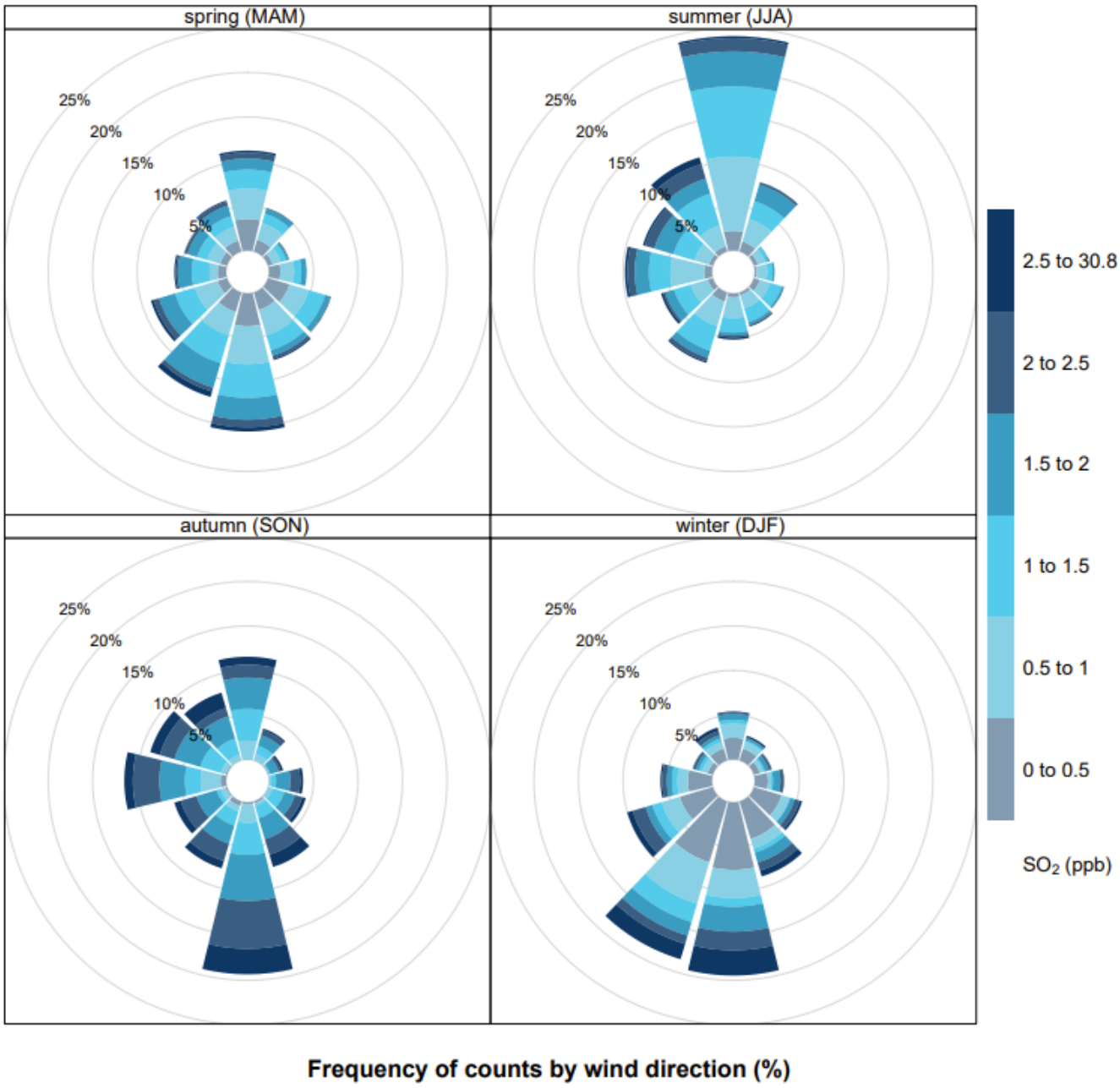


Figure 5.22 Seasonal SO_2 concentration (ppb) pollution roses

5.5.3 Discussion

5.5.3.1 Data comparison with EPA Stations

The 1-hour and 24-hour average SO_2 concentrations observed at the Station Pier AQMS over the monitoring period are presented in Figure 5.23 and Figure 5.24 respectively, alongside observations from the local EPA Stations and the adopted criterion. Hours during which a vessel was present in the port highlighted.

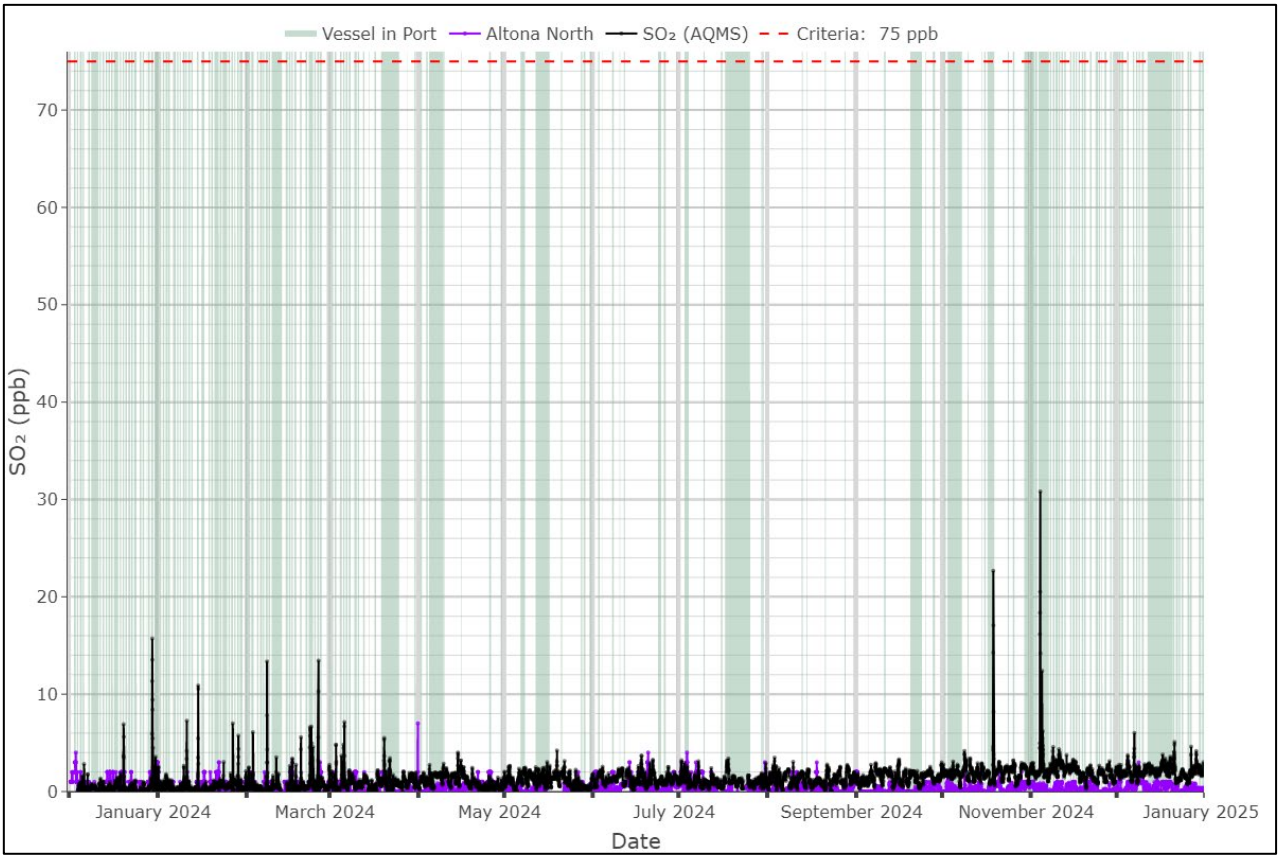


Figure 5.23 1-hour average SO_2 concentrations (ppb) at Station Pier and local EPA stations (criteria: 75 ppb)

Minimal correlation (0.03 for hourly and -0.01 for 24-hour) was observed between the Station Pier observations and the Altona North EPA station observations.

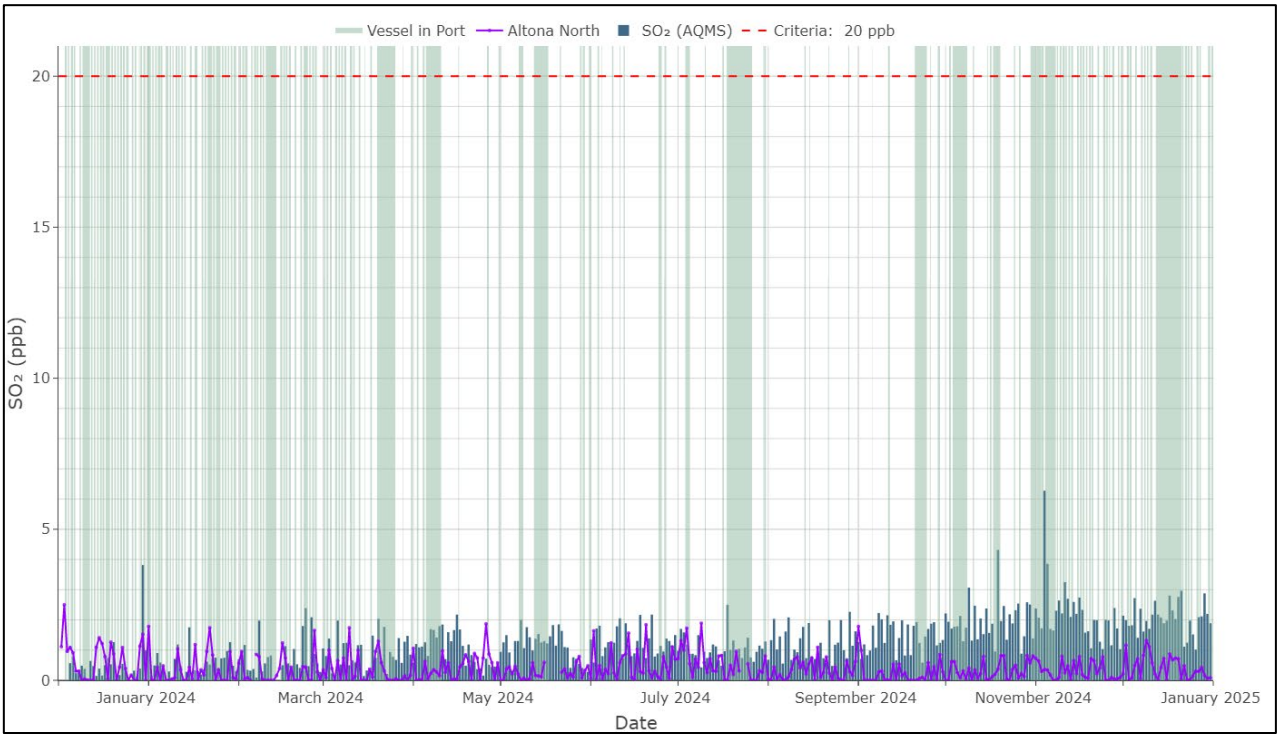


Figure 5.24 24-hour average SO_2 concentrations ($\mu g/m^3$) at Station Pier and local EPA stations (criteria: 20 ppb)

5.5.3.2 Port activity

The hourly average SO_2 concentrations observed at Station Pier at the average wind direction for that hour are presented in Figure 5.25. Colouring indicates the presence or absence of a vessel in the port.

Pollution roses presenting data observed when there were no vessels in port, and when there were vessels in port are shown in Figure 5.26. The pollution rose presents the frequency of occurrence of hourly average SO_2 concentrations in each wind direction for the month.

At least one vessel was present at the port for 37% of the time during the SO_2 observation period. The following average concentrations were observed:

– When a vessel was in port: 1.4 ppb
– When no vessels were in port: 1.2 ppb

The Point-Biserial correlation coefficient between the hourly SO_2 concentrations and vessel presence was 0.11, indicating minimal correlation between SO_2 concentrations and port activity.

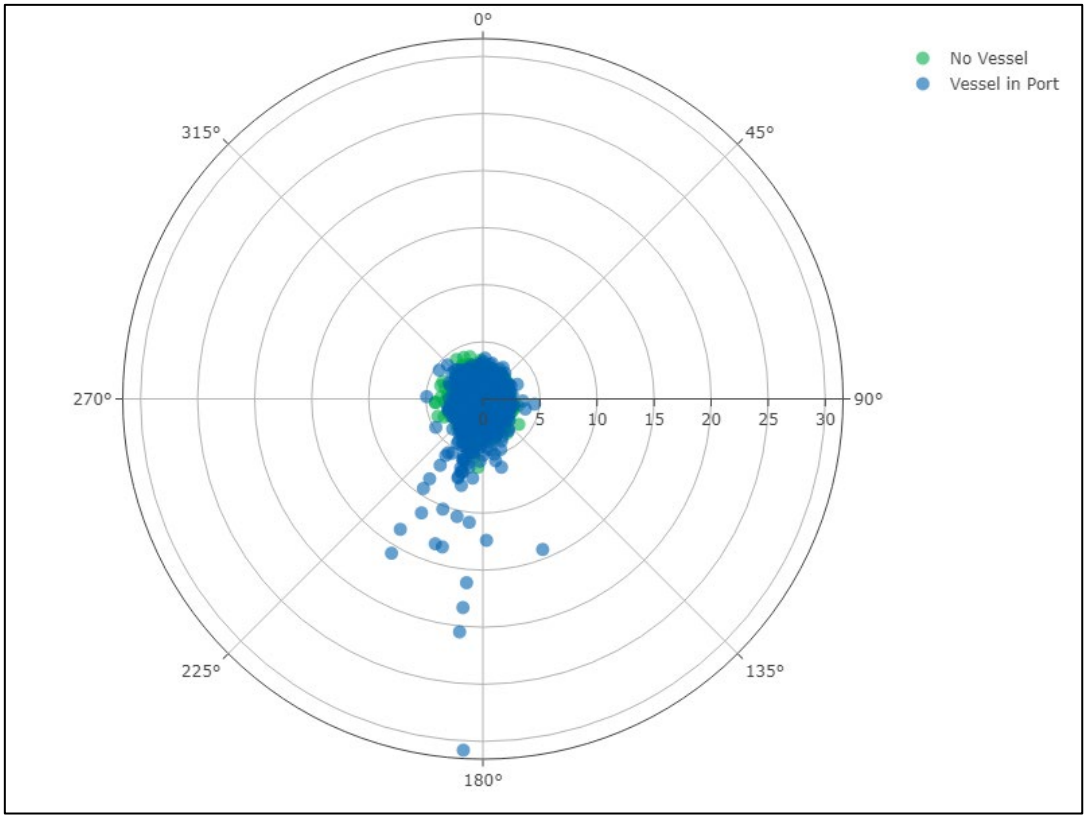


Figure 5.25 Hourly average SO_2 concentration (ppb) by wind direction at Station Pier

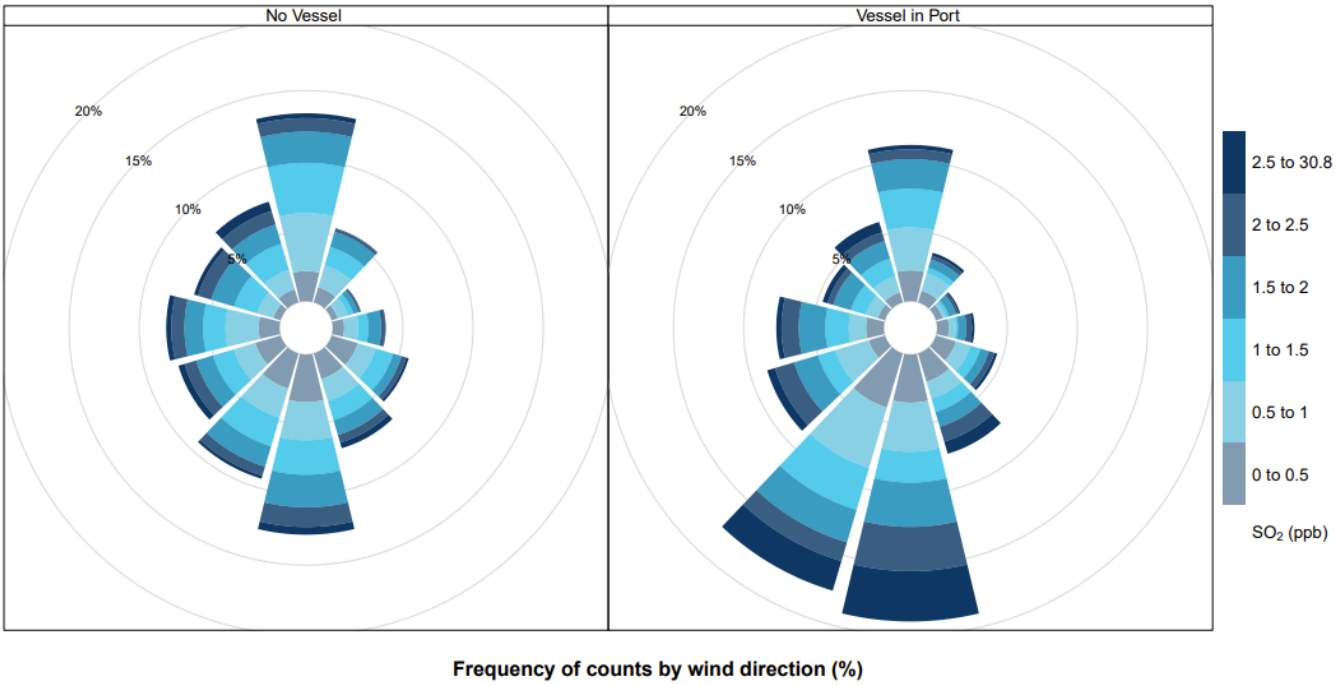


Figure 5.26 Hourly average SO_2 concentration (ppb) pollution roses

5.5.3.3 Exceedances of the criteria

No exceedances of the adopted 1-hour or 24-hour SO_2 criteria were observed at the Station Pier AQMS during the monitoring period.

5.6 Summary of AQMS data

A summary of the AQMS data is provided in Table 5.8.

Table 5.8 Summary of AQMS data

Pollutant	Annual average	Exceedances	Correlation with EPA Stations	Correlation with port activity
PM_{10}	– When a vessel was present: 23.5 µg/m^3 – When no vessels were present: 21.5 µg/m^3 – 2024 average: 22.1 µg/m^3	Exceedances of the 24-hour criterion were observed on two days, both likely due to regional emissions sources rather than a localised source. Annual average concentration was above the criterion by 11%. The average concentrations both while a vessel was in port and when no vessel was in port were both above the criterion, indicating that port activity was likely not the key driver of PM_{10} concentrations in the area.	Positive correlation (>0.75) with all EPA Stations	Minimal correlation (0.08) with vessel presence
$PM_{2.5}$	– When a vessel was present: 6.8 µg/m^3 – When no vessels were present: 6.1 µg/m^3 – 2024 average: 6.3 µg/m^3	Exceedances of the 24-hour criterion were observed on two days, both likely due to regional emissions sources rather than a localised source.	Positive correlation (>0.75) with all EPA Stations	Minimal correlation (0.05) with vessel presence
NO_2	– When a vessel was present: 9.0 ppb	No exceedances of the adopted 1-hour or annual NO_2 criteria were observed	Positive correlation (0.83)	Minimal correlation (-0.03)

Pollutant	Annual average	Exceedances	Correlation with EPA Stations	Correlation with port activity
	– When no vessels were present: 9.4 ppb – 2024 average: 9.5 ppb		with the Altona North EPA Station	with vessel presence
SO_2	– When a vessel was present: 1.4 ppb – When no vessels were present: 1.2 ppb	No exceedances of the adopted 1-hour or annual SO_2 criteria were observed	Minimal correlation with the Altona North EPA Station	Minimal correlation (0.11) with vessel presence

Normalised concentration per pollutant is presented in Figure 5.27 by vessel presence to help visualise the relationship between port activity and the monitored pollutants concentrations in the area. Normalised concentration refers to the concentration series divided by the maximum concentration (for that pollutant) to reduce the concentration range to between 0 and 1.

The mean and interquartile range between vessel and no vessel are very similar across the pollutants. Outliers are slightly increased for $PM_{2.5}$, NO_2 and SO_2 when a vessel is in port, however these are not frequent enough to increase the correlation between concentration and vessel presence.

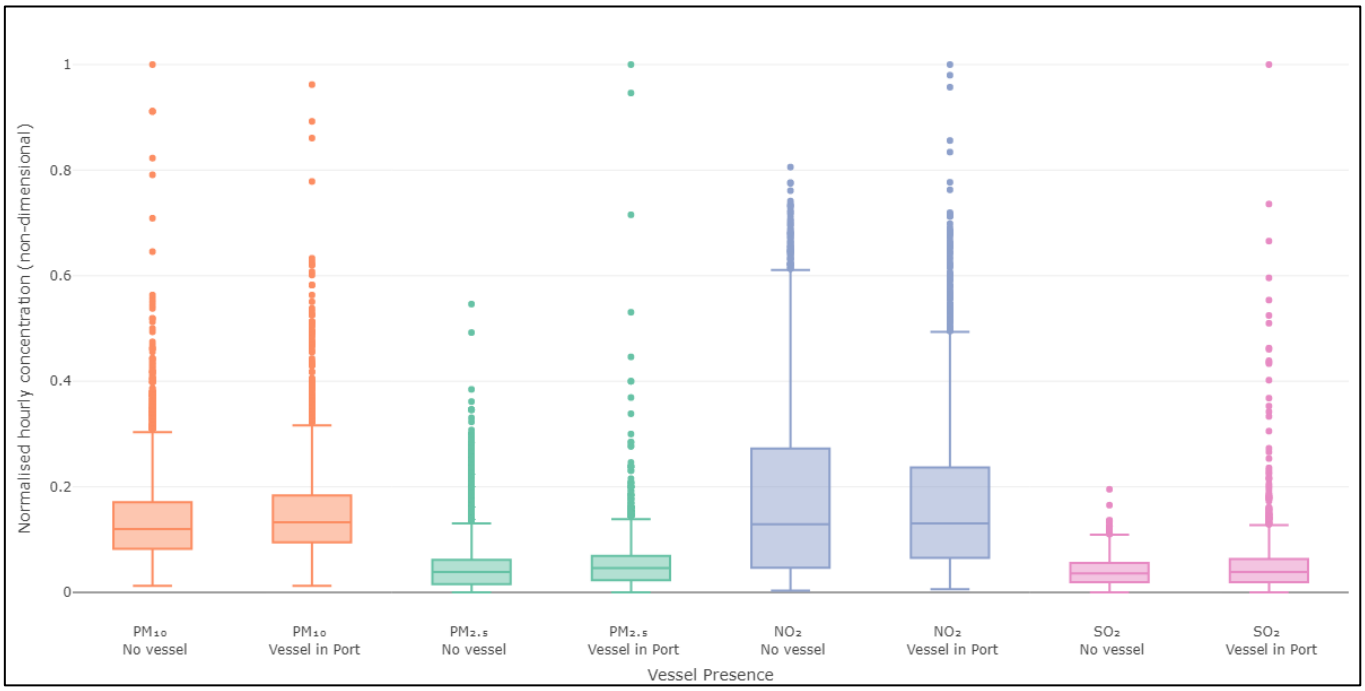


Figure 5.27 Normalised concentration by vessel presence

6. Kunak monitoring overview

A trial using two portable real-time Kunak sensors was carried out between 1 May 2024 and 31 December 2024 with the aim to understand the air quality in the community north of Station Pier. These sensors have been used, in addition to the reference grade instruments (the AQMS), to provide an indicative understanding of the differences in exposure at the monitoring station location versus other locations through the community. One sensor was co-located with the AQMS, and an additional sensor was located to the northwest, as shown in Figure 1.1.

The parameters measured by the Kunak sensor are PM_{10}, $PM_{2.5}$, NO_2, and SO_2 concentrations. The Kunak sensors use an optical particle counter for measurement of $PM_{2.5}$ and PM_{10}, and an electrochemical sensor for measurement of NO_2 and SO_2. It is important to note that these measurement methods are not compliant with Australian Standards and therefore results cannot definitively be compared against the criteria, but rather have been used to provide an indicative understanding of the air quality in the community in comparison to that at Station Pier. Additionally, the Kunak sensors are not able to provide accurate readings for very low concentrations of SO_2 (under 20 ppb). However, they can reflect rapid SO_2 concentration changes in the air.

Review and analysis of observations from these sensors is not presented in this report. Kunak observations and comparison against the AQMS observation are presented in the *Air Quality Monitoring Report – Kunak Monitoring Trial* (GHD, 2025).

– Kunak 1 was installed on 10 April 2024 at the AQMS.
– Kunak 2 was installed on 30 April 2024 at a residential property within the Beacon Cove community.

Photographs of the Kunak sensors are provided in Figure 6.1. The locations of Kunak 1 and Kunak 2 are shown in Figure 1.1.

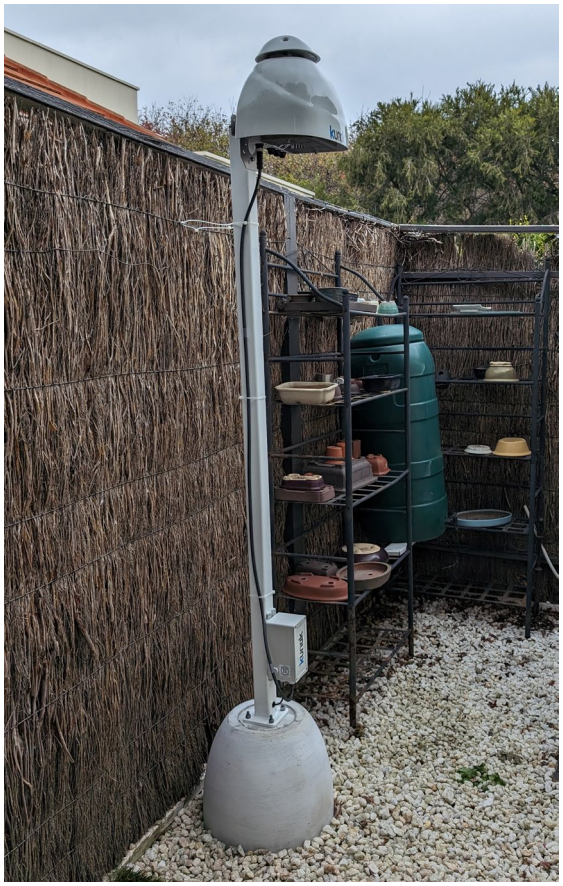
Kunak 1	Kunak 2
	

Figure 6.1 Photographs of the Kunak sensors

The Kunak sensors collected observations of PM_{10}, $PM_{2.5}$, NO_2 and SO_2 over the period between 1 May 2024 to 31 December 2024. During this period, concentrations of all pollutants were generally below the adopted criterion. A small number of exceedances of the PM_{10}, $PM_{2.5}$, and SO_2 criteria were observed. NO_2 concentrations were below the adopted criterion throughout the monitoring period.

PM_{10}, $PM_{2.5}$ and NO_2 concentrations were generally consistent with that observed at Station Pier and the trial was considered to have successfully provided an indication of the concentration of these pollutants in ambient air in the community.

SO_2 concentrations however were variable with a number of high concentrations observed which are not considered accurate or reliable. Throughout the monitoring period, the Kunak sensors recorded increased SO_2 concentrations in comparison with the Station Pier AQMS. This is considered to be due to Kunak sensor only being able to provide estimates of SO_2 in air. The Kunak sensor is able to reflect rapid SO_2 concentration changes in the air, indicating a SO_2 source nearby, but for accurate SO_2 reading in ambient air one has to refer to the AQMS. The SO_2 observations at the Kunaks were discussed with both the EPA and the Kunak manufacturer and it was determined that the results could not be relied upon.

Other portable, low cost equipment for SO_2 monitoring is currently unavailable. Therefore, only the results from the AQMS should be relied upon for SO_2 results.

7. Previous Station Pier Air Quality Monitoring Program

7.1 Background of 2016-2017 study

A previous air quality monitoring program was undertaken in the period 2016-17, which found that:

- Peak SO_2 concentrations at the site corresponded with the presence of ships and were generally higher than concentrations recorded at the local EPA stations.
- Sulphur dioxide concentrations were lower than the SEPP AQM intervention levels or the NAAQ NEPM goal during the monitoring period. It is noted that the Victorian ERS and the AAQ NEPM have since been updated, and measurements from 2016-2017 would be above these levels.
- Peak sulphur dioxide concentrations occurred during Spirit of Tasmania movements near berth.
- Community concerns were noted that the siting/location of the station at ground level, close to vessels, was not representative of the exposure at elevated residences in the Beacon Cove community.

Since the study undertaken in 2017, two significant events have occurred which have the potential to reduce sulphur dioxide emissions, and vessel emissions more broadly. These include the introduction of low-sulphur marine fuels in 2020 and the relocation of the TT line from Station Pier to Geelong in 2020.

The 2023-24 air quality monitoring program provides an indication of the changes to ambient air quality following these events.

7.2 Comparison with 2023-24 data

The 2016-17 study measured $PM_{2.5}$, PM_{10}, and SO_2 from January 2016 through to February 2018. NO_2 measurements commenced in April 2017 and continued for the duration of the monitoring period.

The number of vessels visiting Station Pier during the cruise seasons has been considered. The cruise season in Victoria runs from October through to May. Number of cruise visits to Station Pier are shown in Figure 7.1.

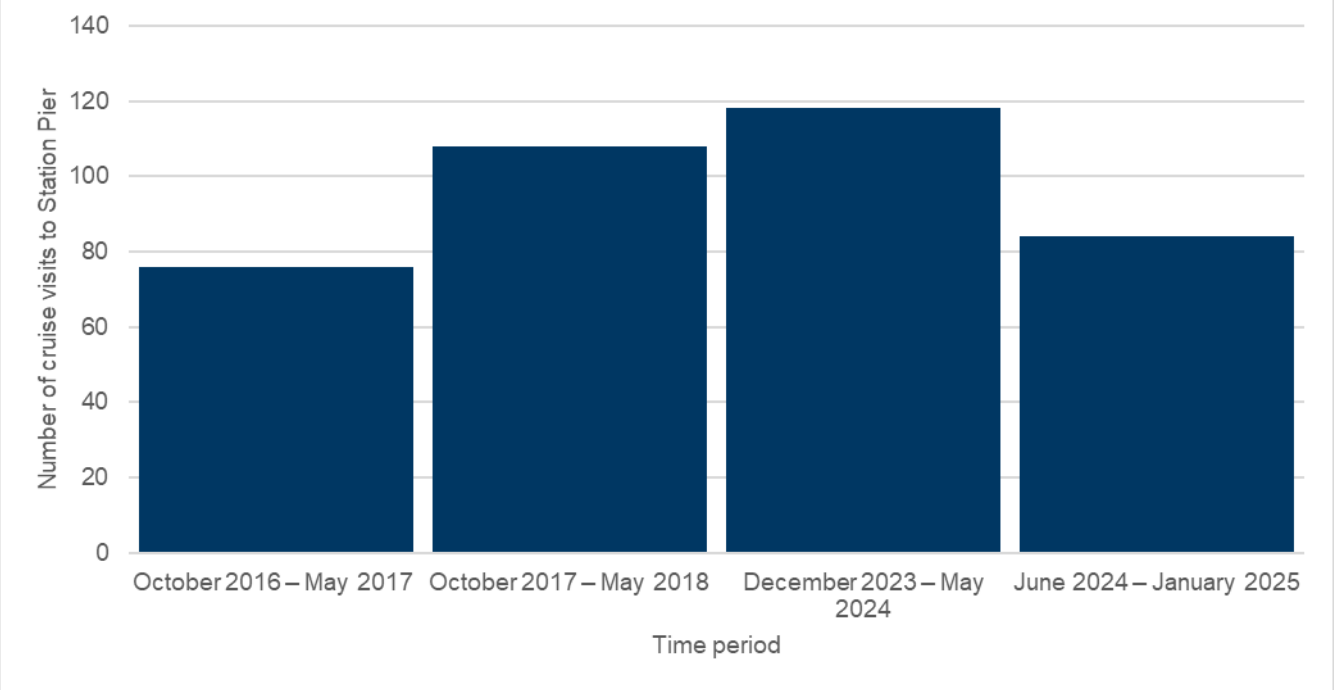


Figure 7.1 Number of cruise visits to Station Pier

Although the 2023-24 monitoring period does not cover a single entire cruise season to compare against the previous monitoring, the number of cruise visits to Station Pier are considered comparable to the previous cruise seasons.

Monthly average measurements from the 2016-17 study are presented in Figure 7.2 alongside the monthly average measurements from the monitoring period presented in this report (2023-24). This comparison indicates the following:

– PM_{10} and NO_2 monthly average concentrations are similar between the monitoring periods
– $PM_{2.5}$ concentrations are slightly reduced during 2023-24 for all months except February
– SO_2 concentrations are reduced during the 2023-24 for all months, with more significant decrease during the cruise season (November to March)

The reduction in ambient SO_2 over the summer months indicates that the port is no longer a key driver of SO_2 concentrations, likely due to the introduction of low-sulphur marine fuels in 2020 and the relocation of the TT line from Station Pier to Geelong.

An annual average comparison is presented in Figure 7.3. The minimum annual average concentration was observed in 2024 for all pollutants except for PM_{10}. Annual average PM_{10} in 2024 was slightly above the 2016 concentration, and below the 2017 concentration.

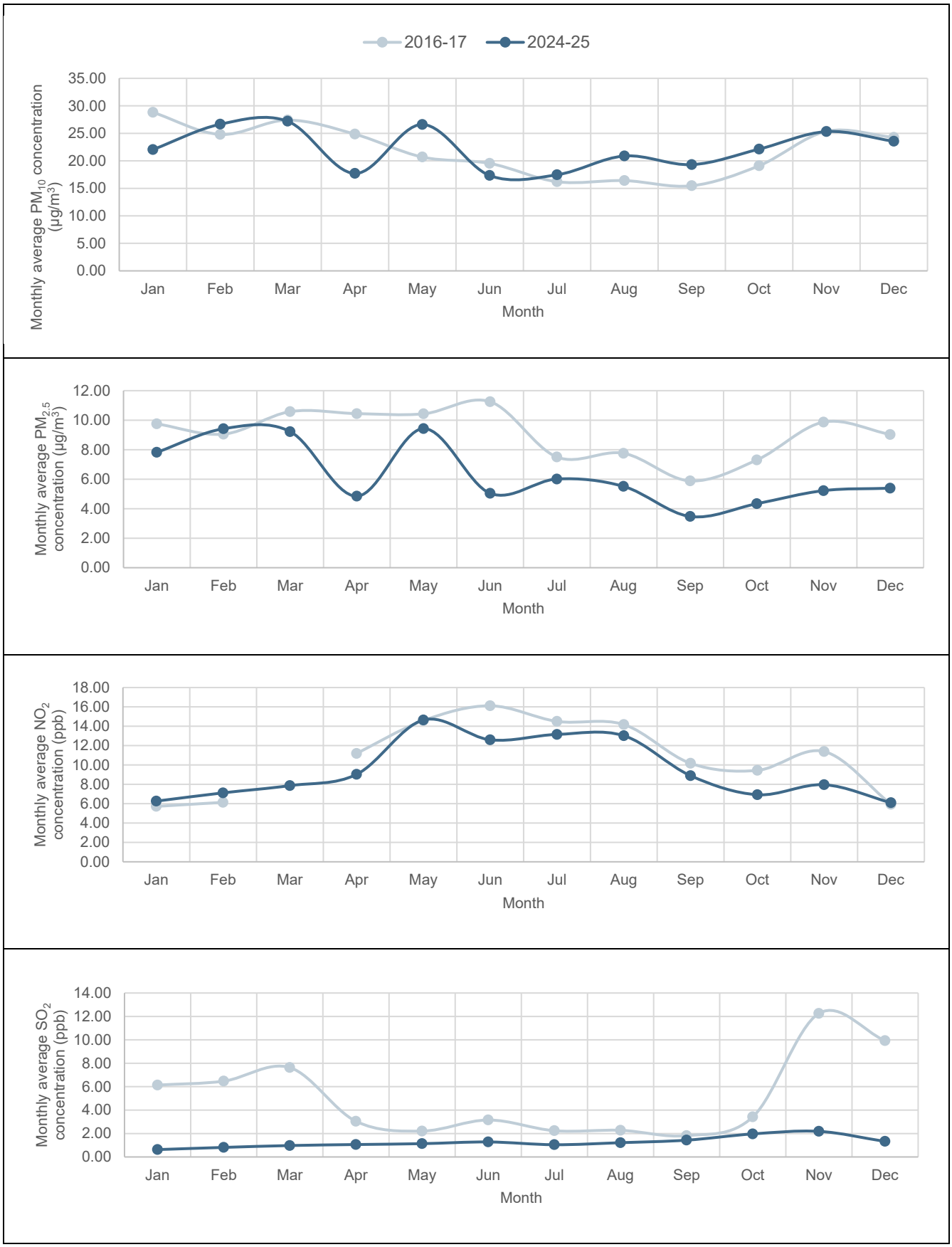


Figure 7.2 Monthly average concentration comparison

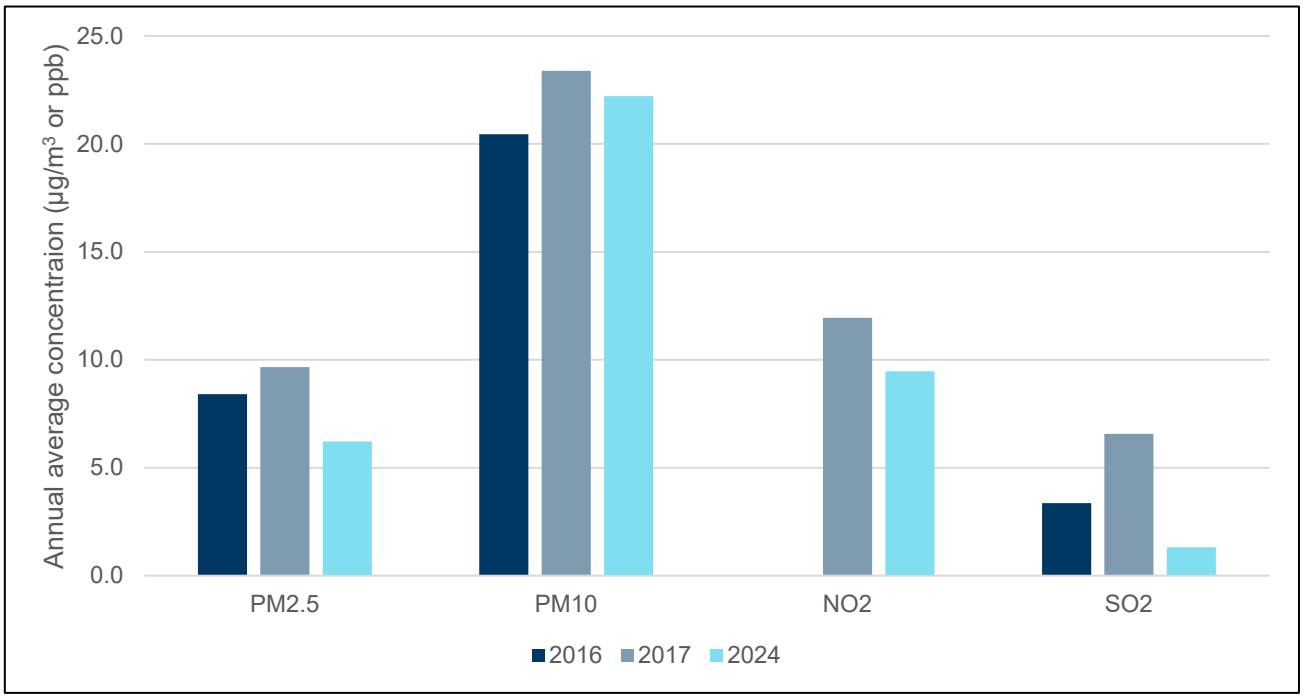


Figure 7.3 ***Annual average concentration comparison***

8. Conclusion

Ports Victoria have implemented an air quality monitoring program at Station Pier, Port Melbourne, Victoria for a period of 12 months from December 2023 to December 2024. Station Pier is the premier cruise ship terminal in Melbourne, with around 100 cruise ship visits every cruise season. The primary objective of this air quality monitoring program was to provide Ports Victoria, EPA Victoria and the local community with a greater understanding of local air quality from Station Pier operations.

This air quality monitoring monthly report presents the analysis of data collected between 1 December 2023 to 31 December 2024. The monitoring data observed at Station Pier AQMS during this monitoring period have been presented and, where relevant, compared against observations from the local EPA Stations and the adopted Air Pollution Assessment Criteria (APACs) from the EPA Publication 1961.

The parameters measured as part of the air quality monitoring program include wind speed, wind direction, temperature, relative humidity, sigma, PM_{10}, $PM_{2.5}$, NO_2, and SO_2 concentrations. Data collected by the AQMS has undergone a NATA accreditation procedure undertaken by ACOEM to ensure all analysed data is valid. AQMS observations were processed into averaging periods defined by the relevant APACs. The processed data is also overlayed with vessel presence at the port.

Two portable real-time Kunak sensors were installed in April 2024 with the aim to understand the air quality in the community north of Station Pier. These sensors have been used, in addition to the reference grade instruments (the AQMS), to provide an indicative understanding of the differences in exposure at the monitoring station location versus other locations through the community. Discussion on the outcome of this trial is presented in Section 6.

In general, analysis of the AQMS data indicated that the observed concentrations at the AQMS had high correlation with the nearby EPA Stations (for all pollutants except for SO_2), and low correlation with port activity. Occasional exceedances of the PM_{10} and $PM_{2.5}$ 24-hour average criteria were observed, which were both identified to be likely due to regional emissions rather than a localised source. The annual average PM_{10} concentration was above the criterion by 11%. The average PM_{10} concentrations both while a vessel was in port and when no vessel was in port were both above the criterion, indicating the port activity was likely not the key driver of PM_{10} concentrations in the area. No exceedances of the NO_2 or SO_2 criteria were observed.

A previous air quality monitoring program was undertaken at Station Pier in 2016-17. Since the study undertaken in 2017, two significant events have occurred which have the potential to reduce sulphur dioxide emissions, and vessel emissions more broadly. These include the introduction of low-sulphur marine fuels in 2020 and the relocation of the TT line from Station Pier to Geelong in 2020. Comparison of the data collected over 2023-24 indicated that PM_{10} and NO_2 results were very similar between the monitoring periods. $PM_{2.5}$ concentrations were slightly reduced during the 2023-24 period. SO_2 concentrations were reduced during the 2023-24 for all months, with more significant decrease during the cruise season (November to March), which indicates that the port is no longer a key driver of SO_2 concentrations.

The air quality monitoring program undertaken at Station Pier generally indicates that ambient air quality has improved since the 2016-17 study. Where exceedances of the criteria were observed, port activity was likely not the key driver.

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