Northern Territory Environment Protection Authority

Northern Territory Ambient Air Quality Monitoring Report 2017

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

July 2018

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1 Summary

This report presents Northern Territory air quality monitoring data for the 2017 calendar year and assesses them against the requirements for National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM). Northern Territory Environment Protection Authority (NT EPA) operates 3 air monitoring stations in the Darwin region. The newest station, located at Stokes Hill was established May 2017 as such it did not collect sufficient data in 2017 to enable assessment of its compliance with the AAQ NEPM.

Between 1 January and 31 December 2017, all the ambient air quality monitoring stations in the Darwin region showed no exceedances of the AAQ NEPM standards for carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). However, as explained below, although some exceedances were recorded for ozone (O_3), particulate matter of 10 micrometres or less (PM_{10}) and 2.5 micrometres or less ($PM_{2.5}$), their NEPM goals were met.

Ozone: To comply with the NEPM goal for 1-hour average ozone, one exceedance day per year is allowed. Ozone data recorded at the stations did not exceed this standard.

To comply with the NEPM goal for 4-hour rolling average for ozone, one exceedance day per year of the standard is permitted. During 2017 there was only one exceedance of this standard, and this occurred at Palmerston.

PM_{10}: To comply with the 24-hour NEPM goal for particulates as PM_{10}, no exceedances of the 24-hour standard of 50.0 $\mu g/m^3$ is allowed, unless determined as an exceptional event. Palmerston recorded 7 exceedances and Winnellie recorded 2, but as with previous years these exceedances were linked to hazardous reduction burns, which are exceptional events.

To comply with the annual NEPM goal for particulates as PM_{10}, the annual average must be less than 25.0 $\mu g/m^3$. All monitoring sites complied with this goal.

$PM_{2.5}$: To comply with the 24-hour NEPM goal for particulates as $PM_{2.5}$, no exceedances of the 24-hour standard of 25.0 $\mu g/m^3$ is allowed, unless determined to be an exceptional event. During 2017, all the exceedances of the $PM_{2.5}$ standard (10 at Palmerston, 6 at Winnellie and 1 at Stokes Hill) were related to hazard reduction burns or other natural fire activities and are therefore classified as exceptional events.

To comply with the annual NEPM goal for particulates as $PM_{2.5}$, the annual average must be less than 8.0 $\mu g/m^3$. During 2017 all monitoring sites complied with this goal.

2 Background

Clause 18 of the AAQ NEPM requires jurisdictions to submit a report on their compliance with the AAQ NEPM for each calendar year. The content of the jurisdictional report is prescribed in clause 17 of the AAQ NEPM.

Consistent with the reporting period defined in the AAQ NEPM this report covers the calendar year ending on 31 December 2017 for data collected from the NT EPA monitoring stations located at Palmerston, Winnellie and Stokes Hill (Figure 1). The report is based on Technical Papers No. 8 (Annual Reports) and No. 5 (Data Collection and Handling) which detail the format and data requirements of the Annual Report. It is a technical report to the National Environment Protection Council (NEPC) and supplements the annual summary report provided each year by each jurisdiction under the NEPC Act on the overall implementation of the AAQ NEPM.

This report is available on the NT EPA website at ntepa.nt.gov.au.

Figure 1: Palmerston, Winnellie and Stokes Hill Air Quality Monitoring sites.

3 Overview of the 2017 AAQ NEPM monitoring network and activities

3.1 Monitoring requirements

The results of air quality monitoring in 2000-2001 were used to determine the monitoring requirements for the Northern Territory over the longer term. This monitoring identified fine particles from landscape fires affecting the Darwin region as the primary air pollutant of concern in the Northern Territory. 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.

Since the initial monitoring, the population and industrial activities in Darwin have increased and more detailed monitoring of airborne pollutants is required. In 2010 the establishment and operation of a comprehensive air quality monitoring system for the Darwin region commenced. This 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 deemed necessary as there are no significant sources close to populated areas in the region and the sale of unleaded petrol ceased in 2002.

The air quality monitoring program consists of three stations (Figure 1), a performance monitoring station located near Palmerston; a long term trend monitoring station located at the Bureau of Meteorology (BoM) site in Winnellie; and a recently added station near Stokes Hill Wharf. The Winnellie station has been operational since the second half of 2012, the Palmerston station has been operational since the beginning of 2011 and the Stokes Hill station started operation in May 2017.

3.2 Current monitoring stations for the purposes of this report

The Winnellie station 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 1). The station consists of an air conditioned instrument shed which houses all instrumentation. Ambient air is analysed for nitrogen oxides, ozone, sulfur dioxide and carbon monoxide via a single gas sampling manifold. Air for particulate sampling is drawn from a separate mast attached to the station roof. Meteorological data comes from BoM instruments located on the same site.

The Palmerston station has been located to provide information on airborne pollutants which may be moving from industrial activities in the middle harbour to populations in the Palmerston area. This station meets all siting and instrumentation requirements for reporting under the AAQ NEPM. It is located in light bushland approximately 4km south west of Palmerston (Figure 1).

The station houses the same gas and particulate sampling instruments as Winnellie and has instruments for collection of meteorological data.

Stokes Hill station (Figure 1) is located about 1 km southeast of the CBD on the Darwin Waterfront and meets all siting and instrumentation requirements for reporting under the AAQ NEPM. This station was established to monitor potential air quality impacts from industrial development and increased shipping traffic in Darwin Harbour. The station houses similar gas and particulate sampling instruments as the other stations and has instruments for collection of meteorological data.

Station instrumentation with siting details for all stations is at Tables 1 and 2 below.

3.3 Determination of exposed population for performance monitoring stations

Two areas within the Northern Territory exceed or are close to the population threshold for ambient air quality monitoring of greater than 25,000. These are the Greater Darwin region (137,000) and Alice Springs (25,000).

The major air pollutant of concern for Darwin and Palmerston is particulate matter from bushfire smoke in the Dry Season (April - October). Prevailing winds during the Dry Season are South-Easterly to Easterly, causing the population of the region to be frequently exposed to particulate pollution from relatively small fires in local bushland and more distant large scale savannah fires.

Monitoring for particulates has been conducted at several sites in the Darwin / Palmerston region since 2002. From 2012 monitoring was conducted at two sites, whilst monitoring at the third site commenced in 2017. Results from simultaneous monitoring have shown that aside from spikes attributable to local fire events particulate levels are reasonably uniform across the region on a seasonal basis. This was supported by the 2017 data: $PM_{2.5}$ annual average levels were 7.3 and 6.7 $\mu g/m^3$ respectively for Palmerston and Winnellie; annual average for Stokes Hill was 7.3 $\mu g/m^3$ (the particulate monitor was installed there in July 2017). As industrial development increases divergence in particulate and other pollutant levels may occur between sites.

No monitoring was undertaken in the Alice Springs region during the reporting period. The NT EPA intends to conduct monitoring of particulates in Alice Springs and other regional centres in future years.

Table 1: Summary of station instrument siting compliance with AS 2922-1987

Station	Location Category	Height above ground	Clear Sky Angle	Unrestricted airflow of 360º	20m from trees	No boilers/ incinerators nearby	Minimum distance from road or traffic
Winnellie DBE 1	Bushland	Yes	Yes	Yes	Yes	Yes	Yes
Palmerston DBE 2	Bushland	Yes	Yes	Yes	Yes	Yes	Yes
Stokes Hill DBE 3	Coastal	Yes	Yes	Yes	Yes	Yes	Yes

Table 2: Ambient air quality station instrumentation

Parameter	Data available from	Data available to	Instrument	Sampling frequency
PM_{10}	01/01/11 (Palmerston) 18/07/12 (Winnellie) 03/07/17 (Stokes Hill)	present	TEOM 1405D	continuous
$PM_{2.5}$	01/01/11 (Palmerston) 18/07/12 (Winnellie) 03/07/17 (Stokes Hill)	present	TEOM 1405D	continuous
SO_2	01/01/11 (Palmerston) 18/07/12 (Winnellie) 04/05/17 (Stokes Hill)	present	Thermo Model 43i.	continuous
NOx, NO, NO_2	01/01/11 (Palmerston) 18/07/12 (Winnellie) 04/05/17 (Stokes Hill)	present	Thermo Model 42i.	continuous
O_3	01/01/11 (Palmerston) 18/07/12 (Winnellie) 04/05/17 (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

Meteorology (mast height: 10 m)				
Wind direction	01/01/12 (Palmerston) 04/05/17 (Stokes Hill)	present	RM Young, model 85000 RM Young, model 3600	continuous
Wind speed	01/01/12 (Palmerston) 04/05/17 (Stokes Hill)	present	RM Young, model 85000 RM Young, model 3600	continuous
Sigma Theta	04/05/17 (Stokes Hill)	present	RM Young, model 3600	continuous
Temperature	01/01/12 (Palmerston) 04/05/17 (Stokes Hill)	present	RM Young, model 41382LC TEOM sensor	continuous
Humidity	01/01/12 (Palmerston) 04/05/17 (Stokes Hill)	present	RM Young, model 41382LC TEOM sensor	continuous
Atmospheric Pressure	01/01/12 (Palmerston) 04/05/17 (Stokes Hill)	present	RM Young, model 61302v 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

Meteorological data for Winnellie Station are sourced from BoM instruments located at the site.

3.4 Monitoring during the reporting period

Stokes Hill, Winnellie and Palmerston stations monitor the same range of pollutants. All instruments at the Winnellie and Palmerston stations provided valid data for more than seventy five per cent of the time during the reporting period. Stokes Hill only started operating towards the end of the 2nd quarter of 2017, so it could not meet the 75% minimum data completeness required for assessing AAQ NEPM compliance for measured pollutants.

3.5 Changes to the approved monitoring plan

No changes; however, an additional station, Stokes Hill, was added to the network in May 2017.

3.6 Unresolved issues

There are no unresolved issues in the reporting period.

3.7 Status of NATA accreditation

All data collection and validation processes were conducted by a National Association of Testing Authorities (NATA) accredited contractor who used Australian Standard methods/instruments for monitoring (Table 3).

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

Pollutant	Standard	Title	Instruments used
Carbon monoxide	AS3580.7.1	Ambient Air – Determination of Carbon Monoxide – Direct Reading Instrument Method	Gas filter correlation/ infra-red
Nitrogen dioxide	AS3580.5.1	Ambient Air – Determination of Oxides of Nitrogen – Chemiluminescence Method	Gas-phase chemiluminescence
Photochemical oxidant (ozone)	AS3580.6.1	Ambient Air – Determination of Ozone – Direct Reading Instrument Method	Non-dispersive ultra-violet
Sulfur dioxide	AS3580.4.1	Ambient Air – Determination of Sulfur Dioxide – Direct Reading Instrument Method	Pulsed fluorescence
Particles as PM_{10}	AS3580.9.8	Determination of Suspended Particulate Matter – PM_{10} continuous direct mass method using a TEOM	Tapered element oscillating microbalance (TEOM)
Particles as $PM_{2.5}$	AS/NZS 3580.9.13	Determination of Suspended Particulate Matter – $PM_{2.5}$ continuous direct mass method using a TEOM	Tapered element oscillating microbalance (TEOM)

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

Standards and goals for pollutants in accordance with the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) are shown in Table 4.

Table 4: Ambient Air Quality NEPM Standards

Pollutant	Averaging period	Maximum (ambient) concentration	Goal
Carbon monoxide	8 hour	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None
Photochemical oxidants (as ozone)	1 hour	0.10ppm	1 day a year
	4 hours	0.08ppm	1 day a year
Sulfur dioxide	1 hour	0.20 ppm	1 day a year
	1 day	0.08 ppm	1 day a year
	1 year	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/m3	None

The following tables (5-10) summarise compliance with the standards and goals of the AAQ NEPM. Data availability (quarterly and annual), the number of days when standards were exceeded, the annual mean (where an annual standard exists) and an assessment of compliance are given for each pollutant.

A station's performance is assessed as complying with the NEPM (i.e. 'Met') if the number of exceedances is no more than the number specified in Schedule 2 of the AAQ NEPM and data availability was at least 75%.

Performance is assessed as not complying (i.e. 'Not Met') if there is more than the number of exceedances specified in Schedule 2 of the AAQ NEPM.

If there is insufficient data (less than 75% availability) then performance is assessed as 'Not Demonstrated' ('ND').

CARBON MONOXIDE

Table 5: 2017 compliance summary for CO in the Northern Territory

AAQ NEPM Standard

9.0 ppm (8 hour average)

Region/ Performance monitoring station	Data Availability Rates (% of Days)					Number of exceedances (days)	Performance against the standard and goal
	Q1	Q2	Q3	Q4	Annual		
Winnellie	95	80	77	94	87	0	Met
Palmerston	91	91	86	84	88	0	Met
Stokes Hill	0	58	95	95	62	0	ND

During 2017 no exceedance of the carbon monoxide (CO) standard was recorded in the Darwin region. Compliance with the AAQ NEPM goal for CO was demonstrated at all sites except Stokes Hill which had insufficient data.

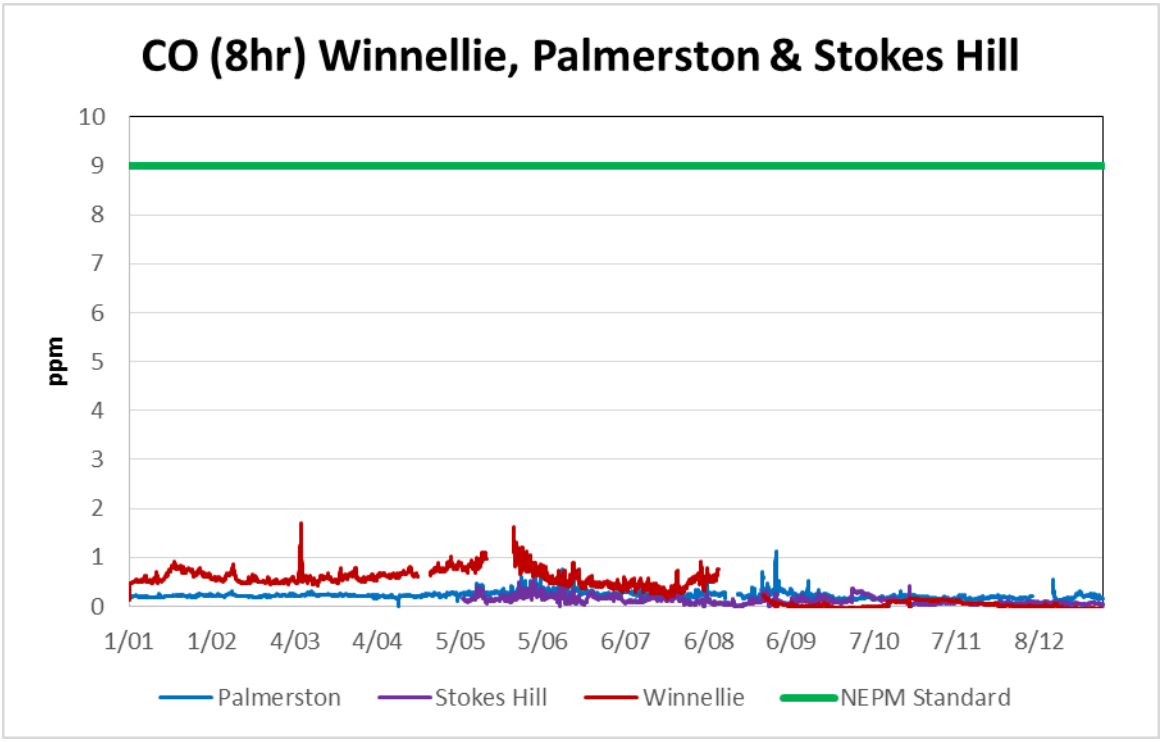

Figure 2: CO 8-hour

NITROGEN DIOXIDE

Table 6: 2017 compliance summary for NO_2 in the Northern Territory

AAQ NEPM Standard

0.12 ppm (1 hour average)

0.03 ppm (1 year average)

Region/ Performance monitoring station	Data Availability Rates (% of Days)					Number of exceedances (days)	Annual mean (ppm)	Performance against the standard and goal	
	Q1	Q2	Q3	Q4	Annual			1h	1y
Winnellie	95	85	95	94	92	0	0.0031	Met	Met
Palmerston	79	91	86	84	85	0	0.0022	Met	Met
Stokes Hill	0	60	95	95	63	0	0.0025	ND	ND

During 2017 no exceedances of the nitrogen dioxide (NO_2) one-hour and annual standards were recorded in the Darwin region. Compliance with the AAQ NEPM goal for NO_2 was demonstrated at all sites except Stokes Hill which had insufficient data.

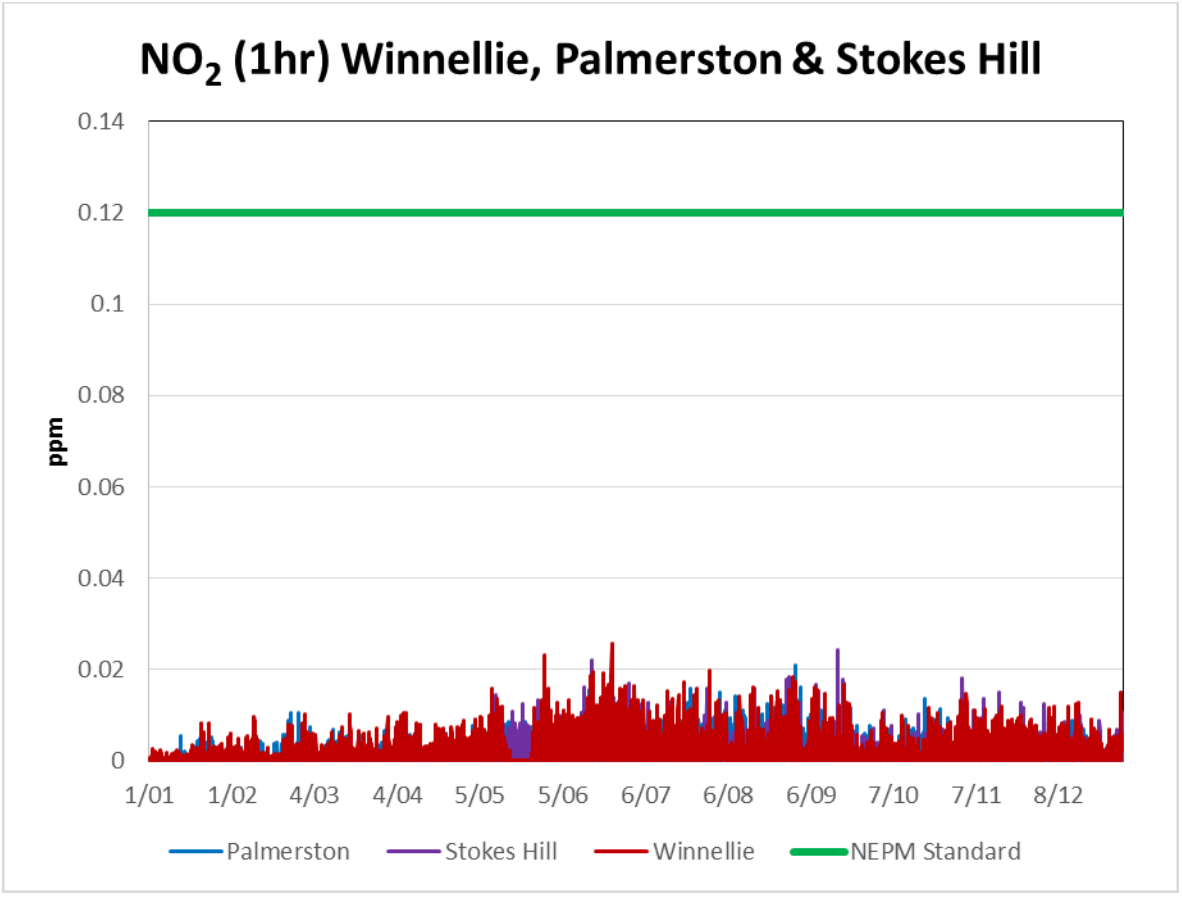

Figure 3: NO_2 1-hour

OZONE

Table 7: 2017 compliance summary for Ozone in the Northern Territory

AAQ NEPM Standard

0.10 ppm (1 hour average)

0.08 ppm (4 hour average)

Region/ Performance monitoring station	Data Availability Rates (% of Days)					Number of exceedances (days)		Performance against the standard and goal	
	Q1	Q2	Q3	Q4	Annual	1 h	4 h	1h	4h
Winnellie	95	86	95	95	93	0	0	Met	Met
Palmerston	95	95	90	88	92	0	1	Met	Met
Stokes Hill	0	60	88	60	52	0	0	ND	ND

During 2017 no exceedance of the ozone (O_3) one-hour standard was recorded in the Darwin region.

An exceedance of the ozone 4-hour rolling average standard was recorded at Palmerston. However, the AAQ NEPM allows one exceedance day for this standard.

Compliance with the AAQ NEPM goal for O_3 was demonstrated at all sites except Stokes Hill which had insufficient data.

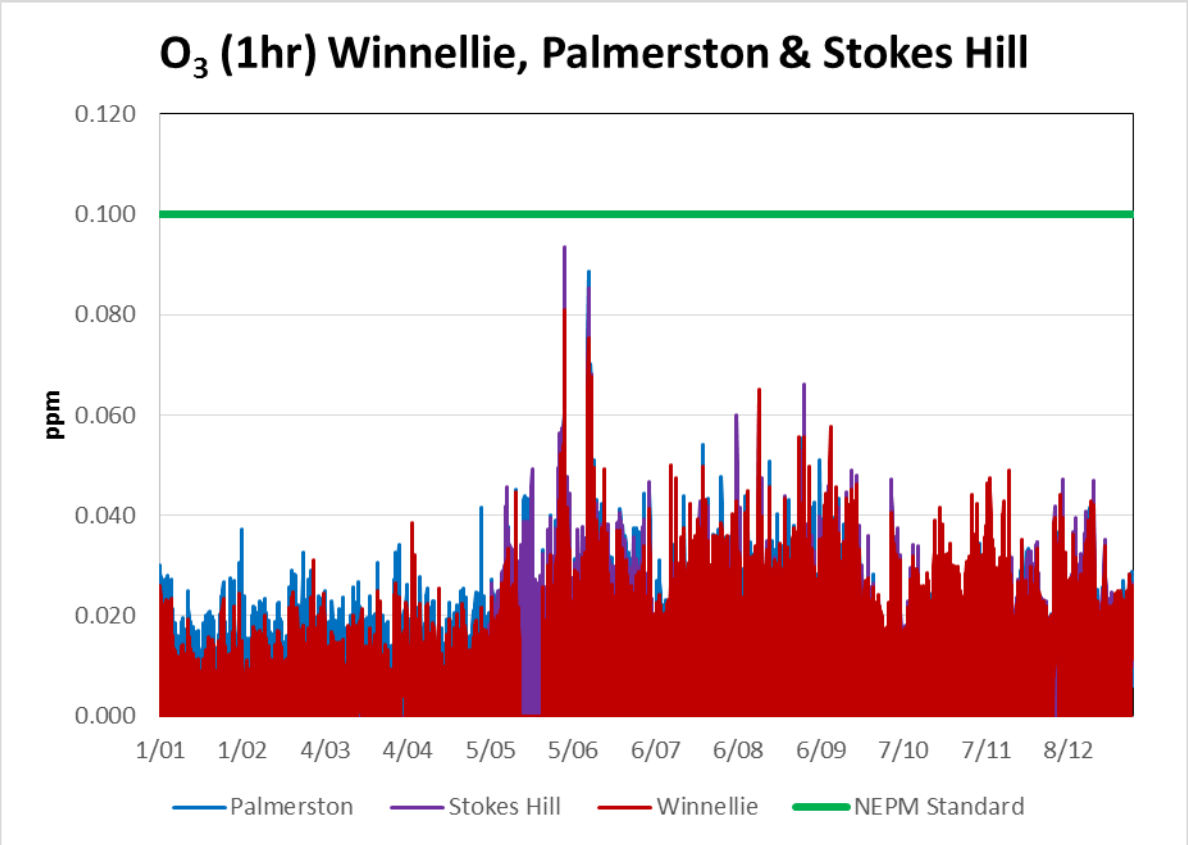

Figure 4: O_3 1-hour

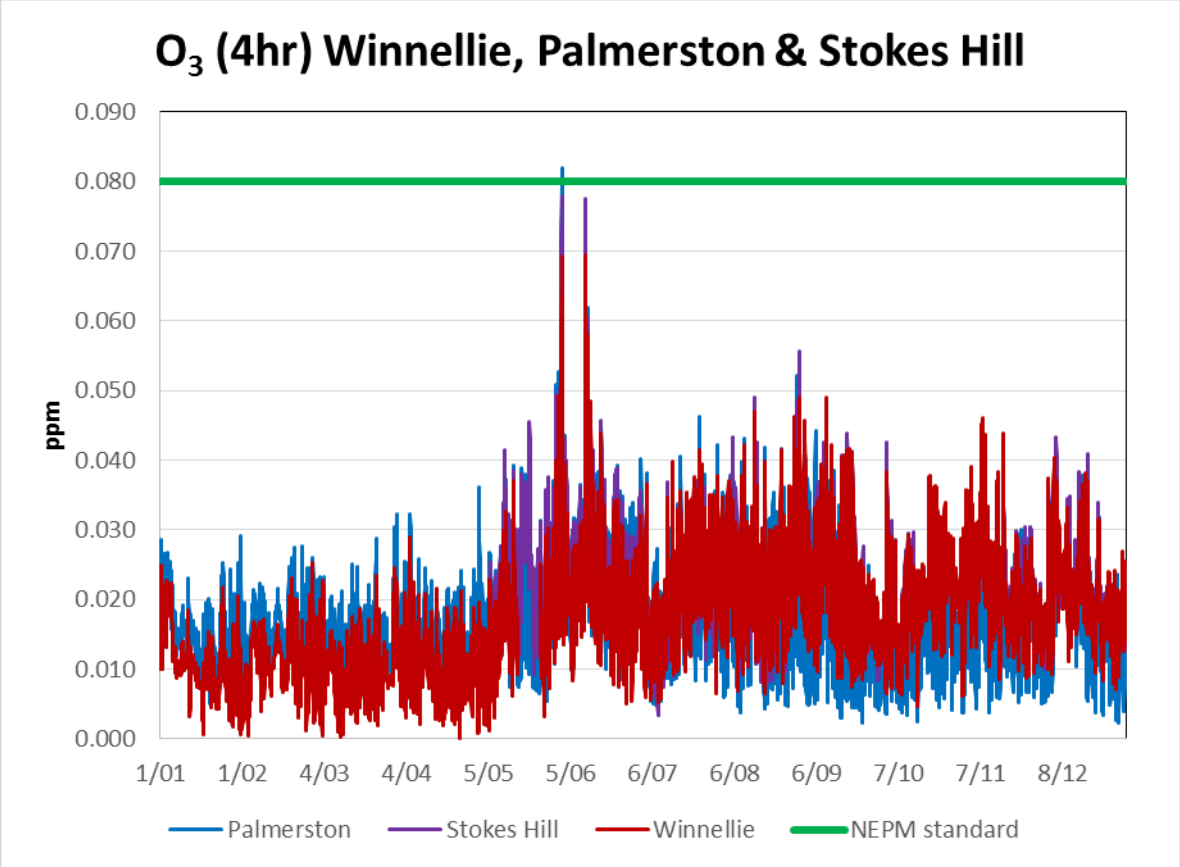

Figure 5: O_3 4-hour

SULFUR DIOXIDE

Table 8: 2017 compliance summary for SO_2 in the Northern Territory

AAQ NEPM Standard

0.20 ppm (1 hour average)

0.08 ppm (24 hour average)

0.02 ppm (1 year average)

Region/ Performance monitoring station	Data Availability Rates (% of Days)					Number of exceedances (days)		Annual mean (ppm)	Performance against the standard and goal		
	Q1	Q2	Q3	Q4	Annual	1h	24h		1h	24h	1y
Winnellie	95	85	95	94	92	0	0	0.0004	Met	Met	Met
Palmerston	91	86	78	84	85	0	0	0.0003	Met	Met	Met
Stokes Hill	0	60	95	95	63	0	0	0.0003	ND	ND	ND

During 2017 no exceedances of the sulfur dioxide (SO_2) one-hour, 24-hour and annual standards were recorded in the Darwin region. Compliance with the AAQ NEPM goal for SO_2 was demonstrated at all sites except Stokes Hill which had insufficient data.

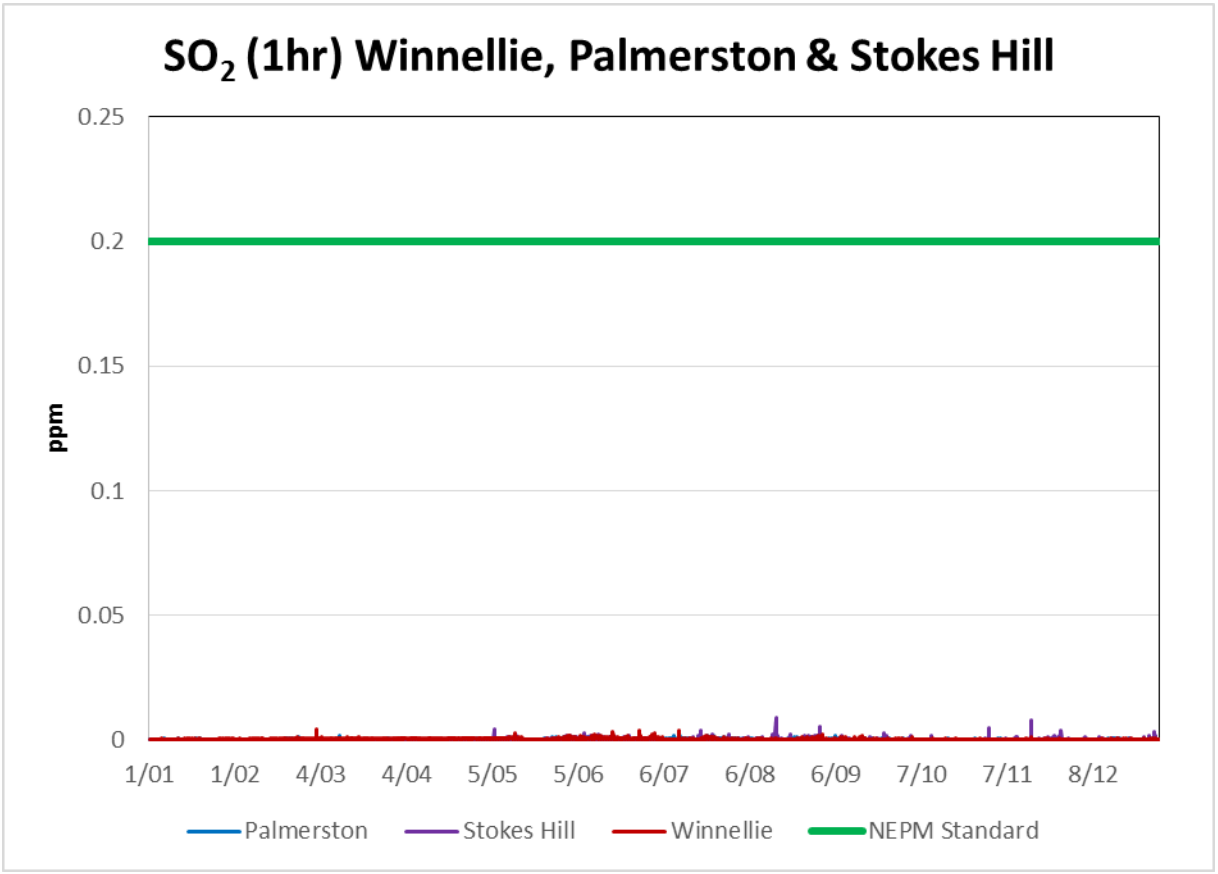

Figure 6: SO_2 1-hour

PARTICULATES PM_{10}

Table 9: 2017 compliance summary for PM_{10} in the Northern Territory

AAQ NEPM Standard

50 µg/m³ (24-hour average)

25 µg/m³ (1-year average)

Region/ Performance monitoring station	Data Availability Rates (% of Days)					Number of exceedances (days)	Annual average (µg/m³)	Performance against the standard and goal	
	Q1	Q2	Q3	Q4	Annual			24h	1y
Winnellie	49	89	99	96	84	2	15.4	Met	Met
Palmerston	99	99	95	92	96	7	19.5	Met	Met
Stokes Hill	0	0	96	100	49	0	19.9	ND	ND

During 2017 exceedances of the PM_{10} 24-hour standard were recorded. However, 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. Annual averages were below the standard. Compliance with the AAQ NEPM goal for PM_{10} was demonstrated at all sites except Stokes Hill which had insufficient data.

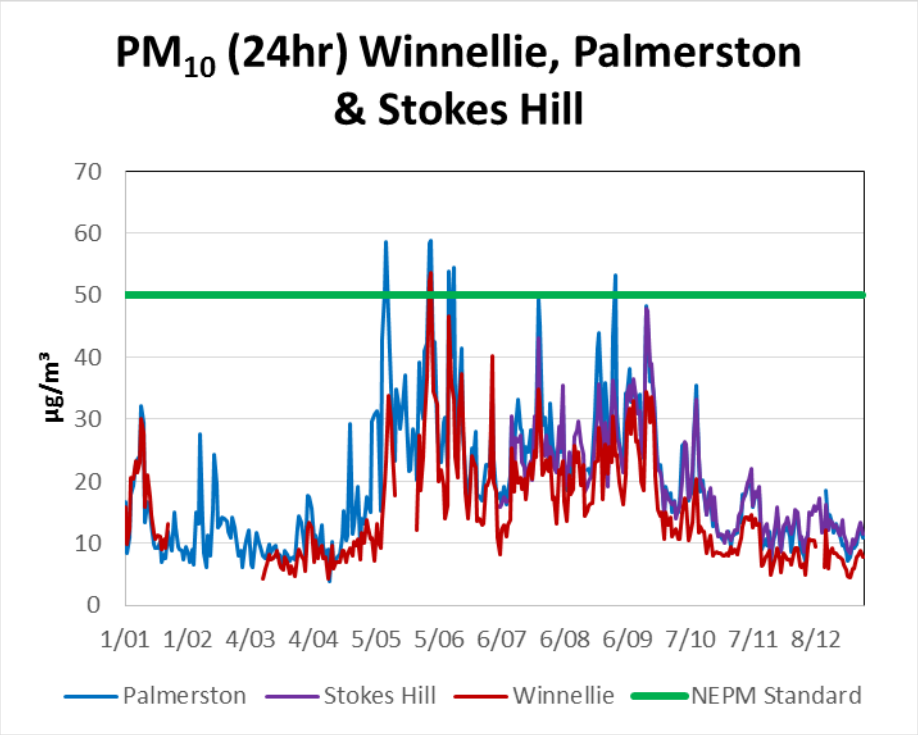

Figure 7: PM_{10} 24-hour

PARTICULATES $PM_{2.5}$

Table 10: 2017 compliance summary for $PM_{2.5}$ in the Northern Territory

AAQ NEPM Standard

25 µg/m³ (24-hour average)

8 µg/m³ (1 year average)

Region/ Performance monitoring station	Data Availability Rates(% of Days)					Number of exceedances (days)	Annual average µg/m³	Performance against the standard and goal	
	Q1	Q2	Q3	Q4	Annual			24h	1y
Winnellie	49	89	99	96	84	6	6.7	Met	Met
Palmerston	99	99	95	92	96	10	7.3	Met	Met
Stokes Hill	0	0	96	100	49	1	7.3	ND	ND

During 2017 exceedances of the $PM_{2.5}$ 24-hour standard were recorded. However, these 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. Annual averages were below the standard. Compliance with the AAQ NEPM goal for $PM_{2.5}$ was demonstrated at all sites except Stokes Hill which had insufficient data.

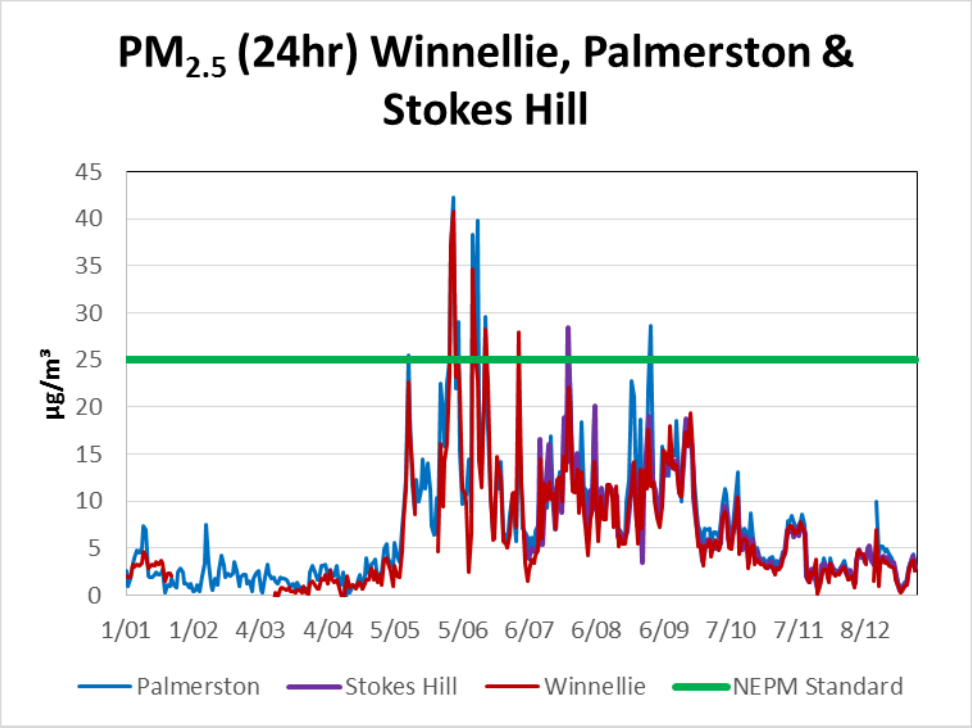

Figure 8: $PM_{2.5}$ 24-hour

5 Analysis of air quality data

Annual summary statistics are presented in this section. The AAQ NEPM states that short-term standards should not be exceeded on more than one day for carbon monoxide, nitrogen dioxide, ozone and sulfur dioxide, or on any day for PM_{10} and $PM_{2.5}$ except when caused by natural events such as bushfires.

Figures 2, 3 & 6 above show that for carbon monoxide, nitrogen dioxide and particularly sulfur dioxide, levels were significantly below the Air NEPM standards.

In this section data availability is presented as the number of valid days, this value represents the number of days during the year when at least 75% of averaging periods during the day are valid.

There must be a minimum of 75% data availability in any averaging period for the data to be reported against the corresponding NEPM standard. For example, the 4-hour ozone NEPM standard is based on four-hour rolling averages. A valid 4-hour rolling average is calculated as the average of the valid one-hour averages over the preceding 4 hours, when at least 3 of those hours (75%) held valid data. In the case of the CO 8-hour rolling average the minimum number of valid hours required for averaging is 6.

Table 11: 2017 summary statistics for daily peak 8 hour CO in the Northern Territory

AAQ NEPM Standard

9.0 ppm (8 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date:hour)	2nd highest (ppm)	2nd Highest (date:hour)
Winnellie	331	1.70	06/03:11	1.62	25/05:04
Palmerston	351	1.14	31/08:08	0.75	12/06:04
Stokes Hill	240	0.51	01/06:03	0.50	27/05:04

Carbon monoxide (CO) levels at all the stations were substantially below the AAQ NEPM carbon monoxide 8-hour rolling average standard. The highest recorded reading was at Winnellie (1.7 ppm) which was 20% of the NEPM standard.

Table 12: 2017 summary statistics for daily peak 1 hour NO_2 in the Northern Territory

AAQ NEPM Standard

0.12 ppm (1 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date:hour)	2nd highest (ppm)	2nd Highest (date:hour)
Winnellie	354	0.026	23/06:08	0.023	29/05:03
Palmerston	339	0.021	31/08:04	0.016	01/09:23
Stokes Hill	241	0.024	15/09:24	0.019	16/09:01

Nitrogen dioxide (NO_2) levels were below the AAQ NEPM one-hour nitrogen dioxide standard. The highest recorded reading was at Winnellie (0.026 ppm), and was not very different from the maximum values at the other stations.

Table 13: 2017 summary statistics for daily peak 1 hour O_3 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)	2nd highest (ppm)	2nd Highest (date:hour)
Winnellie	354	0.081	01/06:19	0.075	10/06:18
Palmerston	351	0.092	01/06:18	0.089	10/06:18
Stokes Hill	197	0.094	01/06:18	0.085	10/06:19

Table 14: 2017 summary statistics for daily peak 4 hour O_3 in the Northern Territory

AAQ NEPM Standard

0.08 ppm (4 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date:hour)	2nd highest (ppm)	2nd Highest (date:hour)
Winnellie	354	0.069	10/06:19 01/06:20	0.058	11/06:19
Palmerston	351	0.082	01/06:20	0.077	10/06:20
Stokes Hill	197	0.078	01/06:20	0.077	10/06:20

There were no exceedances for the 1-hour NEPM ozone standard at any of the monitoring sites.

Although there was an exceedance of the 4-hour ozone standard at Palmerston, the NEPM goal allows for one exceedance day per year.

Each station recorded their highest 1-hour peak on the same day (1/06/2017) as the other stations and at almost the same time (18:00 - 19:00). The period was characterised with high temperatures (26 - 32 deg.), low wind speeds (2 m/s, average) and high solar radiation (800 W/m^2, maximum). The second highest 1-hour ozone peak occurred on the same day (10/06/2017) and similar times for all the stations.

Table 15: 2017 summary statistics for 1 hour SO_2 in the Northern Territory

AAQ NEPM Standard

0.20 ppm (1 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date:hour)	2nd highest (ppm)	2nd Highest (date:hour)
Winnellie	354	0.0042	02/03:10	0.0037	11/07:13
Palmerston	337	0.0023	31/08:04	0.0022	11/07:15
Stokes Hill	241	0.0088	15/08:10	0.0079	15/11:15

Table 16: 2017 summary statistics for 24 hour SO_2 in the Northern Territory

AAQ NEPM Standard

0.08 ppm (24 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (ppm)	Highest (date)	2nd highest (ppm)	2nd Highest (date)
Winnellie	354	0.0014	10/06	0.0013	01/06
Palmerston	337	0.0011	23/07	0.0010	10/06
Stokes Hill	241	0.0011	15/08	0.0010	01/06

Sulfur dioxide (SO_2) levels in the Darwin region were substantially below the AAQ NEPM 1-hour and 24-hour sulfur dioxide standards. The highest recorded 1-hour reading was at Stokes Hill (0.0088 ppm). This value and the second highest recorded value (0.0079 ppm) were much

higher that values recorded at the other stations. The highest recorded 24-hour average was at Winnellie (0.0014 ppm).

Table 17: 2017 summary statistics for 24 hour PM_{10} in the Northern Territory

AAQ NEPM Standard

50 μg/m^3 (24 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (μg/m^3)	Highest (date)	2nd highest (μg/m^3)	2nd Highest (date)
Winnellie	306	53.8	01/06	52.4	31/05
Palmerston	352	58.8	01/06	58.6	10/05
Stokes Hill	181	48.0	15/09	47.5	16/09

Table 18: 2017 summary statistics for 24 hour $PM_{2.5}$ in the Northern Territory

AAQ NEPM Standard

25 μg/m^3 (24 hour average)

Region/ Performance monitoring station	Number of valid days	Highest (μg/m^3)	Highest (date)	2nd highest (μg/m^3)	2nd Highest (date)
Winnellie	306	40.8	01/06	37.0	31/05
Palmerston	352	42.3	01/06	39.8	12/06
Stokes Hill	181	28.5	24/07	20.2	05/08

The highest $PM_{2.5}$ and PM_{10} levels occurred on the same date (01/06/17) for Winnellie and Palmerston, and exceeded the NEPM standards. Stokes Hill particulates monitor had not been installed at that time. These exceedances and others were due to bushfire activity which the AAQ NEPM classifies as a 'natural event'. High fine particle levels are typical of the Darwin air shed during the Dry.

Since all exceedances of particulate standards were attributed to exceptional events, particulate levels were in compliance with NEPM goals.

6 Analysis of exceedances and progress in achieving Air NEPM goals

Particulates generated by vegetation burning are the primary air pollutants in the Darwin region. This results in significant variation in air quality between the Dry (May-November) and the Wet (December-April). In general, air quality was excellent during the Wet and poor during the Dry of 2017. Averaged daily levels of $PM_{2.5}$ across all stations over the six months of the Dry were 10.6 $\mu g/m^3$, well above the Air NEPM annual standard of 8 $\mu g/m^3$ and significantly higher than levels in several Australian cities. Averaged daily $PM_{2.5}$ levels during the Wet were 2.9 $\mu g/m^3$. The elevated $PM_{2.5}$ levels during the Dry are unavoidable and people with respiratory or cardiopulmonary issues may be impacted.

The standard for $PM_{2.5}$ had multiple exceedances in 2017 (Figure 8). There were 10 exceedances of the 24-hour standard at Palmerston station, but the annual limit was not exceeded. The Winnellie station had 6 exceedances of the 24-hour standard, but did not exceed the annual limit. Only one exceedance was recorded at Stokes Hill; most of the exceedances at the other stations occurred before the particulate monitor was installed at Stokes Hill.

The AAQ NEPM standard for PM_{10} was exceeded on 7 days at Palmerston and on 2 days at Winnellie, however, the annual PM_{10} limit was not exceeded.

As explained in previous sections of this report, since the $PM_{2.5}$ and PM_{10} exceedances were caused by natural events such as bushfire activity, they are considered to be exceptional events under the AAQ NEPM.

Tables 19 - 23 show dates and inferred causes of particulate exceedances for all stations.

Table 19: 2017 PM_{10} exceedances of NEPM reporting level at Palmerston

Date	PM_{10} ($\mu g/m^3$)	Inferred Cause
01/06	58.8	smoke
10/05	58.6	smoke
31/05	58.4	smoke
12/06	54.5	smoke
10/06	53.8	smoke
31/08	53.3	smoke
09/05	50.8	smoke

Table 20: 2017 PM_{10} exceedances of NEPM reporting level at Winnellie

Date	PM_{10} ($\mu g/m^3$)	Inferred Cause
01/06	53.8	smoke
31/05	52.4	smoke

Table 21: 2017 $PM_{2.5}$ exceedances of NEPM reporting level at Palmerston

Date	TEOM $PM_{2.5}$ ($\mu g/m^3$)	Inferred Cause
01/06	42.3	smoke
12/06	39.8	smoke
10/06	38.4	smoke
31/05	37.1	smoke
16/06	29.6	smoke
03/06	29.0	smoke
31/08	28.7	smoke
11/06	26.1	smoke
11/05	25.5	smoke
30/05	25.1	smoke

Table 22: 2017 $PM_{2.5}$ exceedances of NEPM reporting level at Winnellie

Date	$PM_{2.5}$ ($\mu g/m^3$)	Inferred Cause
01/06	40.8	smoke
31/05	37.0	smoke
10/06	34.6	smoke
16/06	28.2	smoke
01/07	27.9	smoke
11/06	25.6	smoke

Table 23: 2017 $PM_{2.5}$ exceedances of NEPM reporting level at Stokes Hill

Date	TEOM $PM_{2.5}$ ($\mu g/m^3$)	Inferred Cause
24/07	28.5	smoke

Smoke from burning vegetation contains PM_{10} and $PM_{2.5}$, Figures 9 - 11 show the close relationship between these parameters at all stations during the Dry Season.

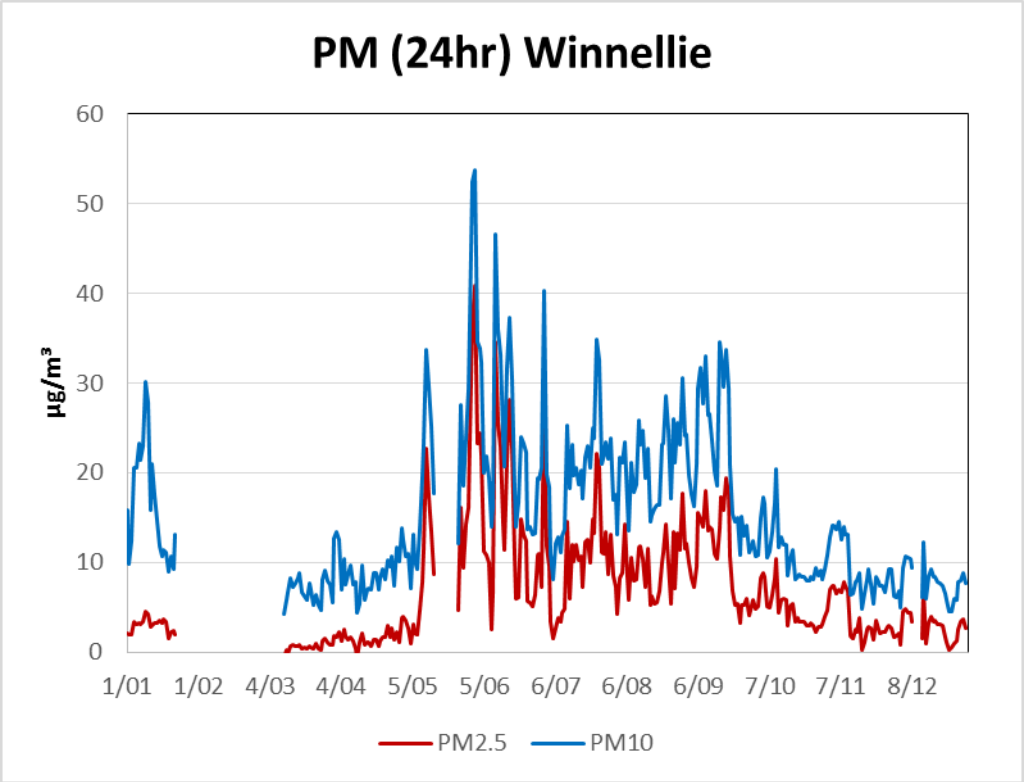

Figure 9

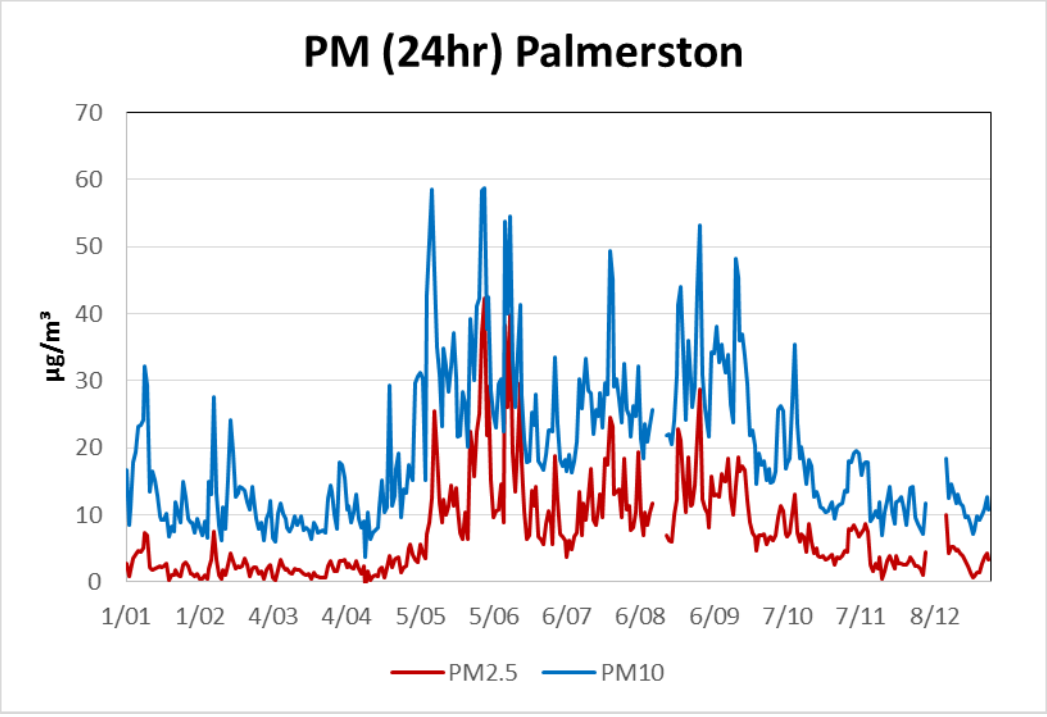

Figure 10

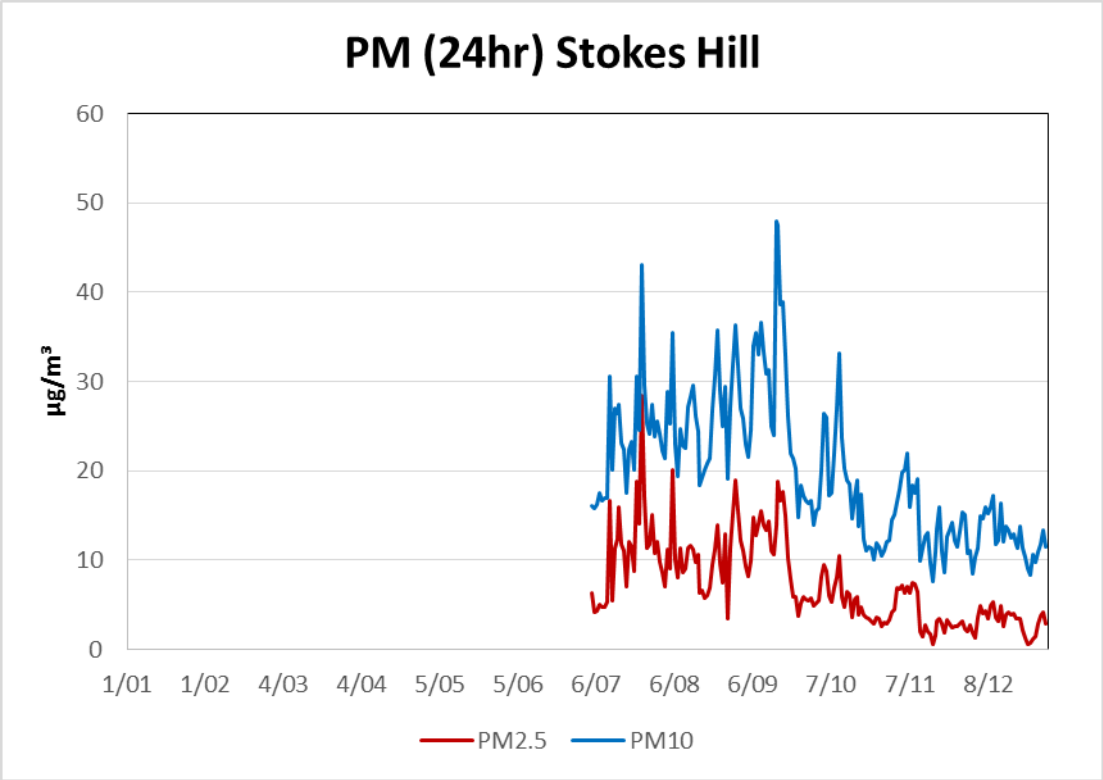

Figure 11

Ozone is not expected to be a pollutant of concern in the Darwin region because of the relatively low emissions of ozone precursors (oxides of nitrogen and organic compounds) into the airshed by motor vehicles as compared to other Australian cities. However, the 4-hour ozone standard was exceeded at Palmerston (Table 24). The AAQ NEPM permits one exceedance day per year of this standard.

On the day of the exceedance (01/06/2017) elevated ozone levels as well as high particulate levels were recorded at all the stations. Particulates were ascribed to smoke from burning vegetation; an activity that has been linked to high ozone episodes.

Table 24: 2017 Ozone (4-hr average) exceedances of NEPM reporting level at Palmerston

Date	Ozone (ppm)	Inferred Cause
01/06	0.082	smoke

7 Data analysis and trends

Tables 25 to 28 below compare the number of exceedances in the NT over a longer period of time 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 have been used since monitoring began in 2002 (TEOM and Partisol) and instruments have not been located consistently throughout the sampling period.

Issues with historical data include:

- 2004 - data collection for this project did not commence until the second quarter.
- 2004 and 2005 - TEOM was located in Palmerston at the Charles Darwin University Palmerston campus.
- 2006 - TEOM data availability was below 75% for each quarter so Partisol data was used.
- 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 also TEOM instruments.
- 2016 - data has not been analysed
- 2017 - Stokes Hill station started operating in May, TEOM data was only available from July.

Since the establishment of the Palmerston station in 2011 and then the Winnellie station in 2012 data quality has generally improved. During the Wet of 2013 the Palmerston TEOM was offline for a number of months resulting in inadequate data collection for NEPM reporting. As the TEOM was operational for most of the Dry, when particulates are an issue, 2013 data from Palmerston is still useful when considering longer term trends in particulates.

Table 25: Trends - PM_{10} 2004-2017

Year	Casuarina			Palmerston			Winnellie			Stokes Hill		
	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)
2004	*69*	*1*	*54*									
2005	98	2	63									
2006	97	0	44									
2007	95	0	45									
2008	97	1	65									
2009	90	0	50									
2010	78	1	54									
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			
2017				96	7	59	84	2	54	49	0	48

Table 26: Averaged PM_{10} Key Metrics 2004-2017

Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)
77	3	61

Table 27: Trends $PM_{2.5}$, 2004-2017

Year	Casuarina			Palmerston			Winnellie			Stokes Hill		
	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)	Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)
2004	60	5	37									
2005	98	5	58									
2006	97	5	30									
2007	-	-	-									
2008	72	2	32									
2009	87	1	26									
2010	62	2	30									
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			
2017				96	10	42	84	6	41	49	1	28

Table 28: Averaged $PM_{2.5}$ Key Metrics 2004-2017

Data Availability (%)	Number of Exceedances	Max Concentration (µg/m³)
75	6	41

Trend data for the 2004 to 2017 period is presented in Figures 12 to 17. This data shows that there is no clear trend in $PM_{2.5}$ or PM_{10} in the Darwin region over the period. Population of the greater Darwin region has increased from approximately 105 000 in 2004 to 140 000 in 2017 showing a clear upward trend. The lack of a relationship between population and particulate levels further demonstrates that the majority of particulate matter in the Darwin airshed derives from natural sources.

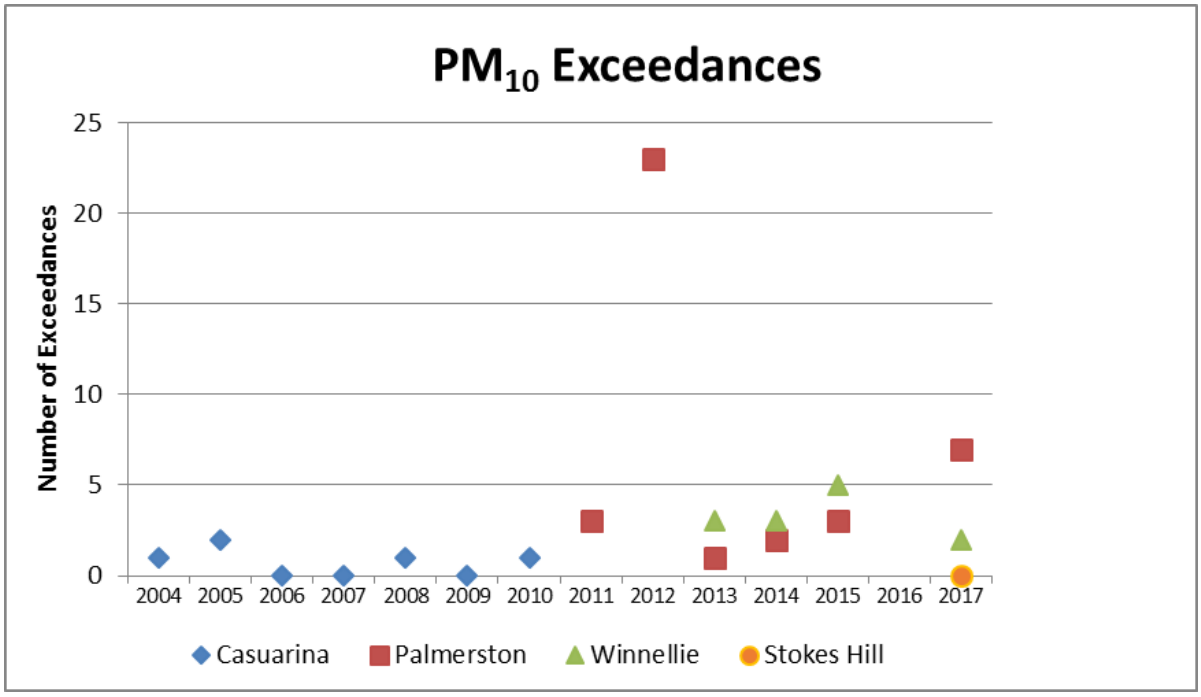

Figure 12

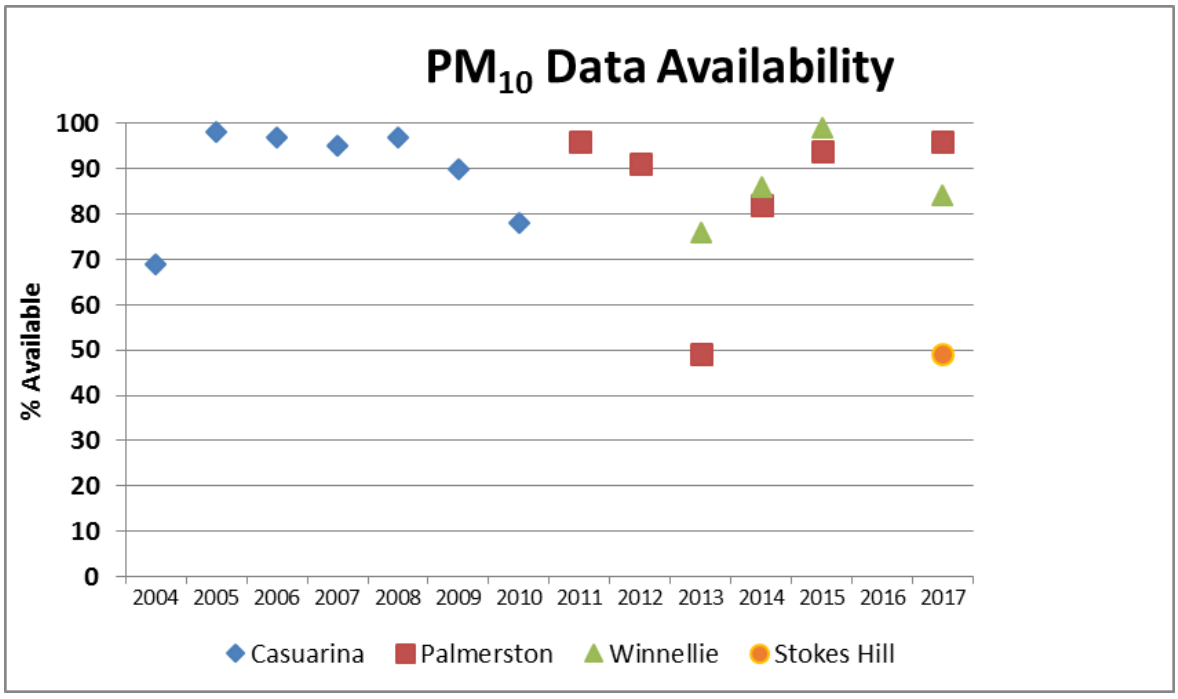

Figure 13

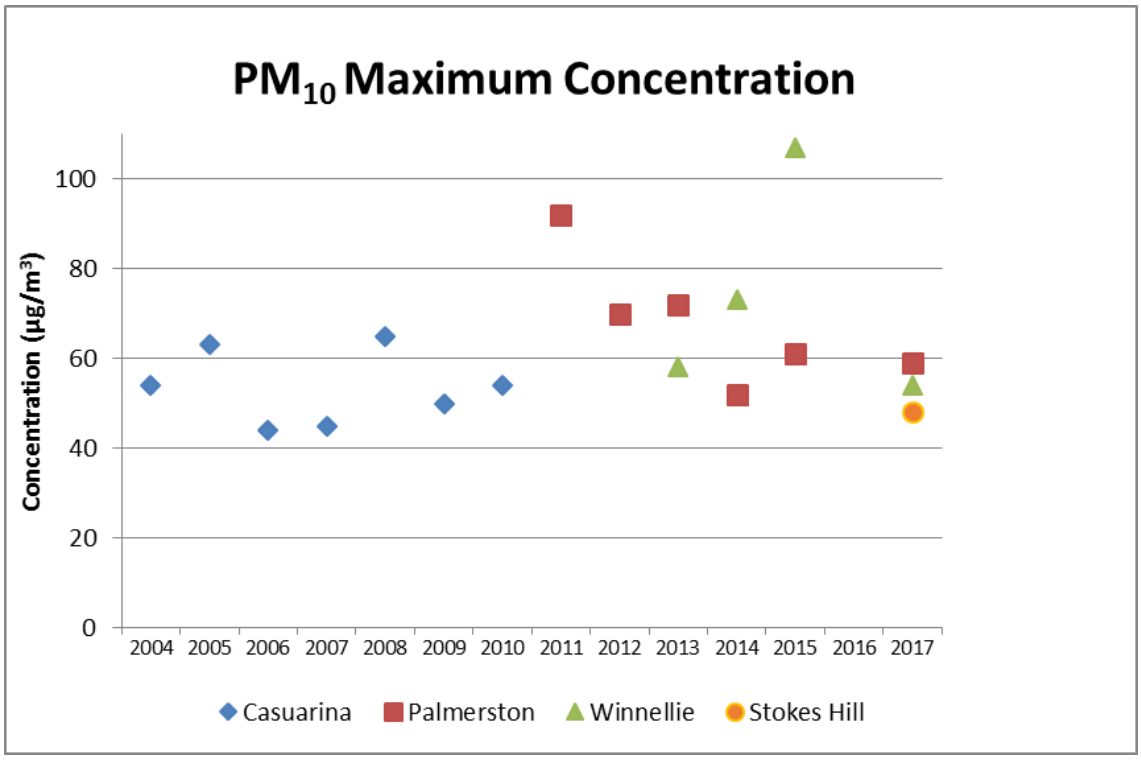

Figure 14

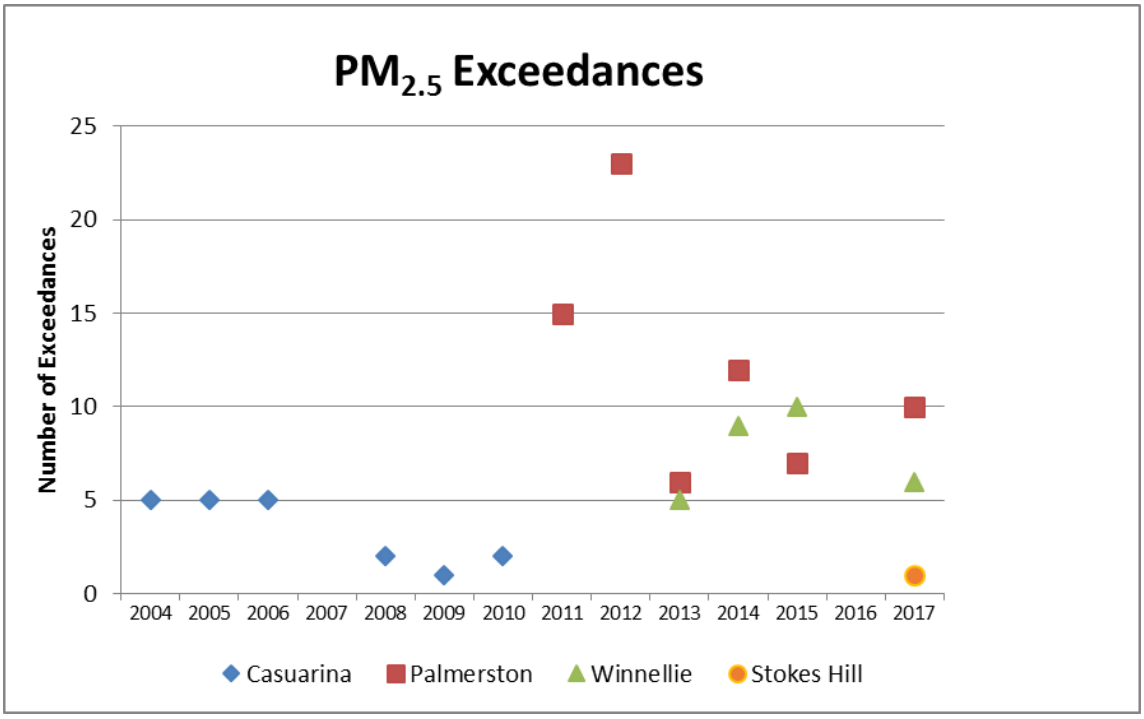

Figure 15

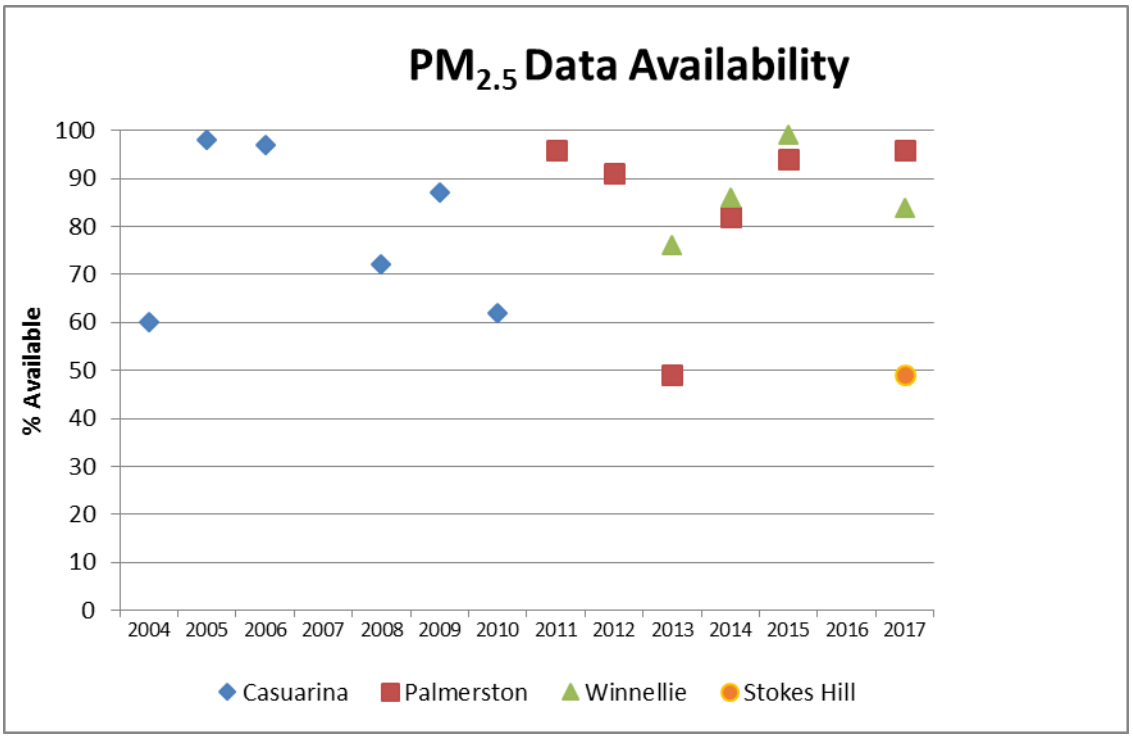

Figure 16

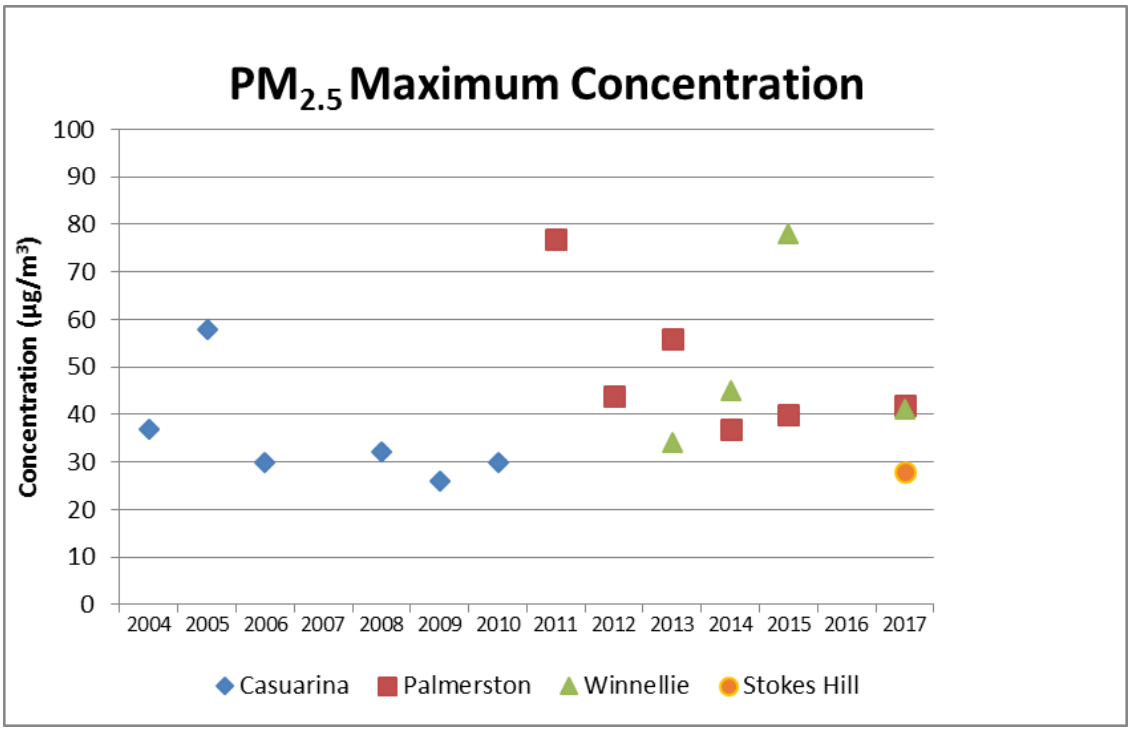

Figure 17

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

Fire-scar data (NAFI 2017) gives percentage area burnt by year for the region likely to generate smoke impacting Darwin. A relationship has been observed between the total area burnt (obtained from fire-scar data in 2017) and the seasonal $PM_{2.5}$ levels measured at the stations. Figure 18 shows that the monthly average $PM_{2.5}$ concentrations increased sharply with area burnt in May, both parameters peaked in June and fell through July to October. The area burnt was measured in a region with a radius of 100km, centred at Darwin CBD.

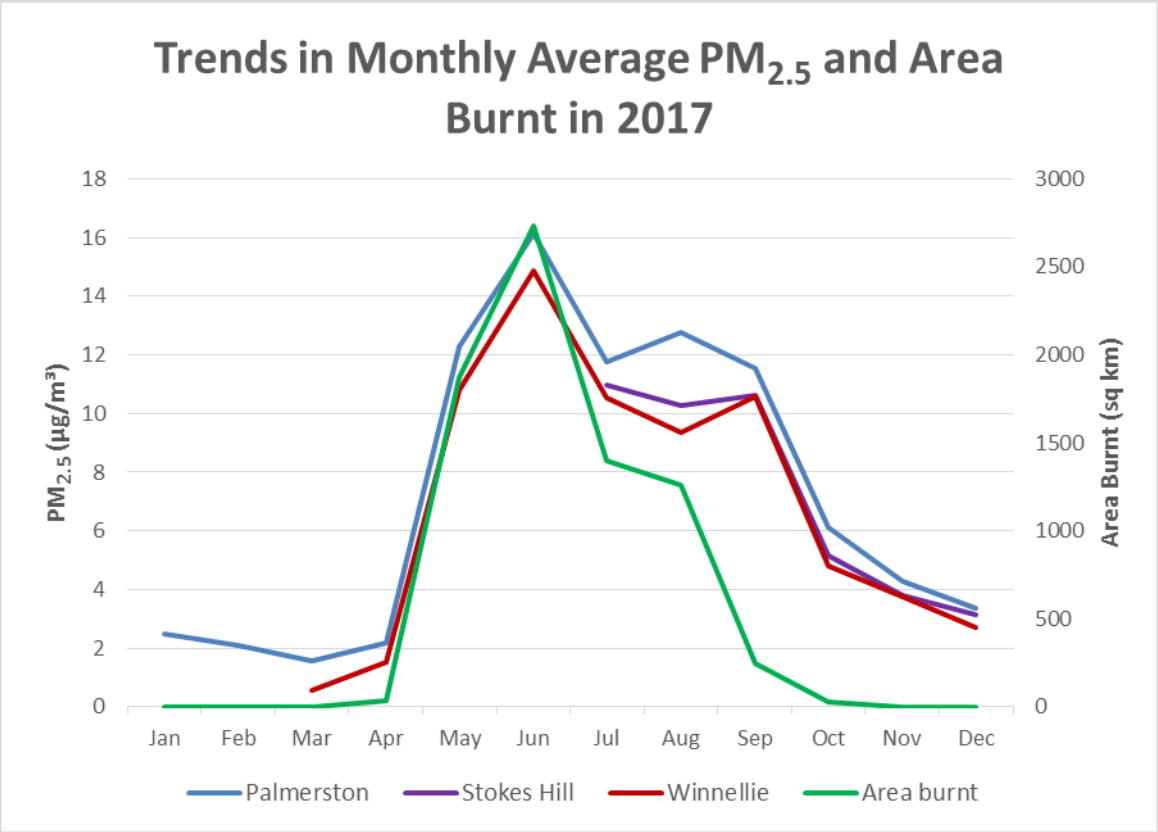

Figure 18 Comparison of $PM_{2.5}$ levels with Total Area Burnt (100 km radius of Darwin)

Historical fire-scar data does not depict a clear long term relationship between area burnt and particulate levels at the monitoring stations. As the total area burnt is not the key driver of particulate impacts on Darwin, other factors such as the timing of burns in relation to meteorological conditions are considered to play a significant part in total particulate impacts on

population centres. Success in reducing these impacts may be possible by addressing the timing of burns in relation to predicted meteorological conditions.

Analysis of fire activity data and particulate monitoring shows that fires greater than 150 km from Darwin are rarely linked to exceedances of the Air NEPM standards. Near ground level conditions such as wind speed and temperature inversions are critical factors in determining the concentration of particulates from distant fires.

Extending the monitoring of particulates to other regional centres in the NT will 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 particulates on urban populations in the future. Controlled burns present some opportunity for managing particulates. By timing the burn in consideration of wind direction and temperature inversion forecasts it may be possible to reduce population exposures to high particulate levels. There may also be scope for control of particulates from unintended fires (arson etc.) by pre-emptively burning areas identified for planned burning activity when conditions (wind direction and temperature inversion activity) were forecast to result in smoke being directed away from population centres.

8 References

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National Environment Protection (Ambient Air Quality) Measure Technical Paper No. 5: Data Collection and Handling (NEPC Peer Review Committee 2001).

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