

Northern Territory Ambient Air Quality Monitoring Report 2024

Compliance with the National Environment Protection
(Ambient Air Quality) Measure

Document title	Northern Territory Ambient Air Quality Monitoring Report 2024
Contact details	Department of Lands, Planning and Environment
Approved by	Executive Director Environmental Regulation
Date approved	9 April 2026
TRM number	33-D26-3610

Version	Date	Author	Changes made
1.0	December 2025	Environmental Regulation	First version

Acronyms	Full form
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
ABS	Australian Bureau of Statistics
AQMS	Air Quality Monitoring Station
ASGS	Australian Statistical Geography Standard
BoM	Bureau of Meteorology
CBD	Central Business District
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEPWS	Department of Environment, Parks and Water Security
DLPE	Department of Lands, Planning and Environment
EWG	Expert Working Group (NEPC)
FDMS	Filter Dynamics Measurement System (used by the TEOM)
GRUB	Generally representative upper bound (AQMS)
KTC	Katherine Town Council
NAFI	North Australian Fire Information
NASA	National Aeronautics and Space Administration (USA)
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NO/ NO ₂ / NO _x	Nitric oxide/ Nitrogen dioxide/ Oxides of nitrogen
NT EPA	Northern Territory Environment Protection Authority
O ₃	Ozone
PM ₁₀	Particulate matter (PM) with aerodynamic diameter less than or equal to 10 µm
PM _{2.5}	Particulate matter with aerodynamic diameter less than or equal to 2.5 µm
ppm	Parts per million by volume
PRC	Peer Review Committee (NEPC)
SA2	Statistical Area Level 2
SO ₂	Sulfur dioxide
TEOM	Tapered element oscillating microbalance
µg/m ³	Micrograms per cubic metre referenced to a temperature of 0 degrees Celsius and an absolute pressure of 101.325 kilopascals
µm	Micrometres (10 ⁻⁶ metres)
WMPC Act	Waste Management and Pollution Control Act 1998

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1 Summary

The *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) is the Commonwealth framework that sets national standards for ambient air quality. The national environment protection goals of the AAQ NEPM are to achieve the national environment protection standards specified in the NEPM.

In the Northern Territory, the AAQ NEPM is given effect through the *Waste Management and Pollution Control Act 1998* (WMPC Act 1998). This annual compliance report, required under clause 18 of the AAQ NEPM, presents the Territory's ambient air quality monitoring data for the 2024 calendar year and assesses compliance with the relevant standards and goals. Compliance requires that air quality standards, as outlined in Schedule 2 of the AAQ NEPM, are not exceeded.

In 2024, the Department of Lands, Planning and Environment (DPLE) operated three designated ambient air quality monitoring stations (AQMS) in the Darwin region: Palmerston, Winnellie and Stokes Hill. These stations measure and report real-time concentrations of six AAQ NEPM pollutants—sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), ozone (O₃), and particulate matter (PM₁₀ and PM_{2.5}). The Katherine Town Council also operates an AQMS under a performance agreement with the Northern Territory Environment Protection Authority (NT EPA); this station monitors PM₁₀ and PM_{2.5} only. Each site is equipped with meteorological instruments measuring wind speed and direction, temperature, relative humidity and atmospheric pressure.

Measured pollutant concentrations were assessed against the corresponding national standards and goals, and compliance was determined in accordance with the AAQ NEPM protocol.

Assessment of Goal Compliance

Overall compliance: In 2024, none of the Darwin-region stations recorded exceedances of the national standards for NO₂, SO₂, O₃ or CO. Data capture was sufficient to demonstrate compliance with the AAQ NEPM goals for these pollutants. Several short-term exceedances of PM₁₀ and PM_{2.5} standards occurred; however, all were attributed to exceptional events such as bushfire smoke, as defined in the AAQ NEPM. All stations exceeded the 1-year average PM_{2.5} standard, while none exceeded the 1-year average PM₁₀ standard.

Carbon monoxide (CO): No exceedances of the standard were recorded at any of the 3 Darwin stations, demonstrating compliance with the 8-hour rolling average standard of 9.0 ppm.

Nitrogen dioxide (NO₂): As no exceedances of the 1-hour average standard (0.08 ppm) or the 1-year average standard (0.015 ppm) were observed, the 3 stations complied with both standards.

Ozone (O₃): No stations recorded exceedances of the 8-hour rolling average standard (0.065 ppm); all stations complied with the AAQ NEPM standard for ozone.

Sulfur dioxide (SO₂): As no exceedances of the 1-hour average standard (0.10 ppm) or the 1-year average standard (0.02 ppm) were observed, all 3 stations complied with both standards.

PM₁₀: The AAQ NEPM 1-day standard for PM₁₀ (50 µg/m³) allows no exceedances unless classified as exceptional events. Winnellie recorded no exceedances; Katherine recorded 2; Palmerston 4; and Stokes Hill 10. All were linked to exceptional events such as bushfire smoke. Annual average PM₁₀ concentrations—16.2 µg/m³ (Katherine), 15.3 µg/m³ (Palmerston), 18.5 µg/m³ (Stokes Hill) and 16.1 µg/m³ (Winnellie)—were below the AAQ NEPM 1-year standard of 25 µg/m³. All stations therefore complied with the PM₁₀ standards.

PM_{2.5}: The AAQ NEPM 1-day standard for PM_{2.5} (25 µg/m³) also allows no exceedances unless classified as exceptional events. In 2024, exceedances occurred at all stations—15 at Katherine, 10 at Palmerston, 18 at Stokes Hill and 12 at Winnellie—each associated with exceptional events such as bushfire smoke. However, annual average PM_{2.5} concentrations—9.9 µg/m³ (Katherine), 8.4 µg/m³ (Palmerston), 10.3 µg/m³ (Stokes Hill) and 9.4 µg/m³ (Winnellie)—all exceeded the AAQ NEPM 1-year standard of 8 µg/m³. As a result, none of the stations complied with the PM_{2.5} annual standard.

Population Exposure Reporting

The AAQ NEPM requires jurisdictions to evaluate and report population exposure to PM_{2.5}, NO₂ and O₃. Using a simplified approach, the following population-weighted annual average concentrations were estimated for the Greater Darwin Region in 2024:

- PM_{2.5}: 9.1 µg/m³
- NO₂: 0.0020 ppm
- O₃: 0.013 ppm

2 Background

The Department of Lands, Planning and Environment (DLPE)¹ which provides services to the Northern Territory Environment Protection Authority (NT EPA), is responsible for implementing the *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) in the Northern Territory. The AAQ NEPM is implemented through the provisions of the *Waste Management and Pollution Control Act 1998* (WMPC Act 1998) and the *National Environment Protection Council (Northern Territory) Act 1994* (NEPC (NT) Act 1994).

Procedures for measuring and reporting pollutant concentrations are set out in the national environment protection protocol (Part 4 of the AAQ NEPM). Clause 18 of the AAQ NEPM requires jurisdictions to submit a report on their compliance with the AAQ NEPM for each calendar year. Clause 17 prescribes the content of the jurisdictional report.

Consistent with the reporting period defined in the AAQ NEPM, this report covers the calendar year ending on 31 December 2024 for data collected from the Northern Territory Government ambient air quality monitoring stations (AQMS): Palmerston AQMS, Winnellie AQMS and Stokes Hill AQMS²; and from the Katherine Town Council AQMS. The format and data requirements for the Annual Report are detailed in Technical Papers No. 8—Annual Reports (PRC 2002) and No. 5—Data Collection and Handling (PRC 2001). This report is a technical report to the National Environment Protection Council (NEPC) and supplements the annual summary report provided by each jurisdiction to NEPC on the overall implementation of the AAQ NEPM.

This technical report, *Northern Territory Ambient Air Quality Monitoring Report 2024 - Compliance with the National Environment Protection (Ambient Air Quality) Measure*, is available on the NT EPA website at [Ambient Air Quality reports | NTEPA](#).

¹ Formerly Department of Environment, Parks and Water Security (DEPWS)

² This station was relocated to Frances Bay in 2021, but will still be referred to as Stokes Hill AQMS

3 Overview of the AAQ NEPM monitoring network and activities

3.1 Monitoring requirements

The monitoring requirements for the Northern Territory over the longer term were determined from the results of air quality monitoring conducted in 2000-2001 and included in a NEPC-approved monitoring plan (NTG, 2001). This monitoring identified fine particles from landscape fires as the primary air pollutant of concern in the Darwin region. Analysis of the 2000-2001 data against the AAQ NEPM standards indicated that nitrogen oxides, sulfur dioxide, carbon monoxide, ozone and lead aerosols were not a cause for concern in the Darwin/Palmerston region or regional population centres (Gras et al., 2001). Since the initial monitoring, the population and industrial activities in Darwin have increased and more detailed monitoring of airborne pollutants was required.

Particulate monitoring commenced at multiple sites in the Darwin/Palmerston region in 2002. The establishment and operation of a comprehensive air quality monitoring system for the Darwin region commenced in 2010 and was completed in July 2012, allowing for monitoring of all pollutants identified in the AAQ NEPM with the exception of lead. Monitoring for lead was not necessary as there are no significant sources close to populated areas in the region and the sale of leaded petrol ceased in 2002.

Two population centres in the Northern Territory—Greater Darwin and Alice Springs—exceed or are approaching the AAQ NEPM population threshold of 25,000 for establishing at least one performance air quality monitoring station (AQMS). A performance AQMS is defined in the AAQ NEPM as a station used to assess achievement against the National Environment Protection goals in the NEPM.

The current network of ambient air quality monitoring stations comprises of three performance stations in the Greater Darwin Region, and one located at Katherine. Palmerston AQMS, located near Palmerston, and Winnellie AQMS, located at the Bureau of Meteorology (BoM) site, are long-term trend monitoring stations.³ Palmerston AQMS has been operational since the beginning of 2011, and Winnellie AQMS has been operational since the second half of 2012. Stokes Hill AQMS started operating in May 2017; and Katherine AQMS (which measures only air particles) was commissioned in September 2020.

³ Nominated performance monitoring stations are operated in the same location for one or more decades to monitor and assess long term changes in ambient air quality.

3.2 Determination of exposed population for performance monitoring stations

In the Darwin and Palmerston region, particulate matter from bushfire smoke is the primary pollutant of concern during the Dry Season (May–October). Prevailing southeasterly to easterly winds regularly transport smoke from both local bushfires and large-scale savannah fires, resulting in seasonal population exposure to elevated particle concentrations. As shown in Figure 1a, the Darwin stations have been located to also monitor emissions from industrial activities.

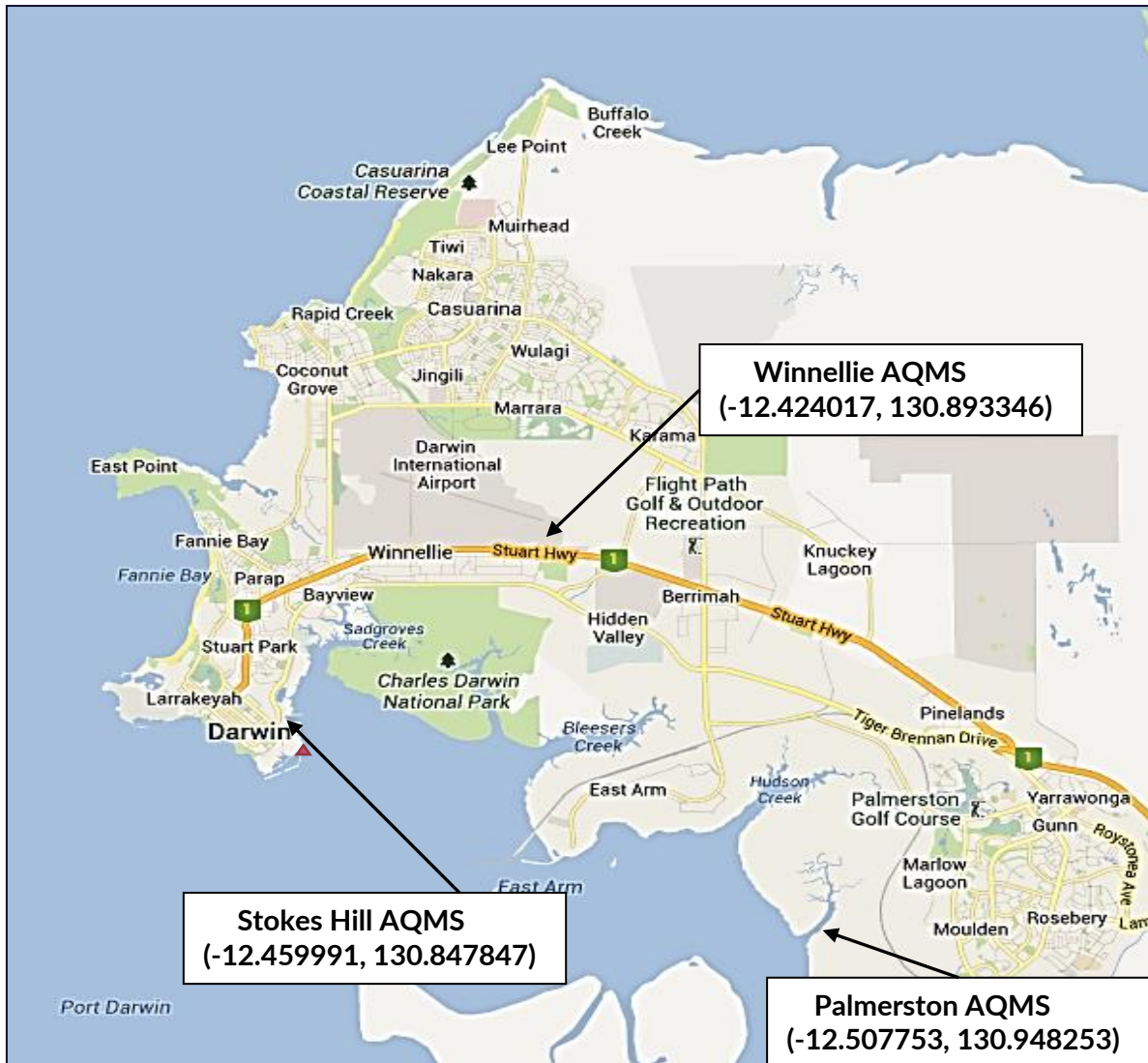


Figure 1a: Locations of Palmerston, Winnellie and Stokes Hill Air Quality Monitoring Stations (AQMS) in the Greater Darwin Region (Stokes Hill AQMS was previously located at -12.466983, 130.850584▲)

Winnellie air quality monitoring station (AQMS) meets requirements as a generally representative upper bound (GRUB) station. It is located between Darwin’s northern suburbs and Darwin CBD, the two most densely populated areas in the Northern Territory (Figure 1a).

Palmerston AQMS is located in light bushland approximately 4 km south-west of Palmerston (Figure 1a). This station has been located to provide information on airborne pollutants which may be moving from industrial sites in the middle harbour to populations in the Palmerston area.

Stokes Hill AQMS (Figure 1a) was initially located about 1 km southeast of the CBD on the Darwin Waterfront, off Stokes Hill Road, in 2017; it was relocated to a site about 600 m east of the CBD (~800 m north of original site) and off Frances Bay Drive in May 2021, as the original site was required for redevelopment. This station, located in a coastal area, monitors potential air quality impacts from industrial development and increased shipping traffic in Darwin Harbour.

In September 2020, Katherine Town Council (KTC) commissioned the Katherine AQMS (Figure 1b) to monitor particles in air, as part of a performance agreement with the NT EPA.

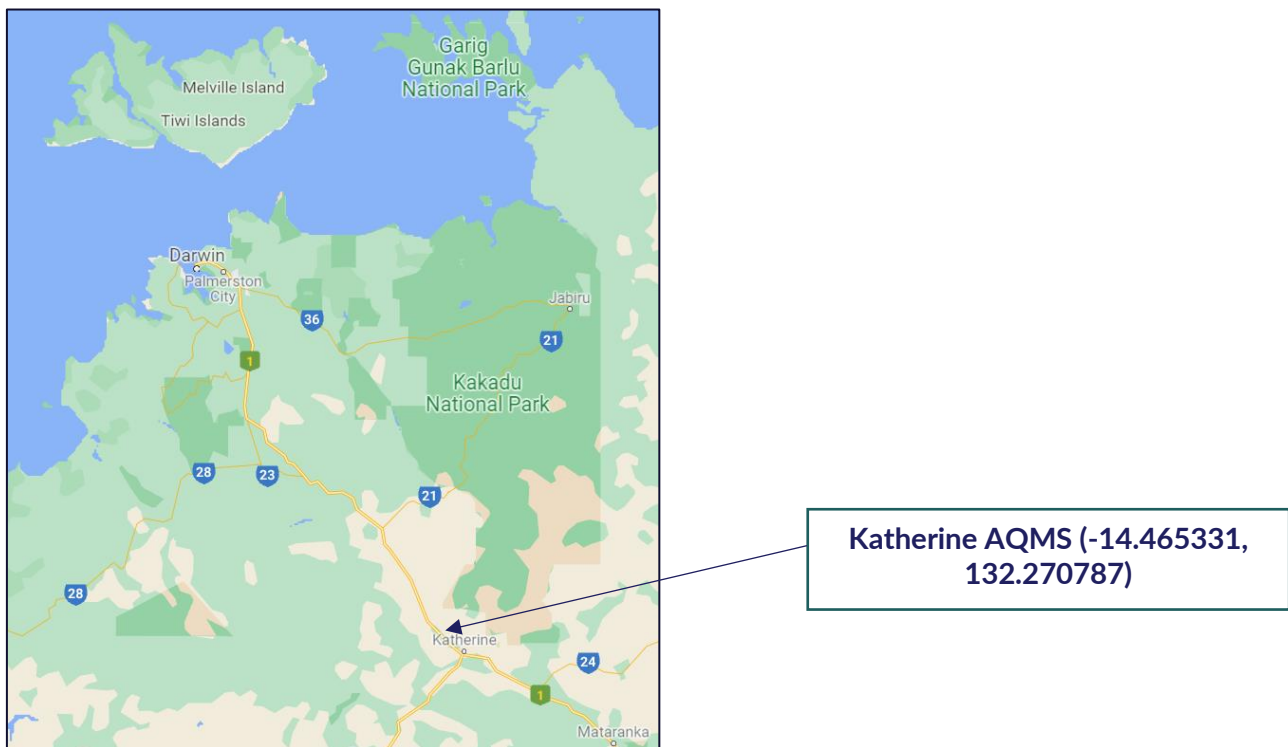


Figure 1b. Katherine AQMS - operated by Katherine Town Council

Table 1 shows that all AQMS have been located to comply with the siting requirements of AS/NZS 3580.1.1:2016 *Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment*.

Table 1: Summary of station siting in compliance with AS/NZS 3580

Station	Location Category	Height above ground	Clear Sky Angle	Unrestricted airflow of 360°	20m from trees	No boilers/incinerators nearby	Minimum distance from road or traffic
Winnellie AQMS	Bushland	Yes	Yes	Yes	Yes	Yes	Yes
Palmerston AQMS	Bushland	Yes	Yes	Yes	Yes	Yes	Yes
Stokes Hill AQMS	Coastal	Yes	Yes	Yes	Yes	Yes	Yes
Katherine AQMS	Bushland	Yes	Yes	Yes	Yes	Yes	Yes

3.3 Current pollutants monitoring for the purposes of this report

Winnellie AQMS consists of an air-conditioned instrument shed, which houses all instrumentation. Ambient air is continuously analysed for ozone (O₃), sulfur dioxide (SO₂), carbon monoxide (CO) and oxides of nitrogen (NO_x) concentrations by various instruments connected to a single gas-sampling manifold protruding through the station roof. NO_x represents the sum of nitrogen dioxide (NO₂) and nitric oxide (NO) concentrations (the instrument provides the concentrations of all three compounds—NO₂, NO and NO_x).

A separate mast protruding through the station roof serves as a conduit for drawing air into the particles sampler. This mast is fitted with appropriate size selection inlets which separate particles into specific particle size ranges (i.e., PM₁₀ which are particles with aerodynamic diameters of 10 µm or less and PM_{2.5} which are particles with aerodynamic diameters of 2.5 µm or less). A dichotomous tapered element oscillating microbalance (TEOM) instrument analyses air flowing through the mast to provide near real-time PM₁₀ and PM_{2.5} concentrations. BoM instruments located at the site provide meteorological data for the station via an optic fibre link from the BoM server.

Palmerston AQMS and Stokes Hill AQMS house the same gas and particle sampling instruments as Winnellie AQMS but have instruments for collecting meteorological data.

Katherine AQMS only measures the concentrations of PM₁₀ and PM_{2.5} and various meteorological parameters.

EnviroNics Multi-Gas Calibrator/Diluter units and EnviroNics Zero Air Generators are installed at the Darwin stations to support automatic daily zero/span checks, as well as manual and remote calibrations of NO_x, SO₂, O₃ and CO analysers.

All stations currently operate Tapered Element Oscillating Microbalance (TEOM) model 1405DF instruments equipped with Filter Dynamics Measurement Systems (FDMS) for PM₁₀ and PM_{2.5} measurement. The FDMS accounts for evaporative losses, removing the need for correction factors to compensate for volatile loss from the filter.

Stations are equipped with instruments for measuring ambient temperature, relative humidity, wind speed and direction, and atmospheric pressure. Palmerston AQMS additionally measures solar radiation and rainfall. The anemometer at Palmerston AQMS is mounted on a 10 m mast, but at Stokes Hill AQMS the anemometer is mounted on a 5 m mast, with the mast base positioned 5 m above ground level.

Table 2 provides the operational status of instruments at each station and the parameters measured.

Table 2: Air quality and meteorological instruments at ambient air quality monitoring stations

Parameter	Data available from	Data available to	Current Instrument	Sampling frequency
PM ₁₀	01/01/11 (Palmerston) 18/07/12 (Winnellie) 03/07/17 (Stokes Hill) 02/09/20 (Katherine)	present	TEOM 1405DF ¹ TEOM 1405DF ² TEOM 1405DF ³ TEOM 1405DF	continuous
PM _{2.5}	01/01/11 (Palmerston) 18/07/12 (Winnellie) 03/07/17 (Stokes Hill) 02/09/20 (Katherine)	present	TEOM 1405DF ¹ TEOM 1405DF ² TEOM 1405DF ³ TEOM 1405DF	continuous
SO ₂	01/01/11 (Palmerston) 18/07/12 (Winnellie) 05/05/17 (Stokes Hill)	present	Thermo Model 43i	continuous
NO _x , NO, NO ₂	01/01/11 (Palmerston) 18/07/12 (Winnellie) 05/05/17 (Stokes Hill)	present	Thermo Model 42i	continuous
O ₃	01/01/11 (Palmerston) 18/07/12 (Winnellie) 05/05/17 (Stokes Hill)	present	Thermo Model 49i	continuous
CO	01/01/11 (Palmerston) 18/07/12 (Winnellie) 05/05/17 (Stokes Hill)	present	Thermo Model 48i	continuous
Wind direction	01/01/12 (Palmerston) 05/05/17 (Stokes Hill) 02/09/20 (Katherine)	present	RM Young, 2D ultra-sonic anemometer model 85000	continuous
Wind speed	01/01/12 (Palmerston) 04/05/17 (Stokes Hill) 02/09/20 (Katherine)	present	RM Young, 2D ultra-sonic anemometer model 85000	continuous

Parameter	Data available from	Data available to	Current Instrument	Sampling frequency
Sigma Theta	05/05/17 (Stokes Hill) 02/09/20 (Katherine)	present	RM Young, 2D ultrasonic anemometer model 85000	continuous
Temperature	01/01/12 (Palmerston) 05/05/17 (Stokes Hill) 02/09/20 (Katherine)	present	RM Young, model 41382LC TEOM sensor TEOM sensor	continuous
Relative Humidity	01/01/12 (Palmerston) 05/05/17 (Stokes Hill) 02/09/20 (Katherine)	present	RM Young, model 41382LC TEOM sensor TEOM sensor	continuous
Atmospheric Pressure	01/01/12 (Palmerston) 05/05/17 (Stokes Hill) 02/09/20 (Katherine)	present	RM Young, model 61302v TEOM sensor TEOM sensor	continuous
Solar Radiation	01/01/12 (Palmerston)	present	Middleton Solar Pyranometer, model EQ08	continuous
Rainfall	01/01/12 (Palmerston)	present	RM Young, Tipping Bucket Rain Gauge	continuous

¹TEOM at Palmerston AQMS was upgraded from 1405D to 1405DF on 18/02/2021.

²TEOM at Winnellie AQMS was upgraded from 1405D to 1405DF on 21/01/2021.

³TEOM at Stokes Hill AQMS was upgraded from 1405D to 1405DF on 21/08/2023.

3.4 Monitoring during the reporting period

During 2024, most instruments (including meteorological instruments) provided valid data for more than 75% of the time to enable assessment of compliance with the AAQ NEPM. Valid meteorology data collected at Winnellie was about 70%; this low value was due to data transfer problems which occurred when data was being transferred from the BoM server that provides data to the station via an optic fibre cable.

3.5 Changes to the approved monitoring plan

There were no changes to the approved monitoring plan this year. The Department plans to expand particle monitoring to Alice Springs and additional regional centres, including Tennant Creek, in future years, when funding is available.

3.6 Unresolved issues

The reporting period did not have any unresolved issues.

3.7 Status of NATA accreditation

A National Association of Testing Authorities (NATA) accredited contractor conducted all data collection and validation processes. The contractor used Australian Standard methods/instruments for monitoring the air pollutants (Table 3), as prescribed in clause 16 of the AAQ NEPM.

Table 3: Australian Standards and monitoring instruments used for air pollutant monitoring

Pollutant	Standard	Title	Instruments used
Carbon monoxide	AS 3580.7.1	Determination of Carbon Monoxide – Direct Reading Instrument Method	Gas filter correlation/ infra-red analyser
Nitrogen dioxide	AS 3580.5.1	Determination of Oxides of Nitrogen – Chemiluminescence Method	Gas-phase chemiluminescence analyser
Photochemical oxidant (ozone)	AS 3580.6.1	Determination of Ozone – Direct Reading Instrument Method	Non-dispersive ultra-violet analyser
Sulfur dioxide	AS 3580.4.1	Determination of Sulfur Dioxide – Direct Reading Instrument Method	Pulsed fluorescence analyser
Particles as PM ₁₀	AS/NZS 3580.9.16:2016	Determination of suspended particulate matter – PM ₁₀ continuous direct mass method using a tapered element oscillating microbalance monitor incorporating a filter dynamic measurement system (FDMS) unit	Tapered element oscillating microbalance (TEOM) dichotomous air monitor with FDMS
Particles as PM _{2.5}	AS/NZS 3580.9.13:2013	Determination of Suspended Particulate Matter – PM _{2.5} continuous direct mass method using a tapered element oscillating microbalance monitor	Tapered element oscillating microbalance (TEOM) dichotomous air monitor with or without FDMS

3.8 Methods other than physical monitoring

No other methods were used in the reporting period.

4 Assessment of compliance with the AAQ NEPM standards and goals

The goal of the *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) is to achieve the existing National Environment Protection Standards shown in Table 4 below (Schedule 2 of the AAQ NEPM). The AAQ NEPM, varied in April 2021, does not allow exceedances of any of the standards except for exceptional events as defined in the NEPM.

Table 4: Ambient Air Quality NEPM Standards (as amended)

Pollutant	Averaging period	Maximum concentration standard	Maximum allowable exceedances
Carbon monoxide	8 hours	9.0 ppm	None
Nitrogen dioxide	1 hour	0.08 ppm	None
	1 year	0.015 ppm	None
Photochemical oxidants (as ozone)	8 hours	0.065 ppm	*None
Sulfur dioxide	1 hour	0.10 ppm	None
	1 day	0.02 ppm	None
Particles as PM ₁₀	1 day	50 µg/m ³	*None
	1 year	25 µg/m ³	None
Particles as PM _{2.5}	1 day	25 µg/m ³	*None
	1 year	8 µg/m ³	None

**For the purpose of reporting compliance against PM₁₀ and PM_{2.5} 1-day average and O₃ 8-hr average standards, monitoring data that has been determined as being directly associated with an exceptional event (such as bushfires) are excluded.*

The AAQ NEPM defines an exceptional event as:

“... a fire or dust occurrence that adversely affects air quality at a particular location that:

(a) causes an exceedance of one or more of the following that is in excess of normal historical fluctuations and background levels:

(i) 1 day average standard for particles as PM₁₀;

(ii) 1 day average standard for particles as PM_{2.5};

(iii) 8 hour average standard for photochemical oxidants (as ozone); and

(b) is directly related to bushfire, jurisdiction authorised hazard reduction burning or continental scale windblown dust.”

The AAQ NEPM further states:

“For the purpose of reporting compliance against the PM_{10} and $PM_{2.5}$ 1 day average and photochemical oxidants (as ozone) 8 hour average standards specified in this measure, participating jurisdictions shall exclude monitoring data that has been determined as being directly associated with an exceptional event.” Clause 18 (3C)

“For the purpose of reporting compliance against the PM_{10} and $PM_{2.5}$ 1 year average standards specified in this measure, participating jurisdictions shall include all measured data, including monitoring data that is directly associated with an exceptional event.” Clause 18 (3D)

The following tables (Table 5 to Table 10) summarise compliance with the standards and hence the goals of the AAQ NEPM. For each air pollutant, the tables show data availability (quarterly and annually), the number of exceedance days for the 1-hour or 8-hour averages (where applicable), the annual mean (where an annual standard exists) and an assessment of compliance. The corresponding figures (Figure 2 to Figure 9) provide graphs of pollutant concentrations.

A station's performance is assessed as meeting the standard(s) and hence the goal of the AAQ NEPM (“Met”) for a pollutant if there are no exceedances of the standard(s) specified in Table 4 for that pollutant and data availability for the year was at least 75%.

Performance is assessed as not meeting the standard(s) and hence the goal of the AAQ NEPM (“Not Met”) for a pollutant, if there are any exceedances of the standard(s) specified in Table 4 for that pollutant.

If there was insufficient data, then performance is assessed as not demonstrated (“ND”), even if there were no exceedances recorded.

There must be a minimum of 75% data availability in any averaging period for the data to be reported against the corresponding AAQ NEPM standard. For example, the 8-hour ozone AAQ NEPM standard is based on eight-hour rolling averages: a valid 8-hour rolling average is calculated as the average of the valid one-hour averages over the preceding 8 hours—when at least six of those hours (75%) had valid data.

4.1 Carbon monoxide compliance

During 2024, none of the stations recorded any exceedance of the carbon monoxide (CO) standard. The daily maximum 8-hour average concentrations were very low compared to the 8-hour standard (Figure 2). Table 5 shows that the stations demonstrated compliance with the AAQ NEPM goal for CO.

Table 5: 2024 compliance summary for CO in the Northern Territory

Region/ Performance monitoring station	Data availability rate (% of hours)					Number of exceedance days	Performance against the standard and goal
	Q1	Q2	Q3	Q4	Year		
Palmerston	97	89	99	97	95	0	met
Stokes Hill	92	100	94	100	96	0	met
Winnellie	67	94	77	100	84	0	met

AAQ NEPM Standard

9.0 ppm (8-hour average)

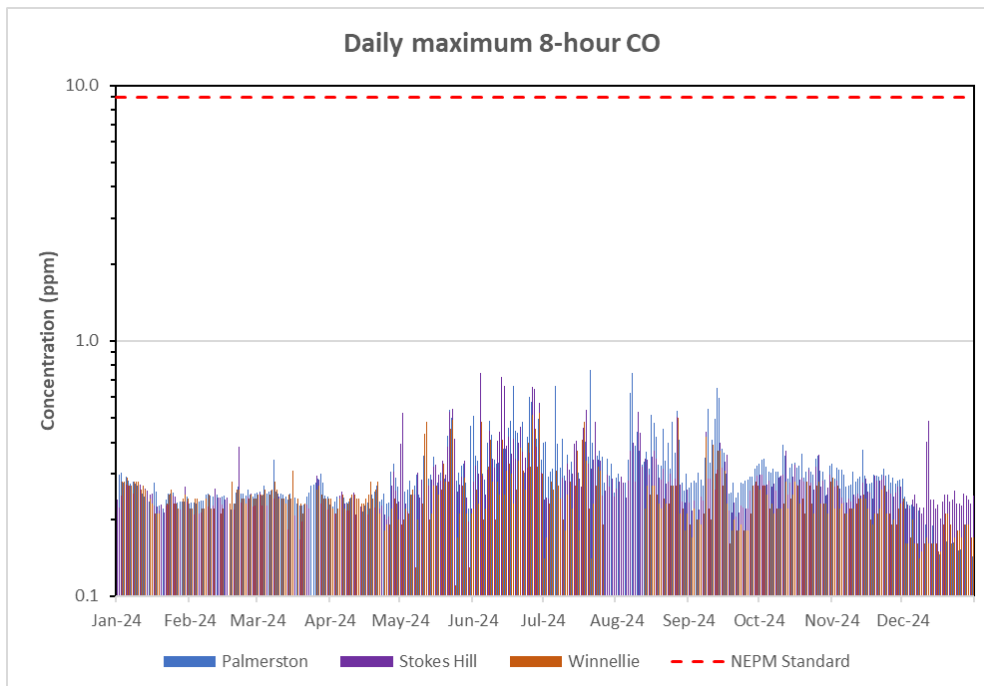


Figure 2: Daily maximum carbon monoxide 8-hour averages for Palmerston, Stokes Hill and Winnellie in 2024

4.2 Nitrogen dioxide compliance

In 2024, none of the stations recorded any exceedance of the nitrogen dioxide (NO₂) 1-hour and 1-year standards. The daily maximum 1-hour average concentrations were low compared to the standard (Figure 3), and all the stations captured sufficient data to demonstrate compliance with the goal for NO₂ (Table 6).

Table 6: 2024 compliance summary for NO₂ in the Northern Territory

AAQ NEPM Standard

0.08 ppm (1-hour average)

0.015 ppm (1-year average)

Region/ Performance monitoring station	Data availability rate (% of hours)					Number of exceedances days	1-year mean (ppm)	Performance against standards and goals	
	Q1	Q2	Q3	Q4	Year			1-hour	1-year
Palmerston	89	83	91	89	88	0	0.0016	met	met
Stokes Hill	88	96	90	95	92	0	0.0036	met	met
Winnellie	67	91	75	92	81	0	0.0019	met	met

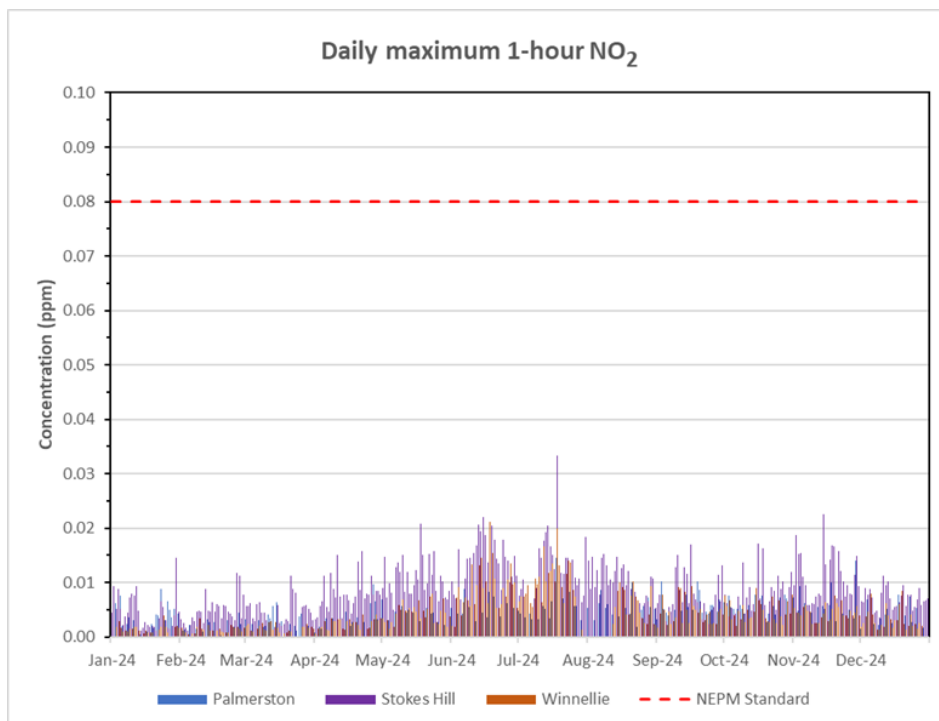


Figure 3: Daily maximum nitrogen dioxide 1-hour averages for Palmerston, Stokes Hill and Winnellie in 2024

4.3 Ozone compliance

During 2024, none of the monitoring stations recorded any exceedance of the ozone (O₃) 8-hour rolling average standard (Figure 4). Sufficient data was collected at all the stations to demonstrate compliance with the O₃ goal at each station (Table 7). There is no 1-hour average standard for ozone; nonetheless the data is shown in Figure 5.

Table 7: 2024 compliance summary for O₃ in the Northern Territory

AAQ NEPM Standard
0.065 ppm (8-hour average)

Region/ Performance monitoring station	Data availability rate (% of hours)					Number of exceedance days	Performance against the standard and goal
	Q1	Q2	Q3	Q4	Year		
Palmerston	97	89	100	95	95	0	met
Stokes Hill	92	100	94	100	96	0	met
Winnellie	68	95	78	100	85	0	met

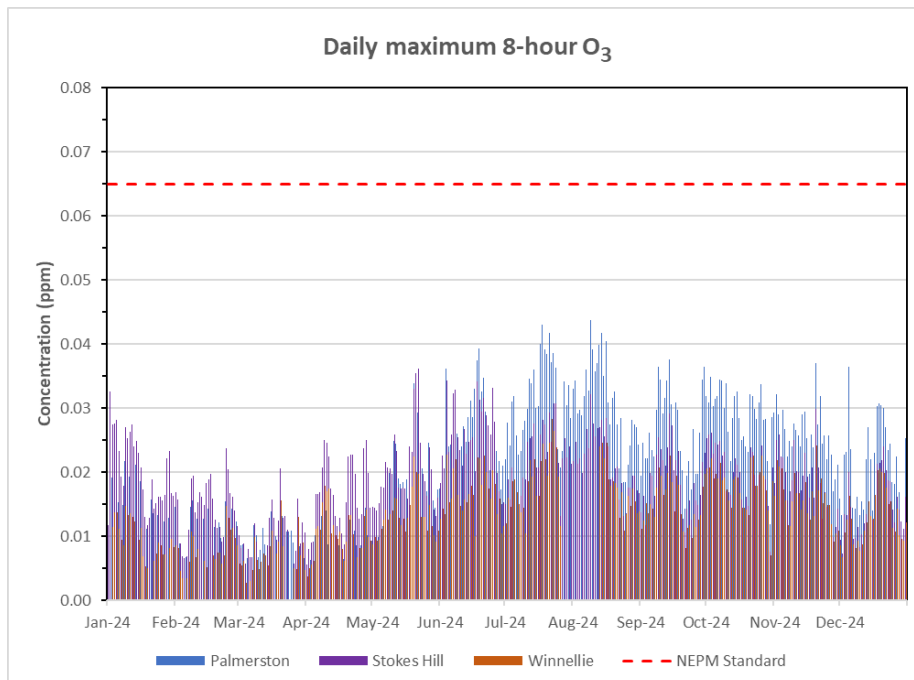


Figure 4: Daily maximum ozone 8-hour averages for Palmerston, Stokes Hill and Winnellie in 2024

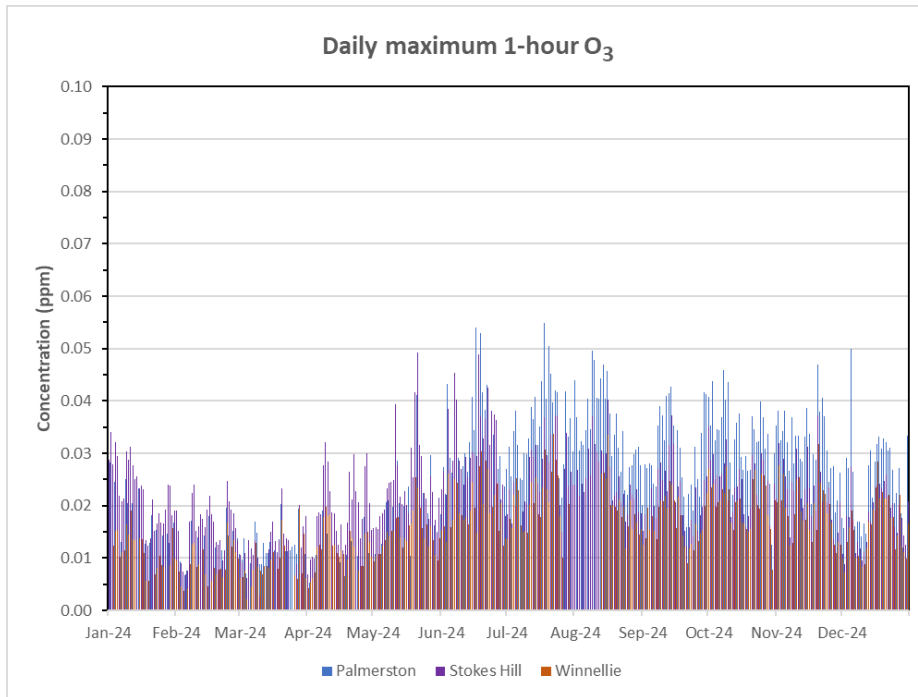


Figure 5: Daily maximum ozone 1-hour averages for Palmerston, Stokes Hill and Winnellie in 2024

4.4 Sulfur dioxide compliance

During 2024, none of the stations recorded any exceedance of the sulfur dioxide (SO₂) 1-hour or 1-day standards. Daily maximum 1-hour and 1-day average concentrations were very low when compared to the respective standards (Figures 6 & 7). Compliance with the AAQ NEPM goal for SO₂ was demonstrated at all the stations (Table 8).

Table 8: 2024 compliance summary for SO₂ in the Northern Territory

AAQ NEPM Standard
 0.10 ppm (1-hour average)
 0.02 ppm (1-day average)

Region/ Performance monitoring station	Data availability rate (% of hours)					Number of exceedance days		Performance against standards and goals	
	Q1	Q2	Q3	Q4	Year	1-h	1-day	1-h	1-day
Palmerston	89	83	90	89	88	0	0	met	met
Stokes Hill	87	95	90	95	92	0	0	met	met
Winnellie	67	91	76	96	82	0	0	met	met

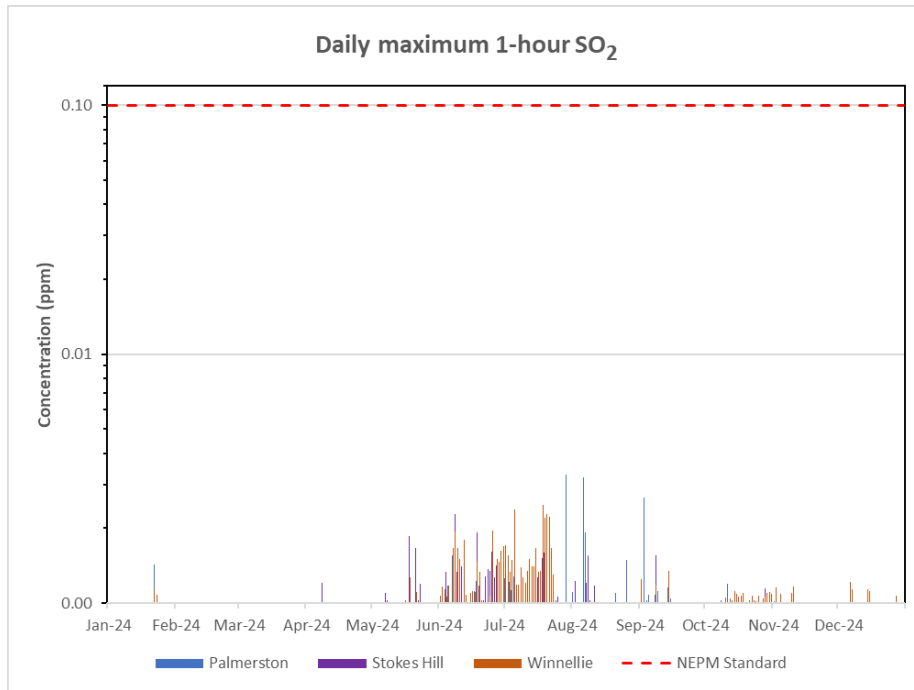


Figure 6: Daily maximum sulfur dioxide 1-hour averages for Palmerston, Stokes Hill and Winnellie in 2024

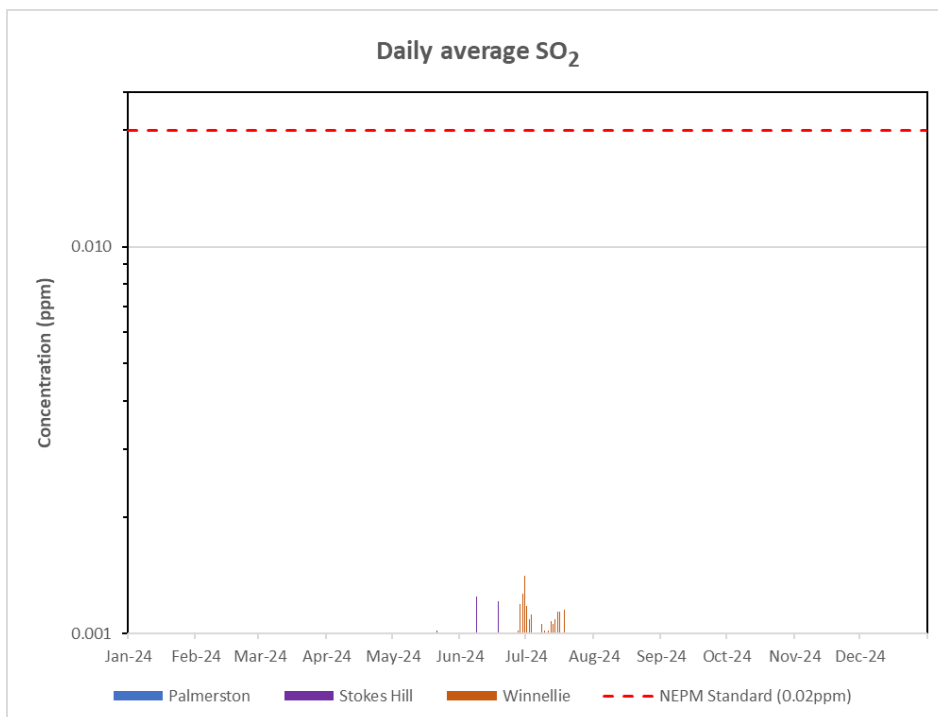


Figure 7: Sulfur dioxide 1-day averages for Palmerston, Stokes Hill and Winnellie in 2024

4.5 Particulates (PM₁₀) compliance

During 2024, all the stations except Winnellie recorded exceedances of the PM₁₀ 1-day standard (Figure 8), but these exceedances were attributed to exceptional events such as smoke from small-scale local bush/grass fires or more distant large-scale savannah fire activity such as hazard reduction burns⁴.

The AAQ NEPM excludes monitoring data associated with exceptional events for reporting compliance against PM₁₀ 1-day average standard. Table 9 shows that the annual averages recorded at all stations were below the 1-year standard of 25 µg/m³. All the stations demonstrated compliance with the AAQ NEPM goal for PM₁₀.

Table 9: 2024 compliance summary for PM₁₀ in the Northern Territory

AAQ NEPM Standard
50 µg/m³ (1-day average)
25 µg/m³ (1-year average)

Region/ Performance monitoring station	Data availability rate (% of days)					Number of exceedance days	1-year average (µg/m ³)	Performance against standards and goals	
	Q1	Q2	Q3	Q4	Year			1-day	1-year
Katherine:									
Katherine	86	90	86	38	75	2	16.2	met	met
Darwin:									
Palmerston	78	71	90	92	83	4	15.3	met	met
Stokes Hill	90	100	92	100	96	10	18.5	met	met
Winnellie	59	92	75	100	82	0	16.1	met	met

⁴ These are verified from Bushfires NT Daily Report bulletins provided by the Incident Management Team of the Department of NT Fire and Emergency Service; also, from the Northern Australian Fire Information Fire Reports (NAFI 2024) and the NASA Worldview satellite data (NASA 2024).

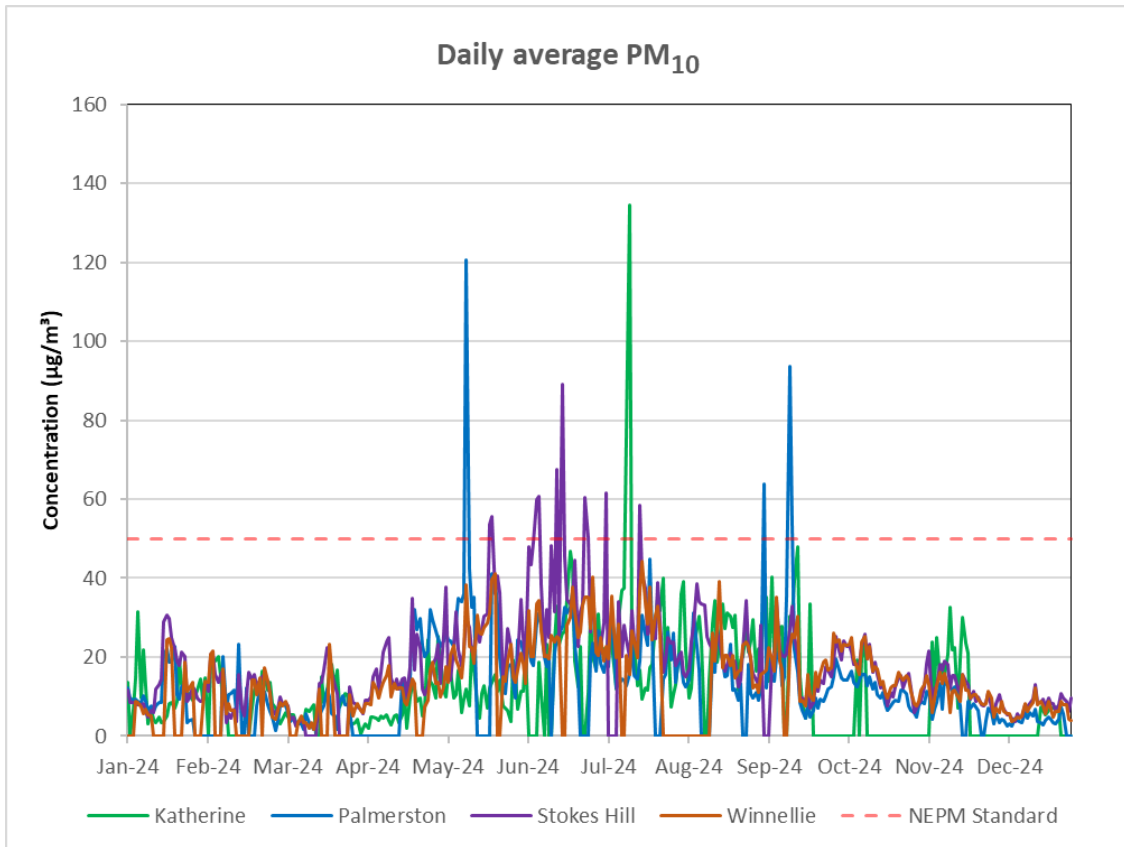


Figure 8: PM₁₀ 1-day averages for Katherine, Palmerston, Stokes Hill and Winnellie in 2024

4.6 Particulates (PM_{2.5}) compliance

During 2024, the Darwin region and Katherine recorded several exceedances of the PM_{2.5} 1-day standard (Figure 9). These exceedances were all attributed to exceptional events such as smoke from small-scale local bush/grass fires or more distant large-scale savannah fire activity such as hazard reduction burns, which were verified as explained in the previous section.

Table 10 shows that none of the stations met the AAQ NEPM PM_{2.5} goal, as their 1-year averages were all above the AAQ NEPM standard of 8 µg/m³.

Table 10: 2024 compliance summary for PM_{2.5} in the Northern Territory

AAQ NEPM Standard
 25 µg/m³ (1-day average)
 8 µg/m³ (1-year average)

Region/ Performance monitoring station	Data availability rate (% of days)					Number of exceedance days	1-year average (µg/m ³)	Performance against the standards and goals	
	Q1	Q2	Q3	Q4	Year			1-day	1-year
Katherine:									
Katherine	86	93	86	26	75	15	9.92	met	not met
Darwin:									
Palmerston	78	71	90	92	83	10	8.39	met	not met
Stokes Hill	90	100	92	100	96	18	10.3	met	not met
Winnellie	59	92	75	99	81	12	9.42	met	not met

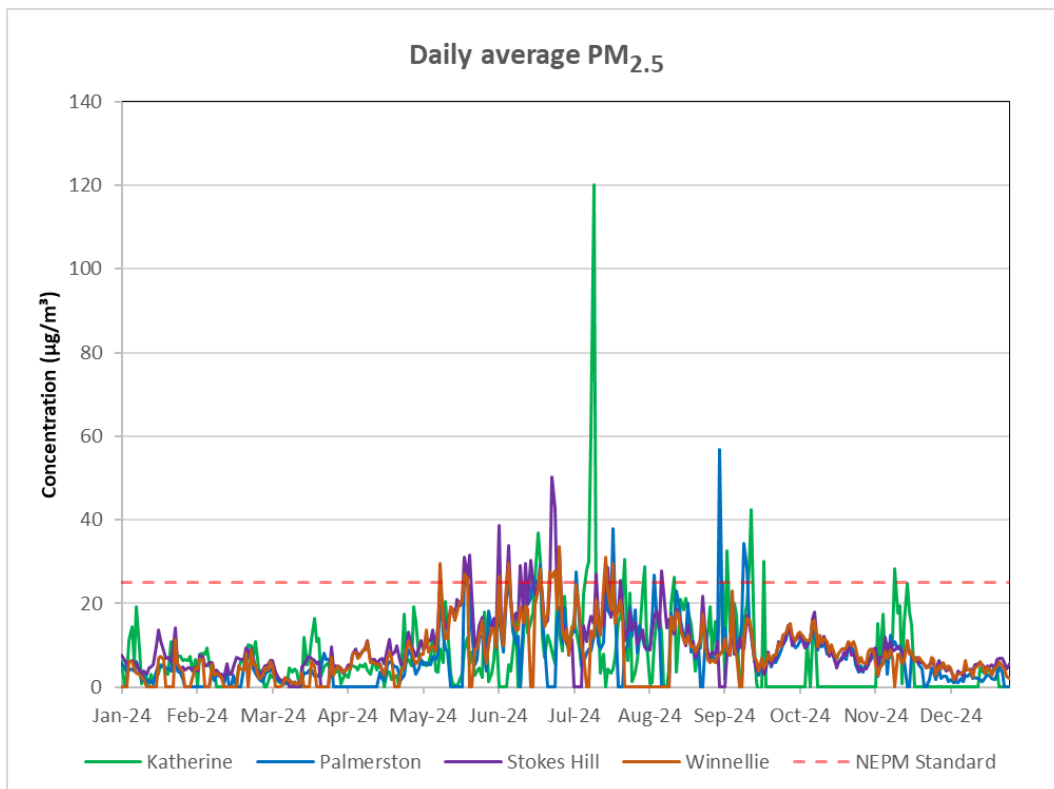


Figure 9: PM_{2.5} 1-day averages for Katherine, Palmerston, Stokes Hill and Winnellie in 2024

5 Analysis of air quality data

This section presents statistics of pollutant concentrations as summaries of the highest and second highest concentrations recorded for each parameter at every station in the NTG ambient air quality monitoring station (AQMS) network during 2024.

The AAQ NEPM does not permit exceedances of any of the standards for all the air pollutants. The NEPM excludes compliance reporting for exceedances of short-term PM₁₀, PM_{2.5} and O₃ standards caused by exceptional events such as bushfires. Data presented in the previous section show that levels of CO and SO₂ were generally significantly below the AAQ NEPM standards and there were no exceedances recorded for CO, NO₂, O₃ and SO₂.

Tables 11 to 18 show data availability as a count of days during 2024 with valid data, the highest value (daily maxima) and second highest value with the dates (and time stamps for sub-daily standards) that these concentrations occurred. A valid day is when at least 75% of averaging periods during the day had valid data.

5.1 Carbon monoxide statistics

Table 11 shows that peak 8-hour carbon monoxide concentrations at all the stations were well below the 8-hour rolling average standard during the year. The highest carbon monoxide concentrations, recorded at Palmerston (0.77 ppm, 6 am on 21 July 2024) was less than 10% of the AAQ NEPM standard. The next highest concentration 0.75 ppm, was not very different from the highest value and was recorded at Palmerston (8 August, 1 am) and Stokes Hill (4 June, 10 am).

Table 11: 2024 summary statistics for daily peak 8-hour CO

Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date/hour)	2 nd highest (ppm)	AAQ NEPM Standard
					9.0 ppm (8-hour average)
Palmerston	349	0.77	21/07/2024 06:00	0.75	08/08/2024 01:00
Stokes Hill	353	0.75	04/06/2024 10:00	0.72	13/06/2024 08:00
Winnellie	309	0.53	29/06/2024 09:00	0.52	26/06/2024 10:00

5.2 Nitrogen dioxide statistics

Table 12 shows that nitrogen dioxide levels were below the AAQ NEPM 1-hour NO₂ standard of 0.08 ppm. The highest recorded reading (0.033 ppm) was recorded at Stokes Hill at 9 pm on 18 July 2024, this is about 40% of the standard; the second highest peak was also recorded at Stokes Hill (0.023 ppm, 9 am on 14 November).

Table 12: 2024 summary statistics for daily peak 1-hour NO₂ in the Northern Territory

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date/hour)	AAQ NEPM Standard	
				2 nd highest (ppm)	2 nd Highest (date/hour)
Palmerston	322	0.015	18/07/2024 22:00	0.014	29/11/2024 18:00
Stokes Hill	338	0.033	18/07/2024 21:00	0.023	14/11/2024 09:00
Winnellie	298	0.021	18/06/2024 22:00	0.020	18/07/2024 20:00

5.3 Ozone statistics

There were no exceedances of the 8-hour O₃ standard at any of the monitoring sites (Table 13). The highest concentration of 0.044 ppm, recorded at Palmerston on 9 August 2024 at 6 pm, was about 70% of the standard. The second highest concentration, 0.043 ppm, was also recorded at Palmerston on 18 July at 8 pm. The highest 1-hour daily peak ozone (0.055 ppm) was recorded on that day at 5 pm, also at Palmerston (Table 14). The other stations recorded elevated ozone levels on that day, with associated high temperatures >25 °C (maximum) and high solar radiation ~900 W/m² (maximum).

There is no 1-hour AAQ NEPM standard for O₃; summary statistics data provided below in Table 14 is for information only.

Table 13: 2024 summary statistics for daily peak 8-hour O₃ in the Northern Territory

AAQ NEPM Standard

0.065 ppm (8-hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date/hour)	2nd highest (ppm)	2 nd Highest (date/hour)
Palmerston	349	0.044	09/08/2024 18:00	0.043	18/07/2024 20:00
Stokes Hill	353	0.036	22/05/2024 00:00	0.034	04/06/2024 18:00
Winnellie	311	0.028	22/07/2024 19:00	0.026	23/07/2024 17:00

Table 14: 2024 summary statistics for daily peak 1-hour O₃ in the Northern Territory

No AAQ NEPM Standard

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date/hour)	2 nd highest (ppm)	2 nd Highest (date/hour)
Palmerston	335	0.055	18/07/2024 17:00	0.054	17/06/2024 17:00
Stokes Hill	341	0.049	21/05/2024 22:00	0.049	18/06/2024 16:00
Winnellie	301	0.034	22/07/2024 17:00	0.033	16/08/2024 18:00

5.4 Sulfur dioxide statistics

Sulfur dioxide levels in the Darwin region were substantially below the AAQ NEPM 1-hour and 1-day SO₂ standards for all days (Tables 15 & 16). The highest recorded 1-hour reading was at Palmerston (0.0033 ppm) at 10 am on 29 July 2024; the second highest was also at Palmerston 0.0032 ppm on 6 August at 6 pm. Both peaks were about 3% of the standard,

Winnellie recorded the highest daily average SO₂ concentration (0.0014 ppm) on 30 June, about 7% of the standard. The second highest, 0.0013 ppm, was recorded at Stokes Hill on 8 June and at Winnellie on 29 June.

Table 15: 2024 summary statistics for daily peak 1-hour SO₂ in the Northern Territory

AAQ NEPM Standard

0.10 ppm (1-hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date/hour)	2 nd highest (ppm)	2 nd Highest (date/hour)
Palmerston	321	0.0033	29/07/2024 10:00	0.0032	06/08/2024 18:00
Stokes Hill	336	0.0023	08/06/2024 00:00	0.0019	18/06/2024 15:00
Winnellie	301	0.0025	18/07/2024 00:00	0.0024	05/07/2024 04:00

Table 16: 2024 summary statistics for 1-day SO₂ in the Northern Territory

AAQ NEPM Standard

0.02 ppm (1-day average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date)	2 nd highest (ppm)	2 nd Highest (date)
Palmerston	345	0.0009	08/08/2024	0.0009	05/06/2024
Stokes Hill	347	0.0013	08/06/2024	0.0012	18/06/2024
Winnellie	302	0.0014	30/06/2024	0.0013	29/06/2024

5.5 Particulates statistics

Table 17 shows that Katherine recorded the highest PM₁₀ event (134.6 µg/m³) on 13 July 2024; Palmerston recorded the next highest PM₁₀ event (120.5 µg/m³) on 11 May, both plumes had elevated levels of PM_{2.5} (see Table 25 in Appendix A) and were associated with smoke events. Although the PM₁₀ events (shown in Table 17) exceeded the AAQ NEPM standard (except Winnellie), they are considered as exceptional events since they were associated with natural events such as smoke from bushfires.

Table 17: 2024 summary statistics for 1-day PM₁₀ in the Northern Territory

AAQ NEPM Standard

50 µg/m³ (1-day average)

Region/ Performance monitoring station	Number of valid days	Highest (µg/m ³)	Highest (date)	2 nd highest (µg/m ³)	2 nd Highest (date)
Katherine	265	134.6	13/07/2024	75.5	12/07/2024
Palmerston	304	120.5	11/05/2024	93.5	13/09/2024
Stokes Hill	350	89.2	17/06/2024	67.6	15/06/2024
Winnellie	299	44.3	18/07/2024	41.2	22/05/2024

The highest PM_{2.5} concentration (120.0 µg/m³) was recorded at Katherine on 13 July 2024 (Table 18). The next highest (60.3 µg/m³) was also recorded at Katherine on 12 July 2024. Palmerston recorded the highest concentration in the Darwin region (56.7 µg/m³ on 3 September). All the events for the Darwin and Katherine stations, shown in Table 18, exceeded the AAQ NEPM standard. These exceedances and others were due to bushfire activity, which the AAQ NEPM classifies as exceptional events. High fine particle levels are typical of the Darwin airshed during the Dry season.

Table 18: 2024 summary statistics for 1-day PM_{2.5} in the Northern Territory

AAQ NEPM Standard

25 µg/m³ (1-day average)

Region/ Performance monitoring station	Number of valid days	Highest (µg/m ³)	Highest (date)	2 nd highest (µg/m ³)	2 nd Highest (date)
Katherine	268	120.0	13/07/2024	60.3	12/07/2024
Palmerston	304	56.7	03/09/2024	37.8	21/07/2024
Stokes Hill	350	50.2	26/06/2024	42.7	27/06/2024
Winnellie	298	33.5	29/06/2024	31.0	18/07/2024

6 Analysis of exceedances and population exposure

This section will analyse exceedance events that were captured at the ambient air quality monitoring stations during 2024.

6.1 Particulates exceedances

The PM_{2.5} annual average concentration across all Darwin stations for 2024 was 9 µg/m³, which exceeded the AAQ NEPM standard of 8 µg/m³, but was less than the 2023 PM_{2.5} annual average of 12 µg/m³. These averages are different from population-weighted averages discussed in the next subsection.

Particles generated by vegetation burning during the Dry season are the primary air pollutants in the Darwin region. This results in significant variation in air quality between the Dry (May to October) and the Wet (November to April) seasons.

Averaged daily levels of PM_{2.5} across all the Darwin stations over the six months of the Dry season was 14 µg/m³; compared to 5 µg/m³ during the Wet season. In Katherine, the average for the Dry season was 13 µg/m³ and for the Wet season was 7 µg/m³. In general, air quality was good during the Wet, but poor during the Dry of 2024.

Table 19 shows that there were several of exceedances of the 24-hour standard for PM_{2.5} at all the stations in 2024. There were fewer PM₁₀ exceedances, and Winnellie did not record any. All these exceedances have been associated with smoke from bushfires. Details of dates and inferred causes of each particulate matter exceedance (as determined from sources such as Bushfires NT Daily Report bulletins and satellite data) are in Tables 26 to 32 of Appendix B.

Table 19: Summary of PM_{2.5} and PM₁₀ exceedances of the 1-day standards in 2024

AQMS	Katherine	Palmerston	Stokes Hill	Winnellie
PM _{2.5}	15	10	18	12
PM ₁₀	2	4	10	0

The elevated PM_{2.5} levels during the Dry are unavoidable and people with respiratory or cardiopulmonary issues may be impacted especially during extended events. For example, there were several instances when the 1-day standard was exceeded on three or more consecutive days at some of the stations. These were, 21 to 23 May at Stokes Hill, 25 to 27 June at Winnellie and 10 to 13 July at Katherine (see Appendix A: Particulates events for 2024).

As explained in previous sections of this report, since natural events such as bushfire activity caused the PM_{2.5} and PM₁₀ exceedances, the exceedances are exceptional events under the AAQ NEPM.

Smoke from burning vegetation contains PM₁₀ and PM_{2.5}, Figures 10 - 13 show the close relationship between these parameters observed at all stations, especially during the Dry Season.

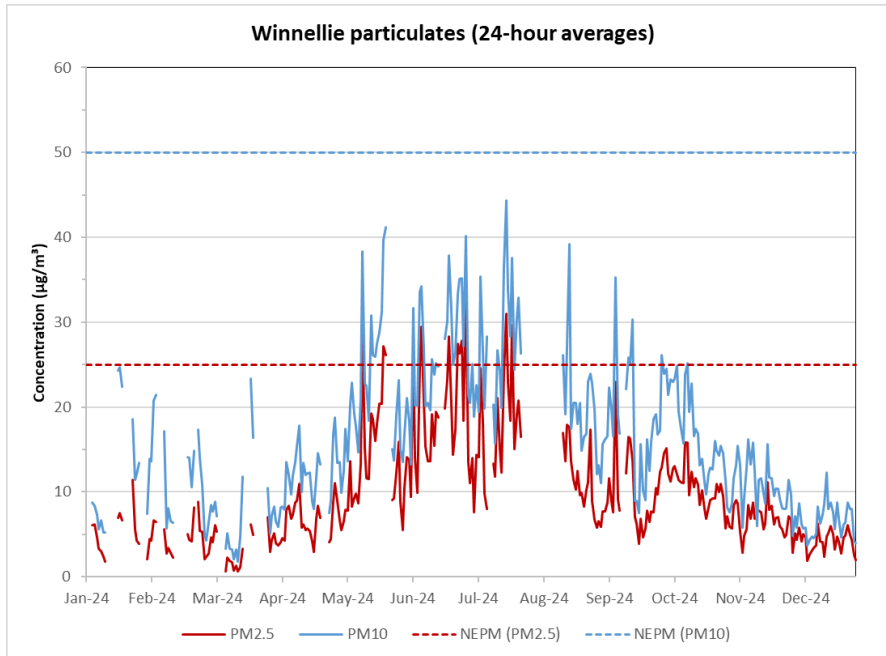


Figure 10: Particulate Matter concentration at Winnellie AQMS during 2024

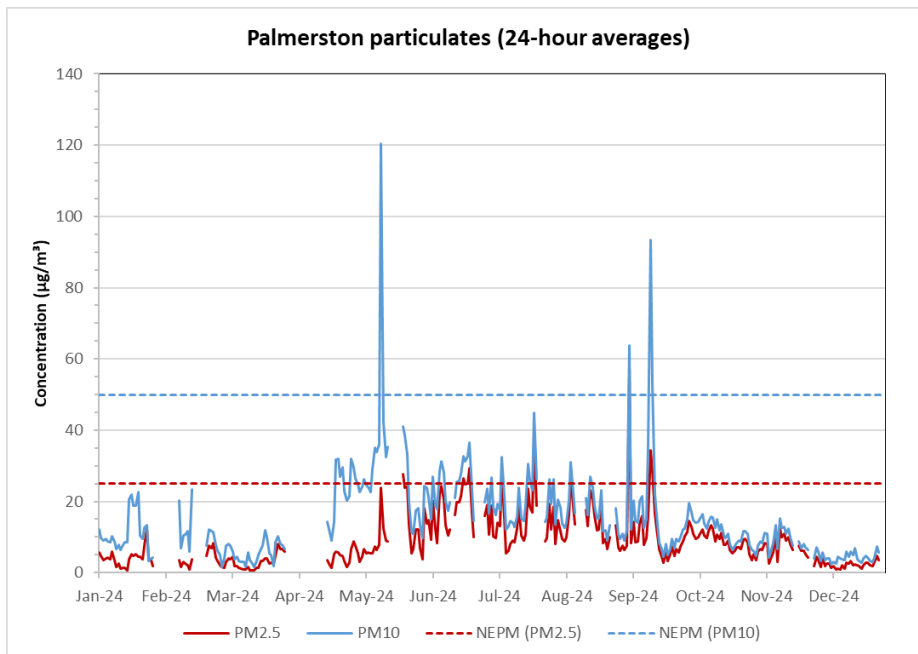


Figure 11: Particulate Matter concentration at Palmerston AQMS during 2024

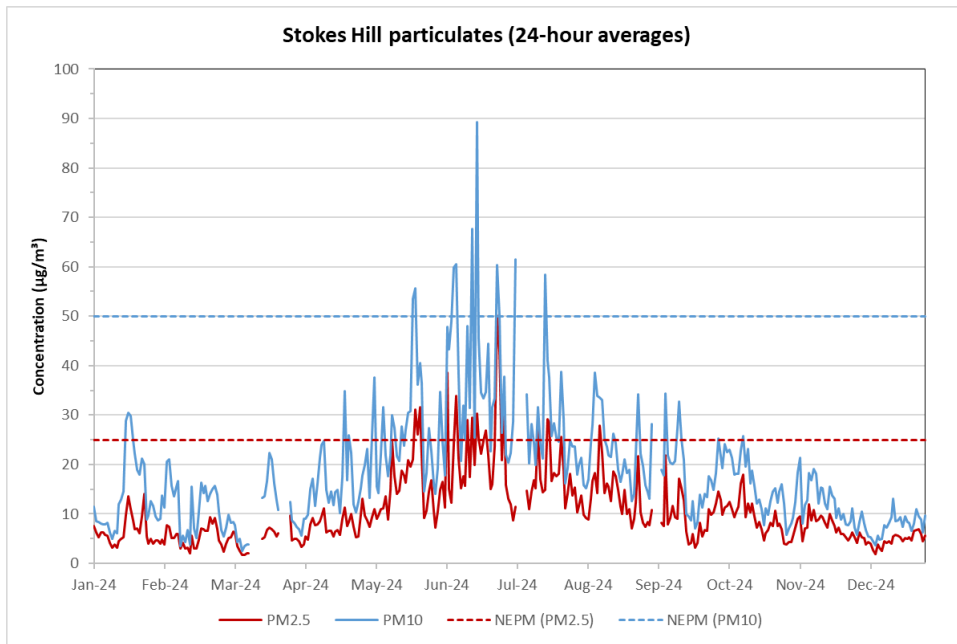


Figure 12: Particulate Matter concentration at Stokes Hill AQMS during 2024

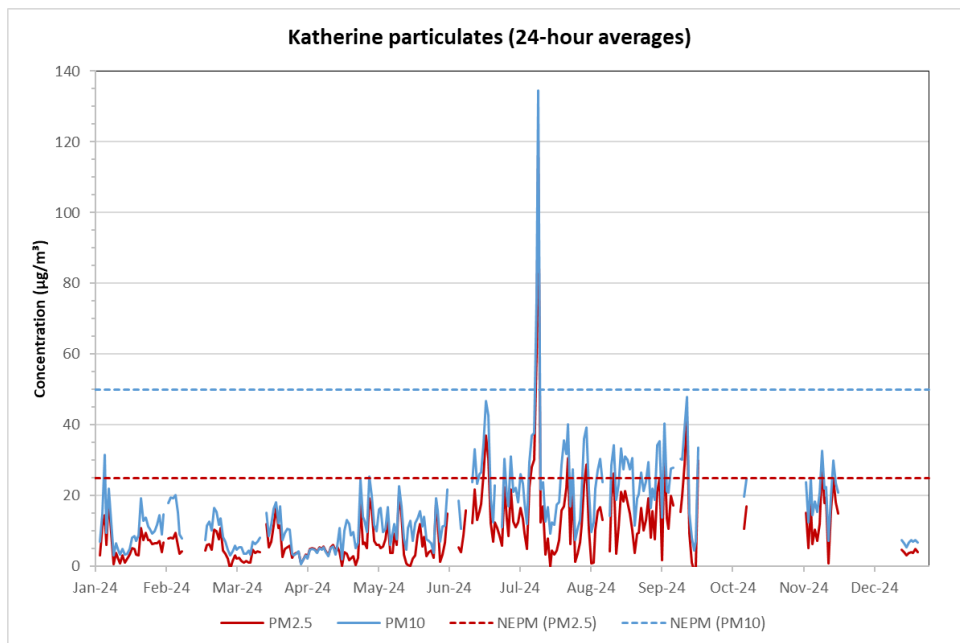


Figure 13: Particulate Matter concentration at Katherine AQMS during 2024

6.2 Population exposure to PM_{2.5}, NO₂ and O₃

It is a requirement under clause 17(2A) of the AAQ NEPM that participating jurisdictions evaluate and report annual population exposure to: (a) particles as PM_{2.5} from June 2018; and (b) NO₂ and O₃ from June 2021.

Population exposure refers to the exposure of the population as a whole to ambient air pollution. It is not a measure of the personal exposure of individuals. During the 2011 AAQ NEPM review, population exposure and risk were flagged as better parameters for assessing air quality, rather than the number of exceedances of the standards (NEPC 2011).

The review recommended to “*Develop nationally consistent approaches to assess population exposure, including appropriate modelling and emissions inventories*”.

In practice, determining population exposure estimates requires information on the average distribution of air pollution and the population density in the area or region of interest, along with other environmental information. Accurate estimation of population exposure requires a significant investment, not only in monitoring and airshed modelling and data assimilation, but also in the development of comprehensive inventories of sources across each airshed (NEPC 2011).

A practical, cost-constrained Base Method for evaluating annual population exposure to air pollutant concentrations that uses readily available data and could be adopted nationally has been developed (EWG 2017). The simplified Base Method, which outputs a single population-weighted annual average pollutant concentration for each jurisdiction for which it is implemented, has been applied to the data collected in the Greater Darwin Region. Due to limited resources, the intermediate Base Method, which requires interpolating concentrations between stations to also calculate a single population-weighted annual average pollutant concentration was not used.

The Australian Statistical Geography Standard (ASGS) is a classification of Australia into a hierarchy of statistical areas. It is a social geography, developed to reflect the location of people and communities. It is used for the publication and analysis of official statistics and other data. The ASGS is updated every 5 years to account for growth and change in Australia’s population, economy and infrastructure. Statistical Area Level 2 (SA2)⁵ represent medium-sized general-purpose areas built to represent communities that interact together socially and economically. Most SA2s have a population range of 3,000 to 25,000 people.

⁵ SA2 areas in the Greater Darwin Region and their respective populations were identified from the Australian Bureau of Statistics (ABS) Population Data for 2024 (ABS 2024). SA2 is an area defined in the ASGS, usually based on officially gazetted State/Territory suburbs and localities.

Annual average PM_{2.5}, NO₂ and O₃ concentrations for each of the three air quality monitoring stations: Stokes Hill, Winnellie and Palmerston, were assigned to each of the identified SA2 areas based on their proximity to the nearest station.

It was assumed that:

1. People living in the SA2 areas of Darwin City, Fannie Bay - The Gardens, Larrakeyah and Stuart Park would be exposed to PM_{2.5}, NO₂ and O₃ levels represented by concentrations measured at Stokes Hill AQMS.
2. All other Darwin SA2 areas would be exposed to PM_{2.5}, NO₂ and O₃ levels measured at Winnellie AQMS.
3. People living in SA2 areas in Palmerston and Litchfield Municipality would be exposed to PM_{2.5}, NO₂ and O₃ levels measured at Palmerston AQMS.

The population-weighted annual average concentration was calculated by multiplying the annual average concentration for each SA2 with the corresponding population of the SA2; then summing the products calculated for each SA2 and dividing by the total population across all identified SA2s.

A population-weighted annual average concentration of 9.1 µg/m³ was estimated for PM_{2.5}; 0.0020 ppm for NO₂; and 0.013 ppm for O₃ in the Greater Darwin Region in 2024 (see Appendix C for details of the calculations). Population-weighted exposure data for 2024 are compared to data from previous years in Table 20.

Table 20: Historical population-weighted annual concentrations for Greater Darwin Region

Year	PM _{2.5} (µg/m ³)	NO ₂ (ppm)	O ₃ (ppm)
2024	9.1	0.0020	0.013
2023	13.9	0.0022	0.014
2022	9.0	0.0022	0.015
2021	9.7	0.0040	0.016
2020	6.7	n/a	n/a
2019	9.3	n/a	n/a

'n/a' – not applicable

7 Data analysis and trends

This section examines historical particulate matter data as well as listing any issues that affected the data collected and discusses the source of smoke emissions.

7.1 Historical events and issues

Historical events and data issues include:

- 2004 - Data collection for this year did not commence until the second quarter.
- 2004 & 2005 - TEOM was located in Palmerston at the Charles Darwin University Palmerston campus. The tapered element oscillating microbalance (TEOM) continuously measures concentrations of particles in air to provide real-time concentration data.
- 2006 - TEOM data availability was below 75% for each quarter so Partisol data was used. Partisol sequentially samples particles onto pre-weighed filter papers, which are weighed again after sampling (normally 24-hours) to determine particles concentration in sampled air.
- 2009 - Dust produced from local construction activity in close proximity to the station required that exceedances for a period over the Dry be removed, as they were not necessarily representative of air quality in the larger air shed.
- 2010 - There was significant downtime with the Partisol and TEOM instruments.
- 2011 - Validated data available from Palmerston AQMS from 1 January (PM₁₀ & PM_{2.5} now measured with a dichotomous TEOM).
- 2012 - Winnellie AQMS started operating on 18 July (PM₁₀ & PM_{2.5} measured with a dichotomous TEOM).
- 2013 - Palmerston TEOM was offline for several months during the Wet resulting in inadequate data collection for NEPC reporting. As the TEOM was operational for most of the Dry, when particles in air are an issue, 2013 data from Palmerston is still useful when considering longer term trends in particle concentrations.
- 2016 - Data has not been analysed.
- 2017 - Stokes Hill AQMS started operating in May; TEOM data was only available from July.
- 2020 - Katherine AQMS started operating in September, measuring particles using a TEOM fitted with FDMS.
- 2021 - TEOMs at Palmerston AQMS and Winnellie AQMS upgraded to models fitted with FDMS.
- 2021 - Stokes Hill AQMS was decommissioned at Stokes Hill Road (Darwin Waterfront) in May and relocated to Frances Bay Drive (Hornibrooks Wharf) - commissioned in June.
- 2023 - TEOM at Stokes Hill upgraded to a model fitted with FDMS.

7.2 Trends in historical particulates data

Tables 21 to 24 in this section compare the number of particulate matter exceedances in the NT over a longer period in accordance with AAQ NEPM technical requirements. This comparison is of limited utility in providing an accurate indication of particulate trends as different sampling techniques, instruments, locations and sampling periods have been used since monitoring began in 2002.

Table 21: Casuarina 24-hour PM₁₀ & PM_{2.5} Trends (2004 -2010)

Year	*PM ₁₀			**PM _{2.5}		
	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m ³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m ³)
2004	69	1	54	60	5	37
2005	98	2	63	98	5	58
2006	97	0	44	97	5	30
2007	95	0	45	-	-	-
2008	97	1	65	72	2	32
2009	90	0	50	87	1	26
2010	78	1	54	62	2	30

- *TEOM data (but Partisol dichotomous PM₁₀ data used for 2006)
- **PM_{2.5} data from Partisol dichotomous sampler

Table 22: 24-hour PM₁₀ Trends (2011-2024)

Year	Palmerston			Winnellie			Stokes Hill			Katherine		
	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m ³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m ³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m ³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m ³)
2011	96	3	92	-	-	-	-	-	-	-	-	-
2012	91	23	70	-	-	-	-	-	-	-	-	-
2013	49	1	72	76	3	58	-	-	-	-	-	-
2014	82	2	52	86	3	73	-	-	-	-	-	-
2015	94	3	61	99	5	107	-	-	-	-	-	-
2016	-	-	-	-	-	-	-	-	-	-	-	-
2017	96	7	59	84	2	54	49	0	48	-	-	-

Year	Palmerston			Winnellie			Stokes Hill			Katherine		
	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)
2018	97	5	143	92	5	78	89	6	64	-	-	-
2019	99	10	85	94	15	85	99	11	95	-	-	-
2020	96	1	52	98	1	53	98	0	46	26	0	45
2021	85	3	120	75	2	52	82	4	95	84	6	94
2022	83	2	71	93	4	66	95	5	90	85	10	71
2023	96	5	164	78	35	104	89	3	100	88	7	96
2024	83	4	121	82	0	44	96	10	89	72	2	135

Table 23: 24-hour PM_{2.5} Trends (2011-2024)

Year	Palmerston			Winnellie			Stokes Hill			Katherine		
	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)	Data Availability (%)	Number of Exceedances	Max Concentration ($\mu\text{g}/\text{m}^3$)
2011	96	15	77	-	-	-	-	-	-	-	-	-
2012	91	23	44	-	-	-	-	-	-	-	-	-
2013	49	6	56	76	5	34	-	-	-	-	-	-
2014	82	12	37	86	9	45	-	-	-	-	-	-
2015	94	7	40	99	10	78	-	-	-	-	-	-
2016	-	-	-	-	-	-	-	-	-	-	-	-
2017	96	10	42	84	6	41	49	1	28	-	-	-
2018	97	15	112	92	19	57	89	13	44	-	-	-
2019	99	21	63	94	17	49	99	20	43	-	-	-
2020	96	7	38	98	7	39	96	4	34	26	1	33
2021	85	12	40	75	27	48	85	12	33	83	15	56
2022	83	12	67	93	19	63	95	5	37	85	19	50
2023	96	34	130	79	67	53	95	3	35	89	16	75
2024	83	10	57	81	12	34	96	18	50	73	15	120

Table 24: Averaged Particulates Key Metrics 2004-2024 (across all historical & current monitoring locations)

	Data Availability (%)	Number of Exceedances	Maximum Concentration ($\mu\text{g}/\text{m}^3$)
PM ₁₀	86	5	77
PM _{2.5}	85	13	51

Historical data for the 2004 to 2024 period, presented in Figures 14 to 19, show that there is no clear trend in PM_{2.5} or PM₁₀ in the Darwin region over the period. The number of exceedances and the maximum concentrations recorded at most of the stations in 2024 were comparable to data from previous years except 2023; but a general trend cannot be established across all the years.

The population of the Greater Darwin region has increased steadily from approximately 108,000 in 2001 to ~150,000 in 2024 showing a clear upward trend in population; however, a relationship has not been established between population and particulate matter levels.

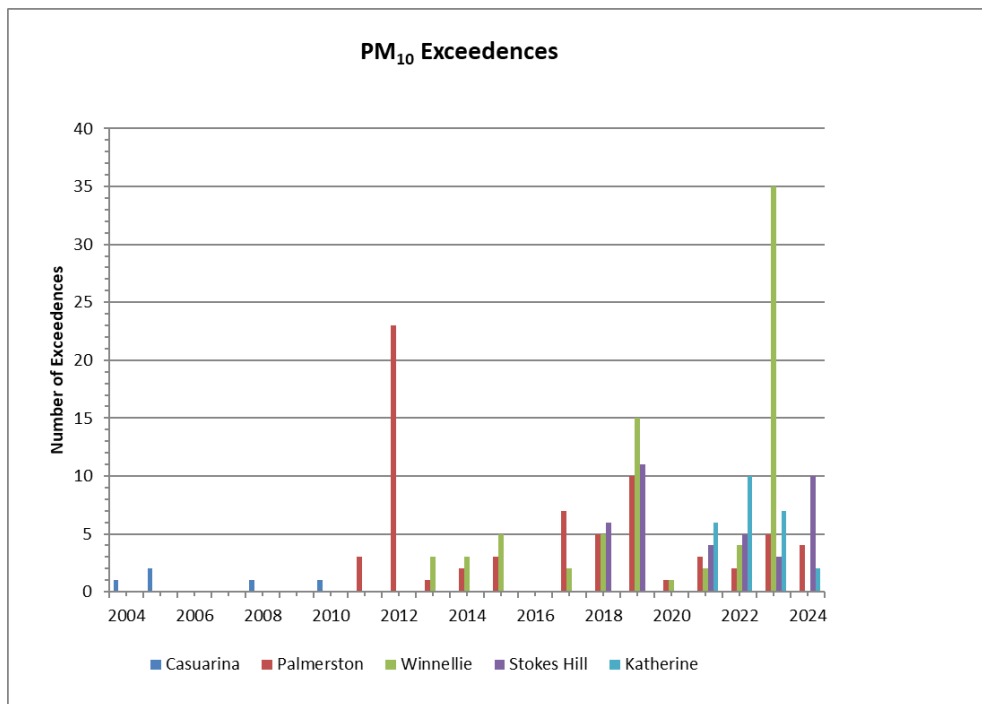


Figure 14: Historical PM₁₀ exceedances of 24-hour AAQ NEPM

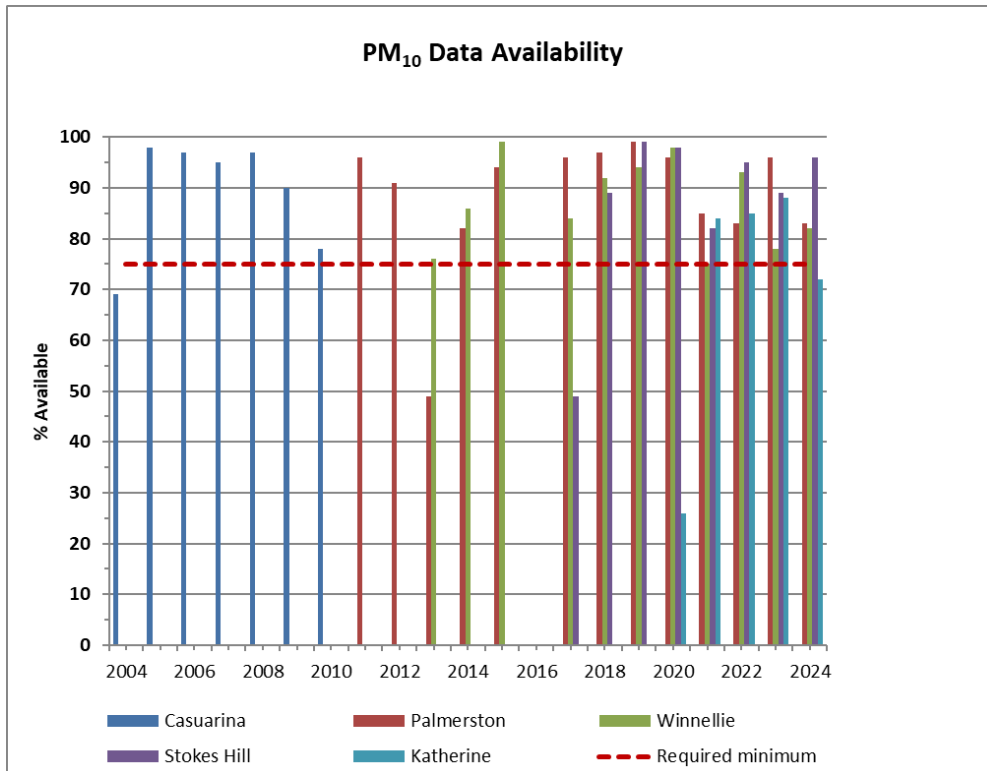


Figure 15: Historical PM₁₀ data availability

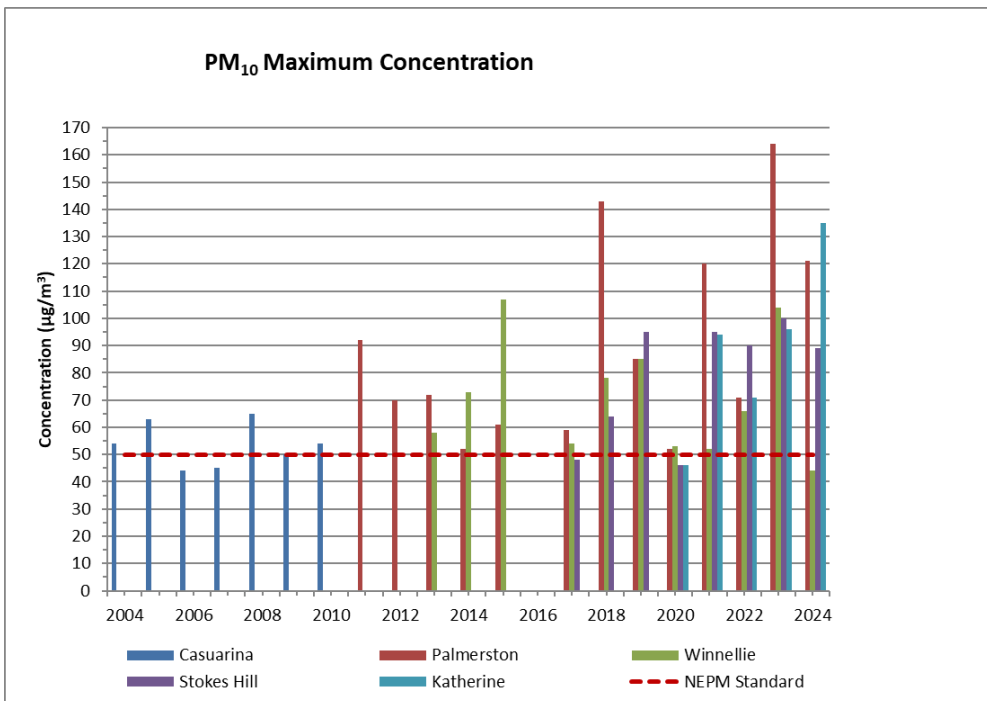


Figure 16: Historical maximum 24-hour PM₁₀ concentrations

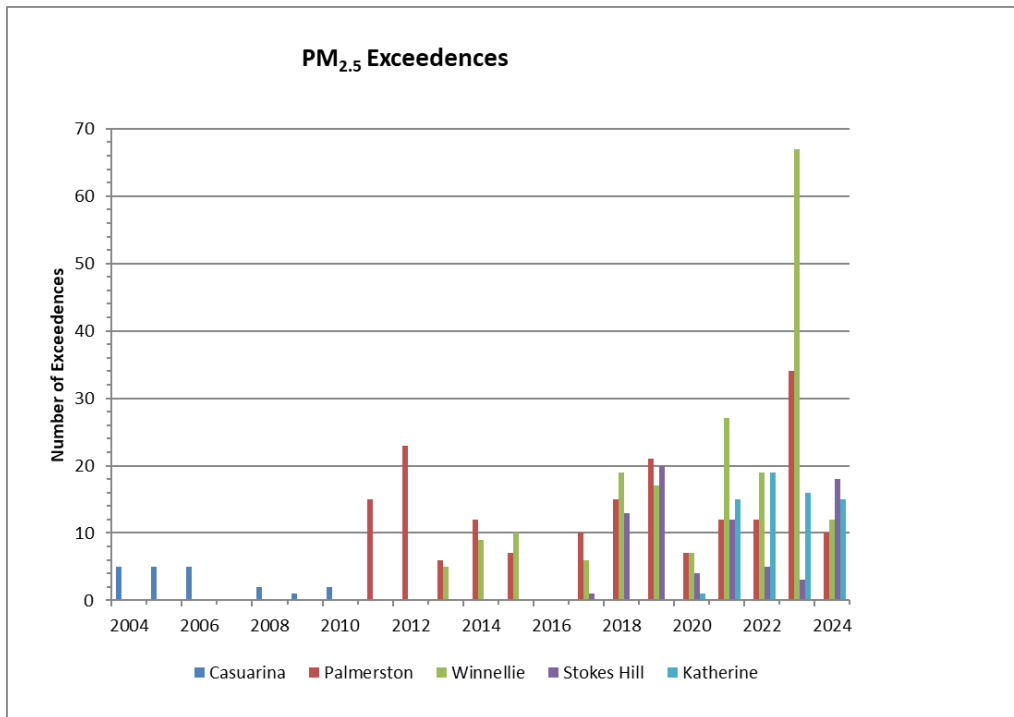


Figure 17: Historical PM_{2.5} exceedences of 24-hour AAQ NEPM

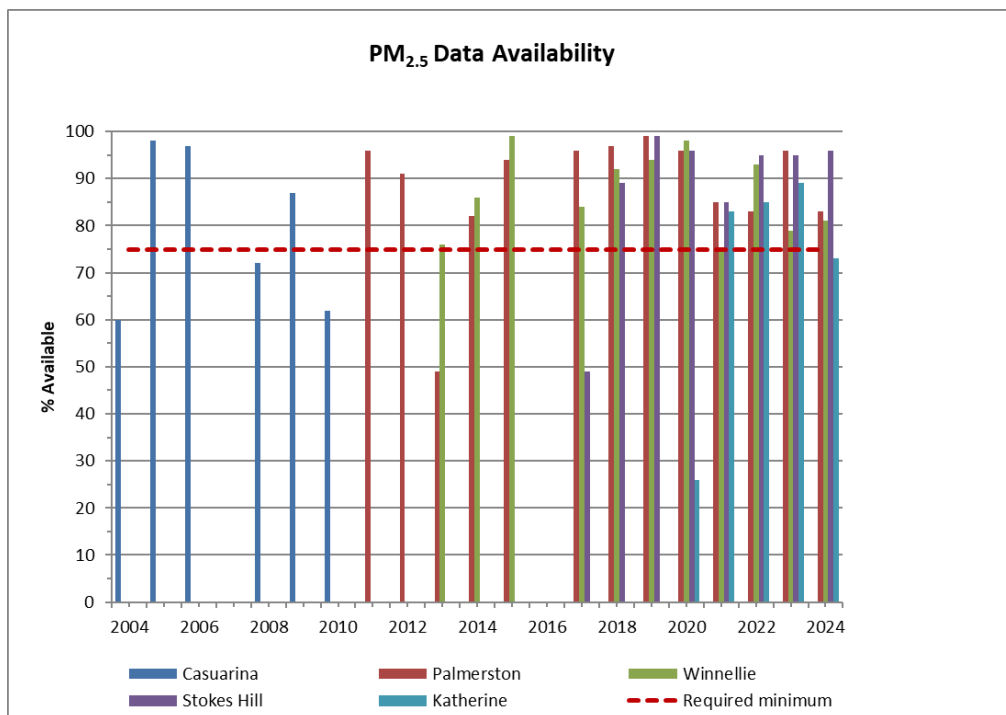


Figure 18: Historical PM_{2.5} data availability

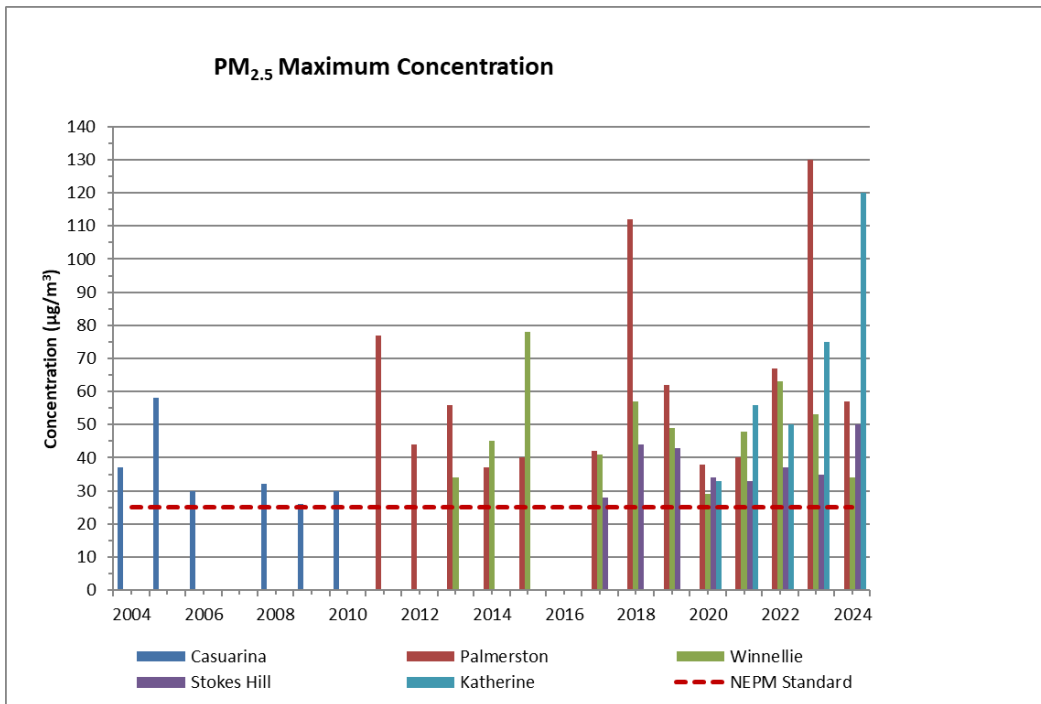


Figure 19: Historical PM_{2.5} 24-hour maximum concentrations

7.3 Smoke from burning vegetation

In the Darwin region generally, smoke from burning vegetation causes exceedances of the particulate matter standards. This connection is based on analysis of monitoring data, satellite imagery and observation of visible smoke on days when particulate matter standards have been exceeded.

Simultaneous monitoring across the Darwin region indicates that, aside from short-term spikes associated with local fire events, particulate matter concentrations are relatively consistent across sites on a seasonal basis. This is supported by 2024 PM_{2.5} annual average concentrations of 8.4 µg/m³ (Palmerston), 10.3 µg/m³ (Stokes Hill) and 9.4 µg/m³ (Winnellie).

Figure 20 shows large scale fires burning in the top end on 21 May 2024, with smoke blowing towards Darwin from fires burning to the southeast, providing a snapshot of visible smoke plumes and hotspots from current and recent fire activity. Although the picture does not show smoke impacting on Darwin or Palmerston, significantly high particulate levels were experienced beyond the visible smoke plume—all the Darwin stations recorded PM_{2.5} levels above the AAQ NEPM standard on that day (see Table 25; Appendix B).

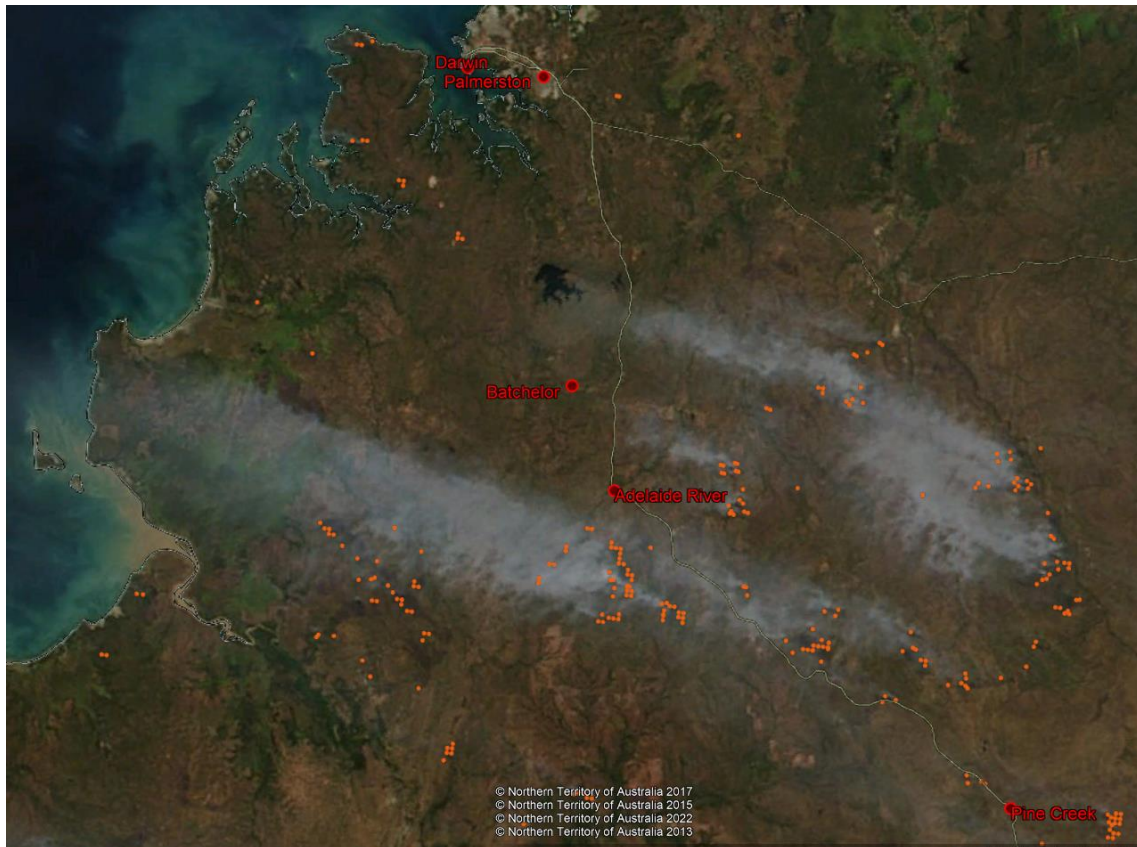


Figure 20: Large-scale fire events impacting the Top End on 21 May 2024 (Source: NASA Worldview)

Historical fire-scar data from the Northern Australia Fire Information website (NAFI 2024) does not depict a clear long-term relationship between area burnt and particulate matter levels measured at the monitoring stations. The total area burnt is not the only key driver of particulate matter impacts on Darwin, other factors such as the timing of burns in relation to meteorological conditions such as wind-speed/direction and temperature inversions play a significant part in total particulate matter impacts on population centres.

Fires include controlled burns, unintended fires or arson. Controlled burns present opportunities for managing particles in air. Unintended fires can be reduced by pre-emptively burning areas with high fuel loads during favourable meteorological condition, which will result in smoke being directed away from population centres.

Extending the monitoring of particles in air to other regional centres in the NT, such as Alice Springs, would contribute towards development of NT Government air quality policy and may provide the basis for the development of management strategies aimed at reducing the impact of particles on urban populations in the future.

References

- ABS 2024. Australian Bureau of Statistics. Population estimates and components by SA2, 2023 to 2024 Regional population, 2023-24 Financial Year. Released on 27 March 2025. Retrieved on 24 November 2025. [Regional population, 2023-24 financial year | Australian Bureau of Statistics](#)
- AAQ NEPM 2021. National Environment Protection (Ambient Air Quality) Measure. [National Environment Protection \(Ambient Air Quality\) Measure - Federal Register of Legislation](#)
- EWG 2017. Annual Evaluation and Reporting Population Exposures to Particles as PM2.5. Expert Working Group.
- Gras et al. 2001. *A Pilot Study of Air Quality in Darwin, NT for the Northern Territory Government, Department of Lands Planning and Environment*. Final Report CSIRO Atmospheric Research Aspendale, Victoria Australia, 15 March 2001. [final report 1.PDF](#)
- PRC 2001. National Environment Protection (Ambient Air Quality) Measure Technical Paper No. 5: Data Collection and Handling (NEPC Peer Review Committee May 2001). Available at: [EPHC Archive - Ambient Air Quality NEPM | nepc](#)
- PRC 2002. National Environment Protection (Ambient Air Quality) Measure Technical Paper No. 8: Annual Reports (NEPC Peer Review Committee October 2002). Available at: [EPHC Archive - Ambient Air Quality NEPM | nepc](#)
- NAFI 2024. Northern Australian Fire Information *Fire Reports*. [Northern Australian Fire Information](#)
- NASA 2024. NASA Worldview application, part of the NASA Earth Observing System Data and Information System (EOSDIS). [NASA Worldview](#)
- NEPC (NT) Act 1994. National Environment Protection Council (Northern Territory) Act 1994 [Northern Territory Legislation](#)
- NEPC 2011. National Environment Protection (Ambient Air Quality) Measure Review, Prepared for the National Environment Protection Council May 2011. [National Environment Protection](#)
- NTG 2001. Monitoring Plan for the Northern Territory, May 2001 [Monitoring Plan May 2001 - no Apps.PDF](#)
- WMPC Act 1998. Waste Management and Pollution Control Act 1998. [Northern Territory Legislation](#)

Appendix A: Particulates events for 2024

Table 25: Pollution events caused by PM_{2.5} and PM₁₀ exceedances of 24-hour AAQ NEPM standards

Date	Particulates Concentration (µg/m ³)							
	Katherine		Palmerston		Stokes Hill		Winnellie	
	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10
11-May	9.2	12.0	24.0	120.5	24.6	30.0	29.5	38.3
20-May	3.1	12.1	n/a	n/a	21.1	53.6	20.4	31.2
21-May	8.8	13.5	27.7	41.0	31.2	55.6	27.1	39.7
22-May	12.0	15.6	23.9	38.6	26.1	36.1	26.1	41.2
23-May	5.6	11.2	24.3	33.1	31.6	40.6	n/a	n/a
4-Jun	n/a	n/a	20.3	27.0	38.6	47.9	26.5	31.6
7-Jun	n/a	n/a	22.2	28.5	24.2	59.9	24.8	33.5
8-Jun	5.4	18.6	24.3	31.2	33.9	60.6	29.4	34.2
13-Jun	n/a	n/a	n/a	n/a	29.1	48.1	19.2	25.6
15-Jun	21.6	33.0	19.7	25.6	29.5	67.6	19.5	25.2
17-Jun	15.6	26.1	21.4	27.7	30.4	89.2	n/a	n/a
18-Jun	17.7	26.5	26.5	32.7	25.3	45.4	n/a	n/a
19-Jun	26.0	34.7	24.8	31.3	22.2	34.5	19.8	28.0
20-Jun	37.0	46.8	25.1	32.6	24.7	33.4	23.3	30.2
21-Jun	30.3	42.6	29.3	36.5	26.9	34.7	28.3	37.8
25-Jun	10.8	n/a	n/a	n/a	23.6	33.4	27.5	33.3
26-Jun	8.5	n/a	n/a	n/a	50.2	60.4	26.3	35.1
27-Jun	5.7	11.0	n/a	n/a	42.7	50.1	27.9	35.2
29-Jun	13.2	20.0	19.0	23.5	32.4	37.7	33.5	40.2
4-Jul	12.3	18.1	14.0	19.4	11.4	61.4	14.4	22.6
6-Jul	13.3	23.2	27.6	32.4	n/a	n/a	24.6	35.3
10-Jul	28.0	36.9	8.1	14.4	11.0	20.3	n/a	n/a
11-Jul	30.1	37.6	9.0	14.1	14.6	28.2	n/a	n/a
12-Jul	60.3	75.5	8.6	12.9	16.8	24.3	13.3	20.3
13-Jul	120.0	134.6	12.3	15.8	15.1	19.9	11.8	15.7
14-Jul	12.4	21.6	18.6	23.9	27.1	31.7	21.0	26.7
17-Jul	7.8	16.6	10.7	19.1	14.8	58.4	24.0	36.5
18-Jul	-0.1	9.3	23.6	30.5	29.1	41.1	31.0	44.3
19-Jul	4.4	12.3	18.6	25.9	28.6	37.6	22.9	33.7
21-Jul	4.4	17.3	37.8	44.9	18.2	28.4	29.6	37.6
24-Jul	16.9	35.5	n/a	n/a	25.6	38.8	20.8	32.9
26-Jul	30.6	40.1	8.8	14.3	11.2	16.1	n/a	n/a
2-Aug	28.9	39.3	9.6	13.7	9.8	15.8	n/a	n/a
7-Aug	10.3	21.8	26.7	31.1	16.6	28.1	n/a	n/a
10-Aug	13.1	23.8	n/a	n/a	27.8	33.6	n/a	n/a
15-Aug	26.2	34.3	13.1	16.2	12.6	21.5	13.6	19.1
3-Sep	21.0	34.3	56.7	63.7	n/a	n/a	7.7	16.2
6-Sep	32.6	40.3	8.7	14.6	8.2	18.9	8.9	19.6
13-Sep	15.4	30.4	34.5	93.5	9.0	27.3	12.1	22.2
14-Sep	19.9	30.2	28.3	53.3	17.1	32.8	16.4	25.8
15-Sep	28.8	39.3	16.4	21.9	15.2	25.1	16.2	25.0

Date	Particulates Concentration ($\mu\text{g}/\text{m}^3$)							
	Katherine		Palmerston		Stokes Hill		Winnellie	
	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5	PM10
16-Sep	42.4	47.9	12.3	16.2	12.7	20.8	13.8	30.4
21-Sep	30.0	33.6	3.3	4.9	3.1	7.1	4.6	10.2
14-Nov	28.2	32.5	10.9	12.8	8.9	12.1	n/a	6.0
Exceedances	15	2	10	4	18	10	12	0

n/a – data not available

A pollution event for particulates occurs when the daily average concentration measured at any of the air quality monitoring stations exceeds any of the AAQ NEPM standards for particulates – $25 \mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$ and $50 \mu\text{g}/\text{m}^3$ for PM_{10} (**Red** – $\text{PM}_{2.5}$ exceedances; **Blue** – PM_{10} exceedances).

Appendix B: Inferred causes of exceedances in 2024

Table 26: 2024 PM₁₀ exceedances of 24-hour AAQ NEPM standard at Katherine AQMS

Date	PM ₁₀ (µg/m ³)	Inferred Cause
12-Jul	75.5	smoke
13-Jul	134.6	smoke

Table 27: 2024 PM₁₀ exceedances of 24-hour AAQ NEPM standard at Palmerston AQMS

Date	PM ₁₀ (µg/m ³)	Inferred Cause
11-May	120.5	smoke
3-Sep	63.7	smoke
13-Sep	93.5	smoke
14-Sep	53.3	smoke

Table 28: 2024 PM₁₀ exceedances of 24-hour AAQ NEPM standard at Stokes Hill AQMS

Date	PM ₁₀ (µg/m ³)	Inferred Cause
20-May	53.6	smoke
21-May	55.6	smoke
7-Jun	59.9	smoke
8-Jun	60.6	smoke
15-Jun	67.6	smoke
17-Jun	89.2	smoke
26-Jun	60.4	smoke
27-Jun	50.1	smoke
4-Jul	61.4	smoke
17-Jul	58.4	smoke

Table 29: 2024 PM_{2.5} exceedances of 24-hour AAQ NEPM standard at Katherine AQMS

Date	PM _{2.5} (µg/m ³)	Inferred Cause
19-Jun	26.0	smoke
20-Jun	37.0	smoke
21-Jun	30.3	smoke
10-Jul	28.0	smoke
11-Jul	30.1	smoke
12-Jul	60.3	smoke
13-Jul	120.0	smoke
26-Jul	30.6	smoke
3-Aug	28.9	smoke
15-Aug	26.2	smoke

Date	PM _{2.5} (µg/m ³)	Inferred Cause
6-Sep	32.6	smoke
15-Sep	28.8	smoke
16-Sep	42.4	smoke
21-Sep	30.0	smoke
14-Nov	28.2	smoke

Table 30: 2024 PM_{2.5} exceedances of 24-hour AAQ NEPM reporting level at Palmerston AQMS

Date	PM _{2.5} (µg/m ³)	Inferred Cause
21-May	27.7	smoke
18-Jun	26.5	smoke
21-Jun	29.3	smoke
6-Jul	27.6	smoke
21-Jul	37.8	smoke
7-Aug	26.7	smoke
3-Sep	56.7	smoke
13-Sep	34.5	smoke
14-Sep	28.3	smoke

Table 31: 2024 PM_{2.5} exceedances of 24-hour AAQ NEPM reporting level at Stokes Hill AQMS

Date	PM _{2.5} (µg/m ³)	Inferred Cause
21-May	31.2	smoke
22-May	26.1	smoke
23-May	31.6	smoke
4-Jun	38.6	smoke
8-Jun	33.9	smoke
13-Jun	29.1	smoke
15-Jun	29.5	smoke
17-Jun	30.4	smoke
18-Jun	25.3	smoke
21-Jun	26.9	smoke
26-Jun	50.2	smoke
27-Jun	42.7	smoke
29-Jun	32.4	smoke
14-Jul	27.1	smoke
18-Jul	29.1	smoke
19-Jul	28.6	smoke
24-Jul	25.6	smoke
10-Aug	27.8	smoke

Table 32: 2024 PM_{2.5} exceedances of 24-hour AAQ NEPM reporting level at Winnellie AQMS

Date	PM _{2.5} (µg/m ³)	Inferred Cause
11-May	29.5	smoke
21-May	27.1	smoke
22-May	26.1	smoke
4-Jun	26.5	smoke
8-Jun	29.4	smoke
21-Jun	28.3	smoke
25-Jun	27.5	smoke
26-Jun	26.3	smoke
27-Jun	27.9	smoke
29-Jun	33.5	smoke
18-Jul	31.0	smoke
21-Jul	29.6	smoke

Appendix C: Population-weighted exposure

A simplified approach was used to calculate population-weighted annual averages for particles as PM_{2.5}, nitrogen dioxide (NO₂) and ozone (O₃) concentrations for the Greater Darwin Region.

Table 33: Calculation of population-weighted exposures for 2024

SA2 ¹	Population ² (P _i)	PM _{2.5} (µg/m ³) (P _i × C _i)	NO ₂ (ppm) (P _i × C _i)	O ₃ (ppm) (P _i × C _i)
Darwin City	7872	81081.6	28.3392	113.90784
Fannie Bay - The Gardens	3875	39912.5	13.95	56.07125
Larrakeyah	4389	45206.7	15.8004	63.50883
Stuart Park	4420	45526	15.912	63.9574
Darwin Airport	20	188.4	0.038	0.2082
East Point	0	0	0	0
Ludmilla - The Narrows	2695	25386.9	5.1205	28.05495
Parap	2969	27967.98	5.6411	30.90729
Woolner - Bayview - Winnellie	2836	26715.12	5.3884	29.52276
Alawa	2206	20780.52	4.1914	22.96446
Anula	2524	23776.08	4.7956	26.27484
Berrimah	2300	21666	4.37	23.943
Brinkin - Nakara	3421	32225.82	6.4999	35.61261
Buffalo Creek	0	0	0	0
Charles Darwin	3	28.26	0.0057	0.03123
Coconut Grove	3007	28325.94	5.7133	31.30287
East Arm	23	216.66	0.0437	0.23943
Jingili	1906	17954.52	3.6214	19.84146
Karama	5040	47476.8	9.576	52.4664
Leanyer	4988	46986.96	9.4772	51.92508
Lyons (NT)	6989	65836.38	13.2791	72.75549
Malak - Marrara	4656	43859.52	8.8464	48.46896
Millner	2635	24821.7	5.0065	27.43035
Moil	2112	19895.04	4.0128	21.98592
Nightcliff	4121	38819.82	7.8299	42.89961
Rapid Creek	3408	32103.36	6.4752	35.47728
Tiwi	2585	24350.7	4.9115	26.90985
Wagaman	2055	19358.1	3.9045	21.39255
Wanguri	1866	17577.72	3.5454	19.42506
Wulagi	2687	25311.54	5.1053	27.97167
Howard Springs	5929	49744.31	9.4864	92.55169
Humpty Doo	9266	77741.74	14.8256	144.64226
Koolpinyah	14	117.46	0.0224	0.21854
Virginia	3598	30187.22	5.7568	56.16478
Weddell	4642	38946.38	7.4272	72.46162
Bakewell	3345	28064.55	5.352	52.21545
Driver	2894	24280.66	4.6304	45.17534

SA2 ¹	Population ² (P _i)	PM _{2.5} (µg/m ³) (P _i × C _i)	NO ₂ (ppm) (P _i × C _i)	O ₃ (ppm) (P _i × C _i)
Durack - Marlow Lagoon	4883	40968.37	7.8128	76.22363
Gray	3387	28416.93	5.4192	52.87107
Moulden	3253	27292.67	5.2048	50.77933
Palmerston - North	4747	39827.33	7.5952	74.10067
Palmerston - South	8546	71700.94	13.6736	133.40306
Rosebery - Bellamack	6950	58310.5	11.12	108.4895
Woodroffe	3427	28752.53	5.4832	53.49547
Population Weighted Exposure	Population	PM_{2.5} (µg/m³)	NO₂ (ppm)	O₃ (ppm)
Greater Darwin Region	152489	9.10	0.00200	0.0132

¹SA2 – ABS Statistical Areas Level 2 are normally designed around whole gazetted suburbs

²Population from ABS 2024 census for the SA2 areas

$$\text{Population weighted exposure} = \sum_i \frac{C_i \times P_i}{P_T}$$

C_i = annual average pollutant concentration at each suburb

P_i = population at each suburb

P_T = total population in Greater Darwin Region

Table 35: Annual average pollutants concentrations (C_i) used to determine population weighted exposure

	PM _{2.5} (µg/m ³)	NO ₂ (ppm)	O ₃ (ppm)
Palmerston	8.39	0.0016	0.01561
Stokes Hill	10.3	0.0036	0.01447
Winnellie	9.4	0.0019	0.01041