Air quality in Newcastle: Autumn 2019

Air quality in Newcastle from 1 March to 31 May 2019 was generally good.

- Levels of nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ammonia (NH_3) were all well below national benchmark concentrations and assessment goals.
- Daily average levels of fine particulate matter $PM_{2.5}$ (particles less than or equal to 2.5 microns in diameter) were below the 25 micrograms per cubic metre (µg/m^3) benchmark.
- Daily average levels of particulate matter PM_{10} (particles less than or equal to 10 microns in diameter) were above the 50 µg/m^3 benchmark on 15 days (4–8, 11–12, 14 and 31 March, 8–9, 21 and 29 April, 16 and 25 May). Regional maximum daily PM_{10} levels on these days ranged from 52.3 to 77.7 µg/m^3.
  - Carrington, Newcastle and Wallsend each recorded one day over the PM_{10} benchmark, Beresfield and Mayfield recorded two days and Stockton recorded 15 days.
  - The most extensive events occurred on 6 and 31 March, being exceptional events due to long-range dust. March 2019 was the dustiest March since DustWatch records began in 2005[1].
    - On 6 March, PM_{10} levels over the benchmark were recorded at all 21 Newcastle, Upper Hunter and Central Tablelands sites. The region was affected by long-range dust transported from central and west NSW, ahead of a cold front.
    - On 31 March, 19 sites in the Northern Tablelands, North-West Slopes, Upper Hunter and Newcastle regions, including Beresfield, Mayfield and Stockton, recorded PM_{10} levels over the benchmark. Elevated particle levels were observed at all sites in the Newcastle region in the early morning on this day, under light to moderate west-northwest to northwest winds.
  - At Stockton, elevated levels occurred 52% of the time under onshore easterly winds. Stockton particle levels are influenced by sea salt spray transported by onshore winds[2], which are dominant during the warmer months.

Annual air quality trends in the Newcastle region

A comparison of annual average PM_{10} and $PM_{2.5}$ levels shows the long-term trends. The national annual average benchmarks are 25 µg/m^3 for PM_{10} and 8 µg/m^3 for $PM_{2.5}$, based on a calendar year.

Figure 1 shows the PM_{10} and $PM_{2.5}$ *rolling* annual averages, based on the 12-month periods to the end of autumn, for 2015 to 2019.

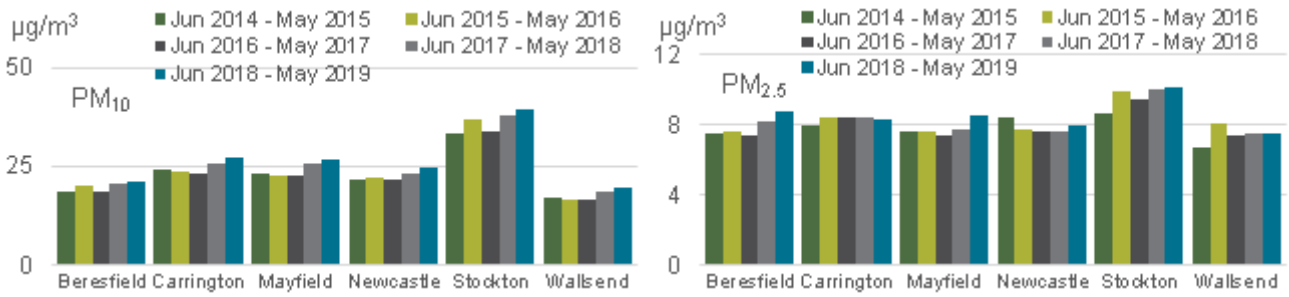

Figure 1 PM_{10} and $PM_{2.5}$ rolling annual averages to the end of autumn each year from 2015 to 2019

The comparison in Figure 1 shows that the rolling annual average particle levels have increased throughout the region for the 12-month period to the end of autumn 2019. A large portion of New South

[1] DustWatch report March 2019

[2] Lower Hunter Particle Characterisation Study

Wales experienced below to very much below average rainfall in the past 12 months (Figure 2) and was drought-affected (Figure 3). This is particularly evident in the intensely drought-affected North West and Northern Tablelands regions. Long-range dust from drought-affected areas in New South Wales contributed to the increase in particles observed in the region to the end of autumn 2019:

- For PM_{10}, rolling annual averages increased at all sites compared with the four previous years.
- For $PM_{2.5}$, rolling annual averages have remained similar to those observed in previous years at Carrington, Newcastle and Wallsend. At Stockton, rolling annual averages have increased slightly (with levels at the end of autumn 2019 2% higher than the previous 12-month period). At Beresfield and Mayfield, rolling annual averages increased compared to the four previous years.

The higher $PM_{2.5}$ annual averages at Stockton is consistent with the Lower Hunter Particle Characterisation Study, which found 40% more $PM_{2.5}$ at Stockton compared to Mayfield, Beresfield and Newcastle. This was due to more sea salt in onshore winds and primary ammonium nitrate in north west winds, particularly in winter (and very likely due to Orica's ammonium nitrate manufacturing facility on Kooragang Island).

Rolling annual averages are not intended to be compared to annual benchmarks. The rolling annual averages provide a guide to long-term trends, using the most up to date monitoring data.

The annual averages for the 2015 to 2018 calendar years can be found in the Newcastle spring 2018 seasonal newsletter.

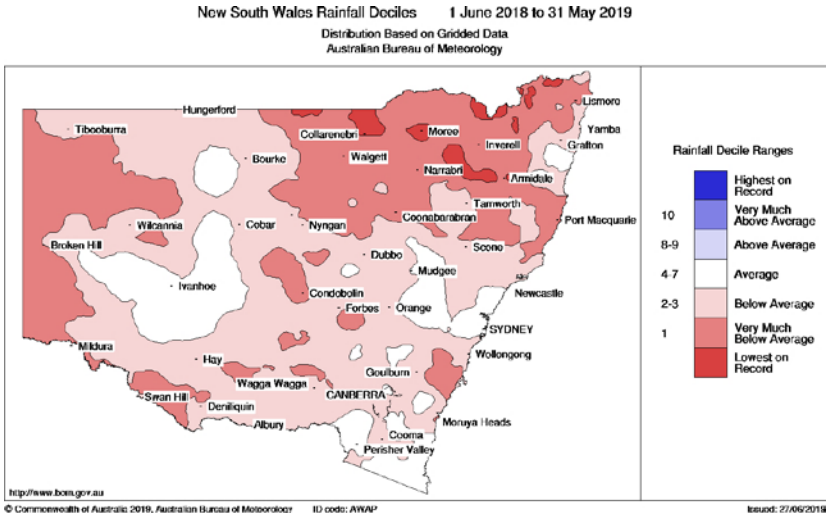

Figure 2 NSW rainfall deciles - 1 June 2018 to 31 May 2019[3]

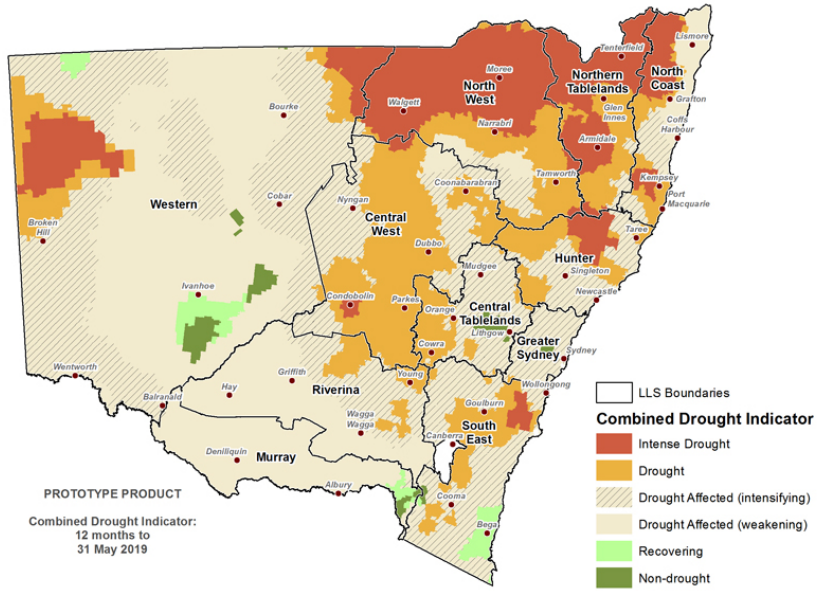

Figure 3 Department of Primary Industries NSW Combined Drought Indicator to 31 May 2019[4]

[3] Rainfall deciles map sourced from the Bureau of Meteorology (accessed July 2019)

[4] Sourced from Department of Primary Industries NSW State seasonal update - May 2019 (accessed June 2019).

Daily time series plots

Daily average time series plots for PM_{10} and $PM_{2.5}$ and daily one–hour maximum plots for NO_2, SO_2 and NH_3 show the daily concentrations throughout the autumn season.

Levels of NO_2, SO_2 and NH_3 remained well below the benchmarks and assessment criterion throughout the season. Long-range dust resulted in elevated particle levels on 6 and 31 March.

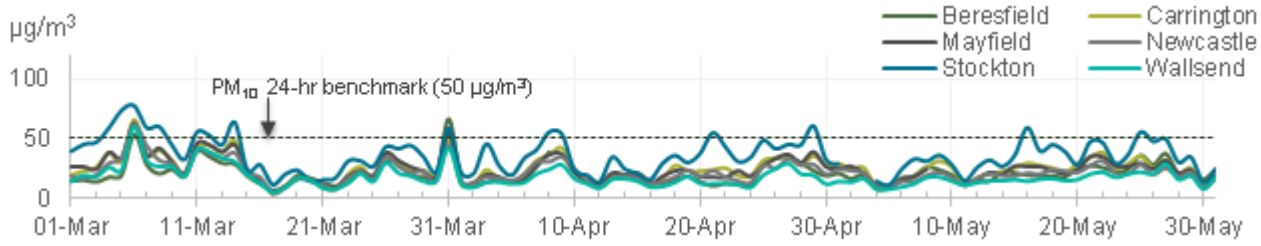

Figure 4 Daily average PM_{10} during autumn 2019

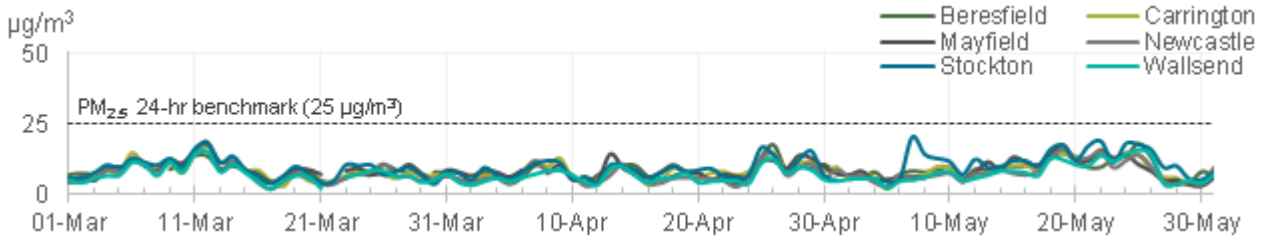

Figure 5 Daily average $PM_{2.5}$ during autumn 2019

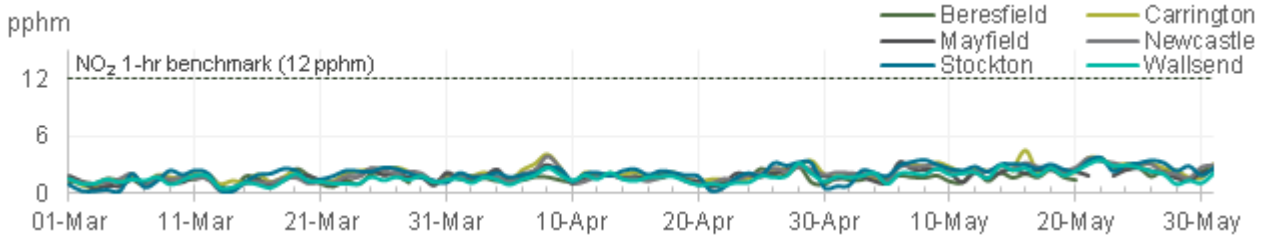

Figure 6 Daily maximum 1-hr NO_2 during autumn 2019

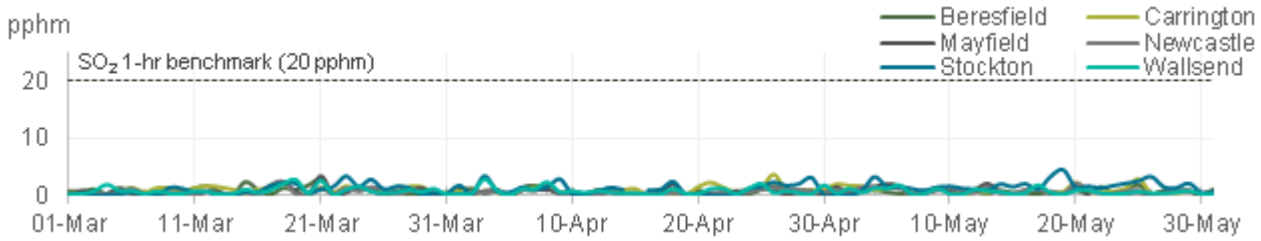

Figure 7 Daily maximum 1-hr SO_2 during autumn 2019

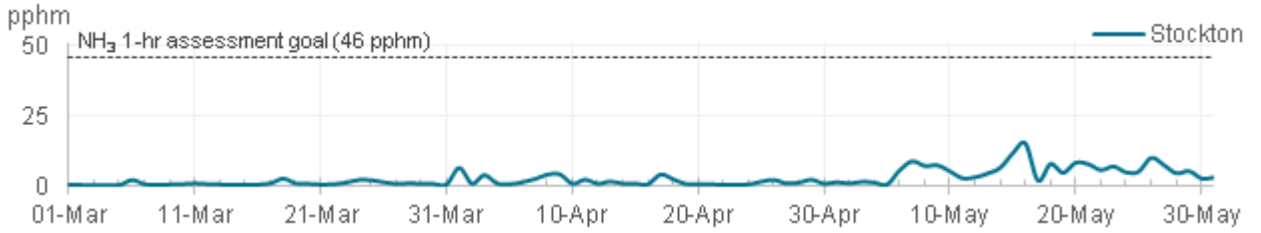

Figure 8 Daily maximum 1-hr NH_3 during autumn 2019

Pollution roses from hourly data

The seasonal pollution rose maps[5] show that elevated hourly[6] PM_{10} levels predominantly occurred at Stockton under north east winds, due to sea salt (see Stockton section below for more detail). A small percentage of elevated PM_{10} levels was observed from the north west, especially at Beresfield, Mayfield and Stockton. These predominantly occurred during the 6 and 31 March dust storm events.

$PM_{2.5}$ levels generally remained low during autumn 2019.

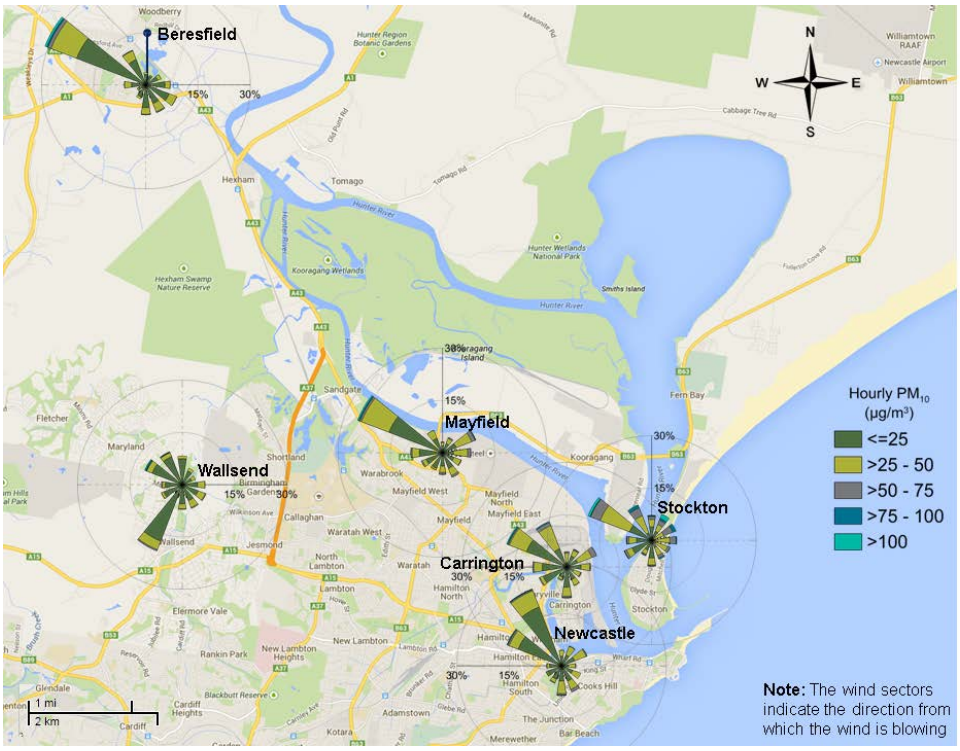

Figure 9 Hourly PM_{10} pollution roses for the Newcastle region for autumn 2019

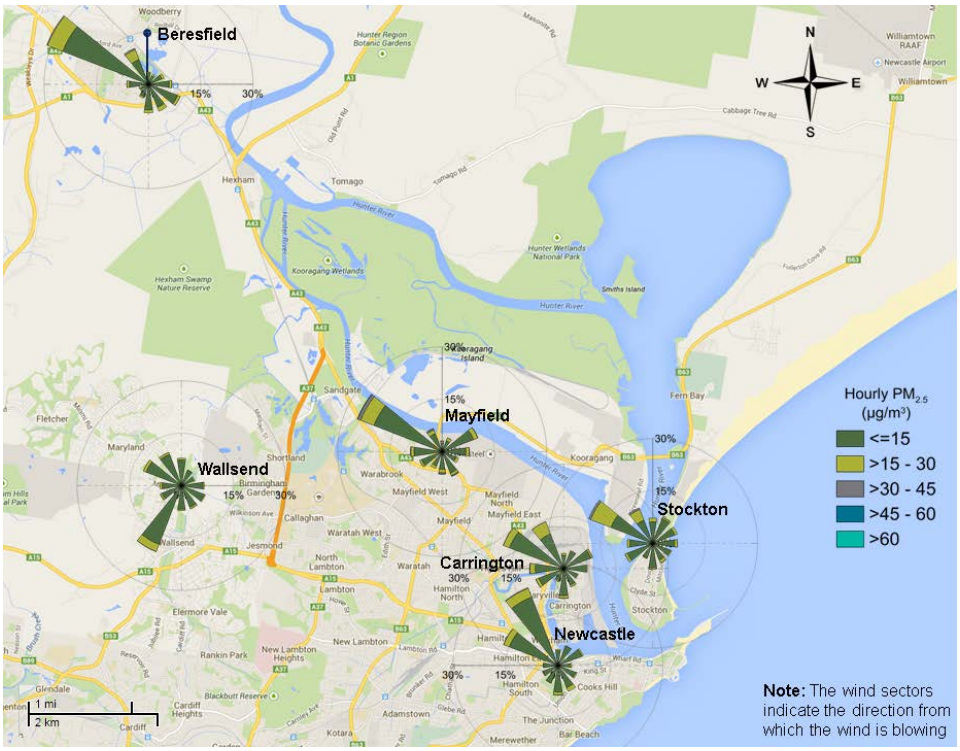

Figure 10 Hourly $PM_{2.5}$ pollution roses for the Newcastle region for autumn 2019

[5] Pollution roses show the wind direction and particle levels at a location. The length of each bar around the circle shows the percentage of time the wind blows from a particular direction. The colours along the bars indicate categories of particle levels.

[6] Note: There are no standards for hourly PM_{10}/$PM_{2.5}$ in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

Days above benchmark concentrations

There were 15 days over the PM_{10} daily benchmark in autumn 2019, predominantly at Stockton which is influenced by sea salt spray under onshore winds. See Stockton section for more information.

Table 1 Number of days above the relevant benchmarks – autumn 2019

Station	PM_{10} daily [50 µg/m³ benchmark]	$PM_{2.5}$ daily [25 µg/m³ benchmark]	SO_2 hourly [20 pphm benchmark]	SO_2 daily [8 pphm benchmark]	NO_2 hourly [12 pphm benchmark]	NH_3 hourly [46 pphm benchmark]
Beresfield	2	0	0	0	0	-
Carrington	1	0	0	0	0	-
Mayfield	2	0	0	0	0	-
Newcastle	1	0	0	0	0	-
Stockton	15	0	0	0	0	0
Wallsend	1	0	0	0	0	-

µg/m³ = microgram per cubic metre
pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air)
- = not monitored

Seasonal comparisons

This section further compares air quality levels in autumn 2019 with previous autumn seasons, where data were available. Monitoring at Stockton commenced in October 2012[7] and at Mayfield and Carrington in August 2014. Monitoring of $PM_{2.5}$ at Newcastle commenced in December 2013.

All days were below benchmark concentrations for NO_2 and SO_2 in autumn during the past six years at Beresfield, Newcastle, Stockton and Wallsend and since monitoring began at Carrington and Mayfield.

For NH_3 at Stockton, there were no days over the assessment criterion in autumn during the past six years.

There were no days above the $PM_{2.5}$ benchmark during autumn 2019. In earlier years, Wallsend recorded one day above the $PM_{2.5}$ benchmark during autumn 2013.

Carrington, Newcastle and Wallsend each recorded one day over the benchmark in autumn 2019, while Beresfield and Mayfield each recorded two days and Stockton recorded 15 days. This was similar to observations in previous years at all sites. At Stockton, 15 days was the same as in 2018 and within the range of earlier years (ranging from one to 21 days).

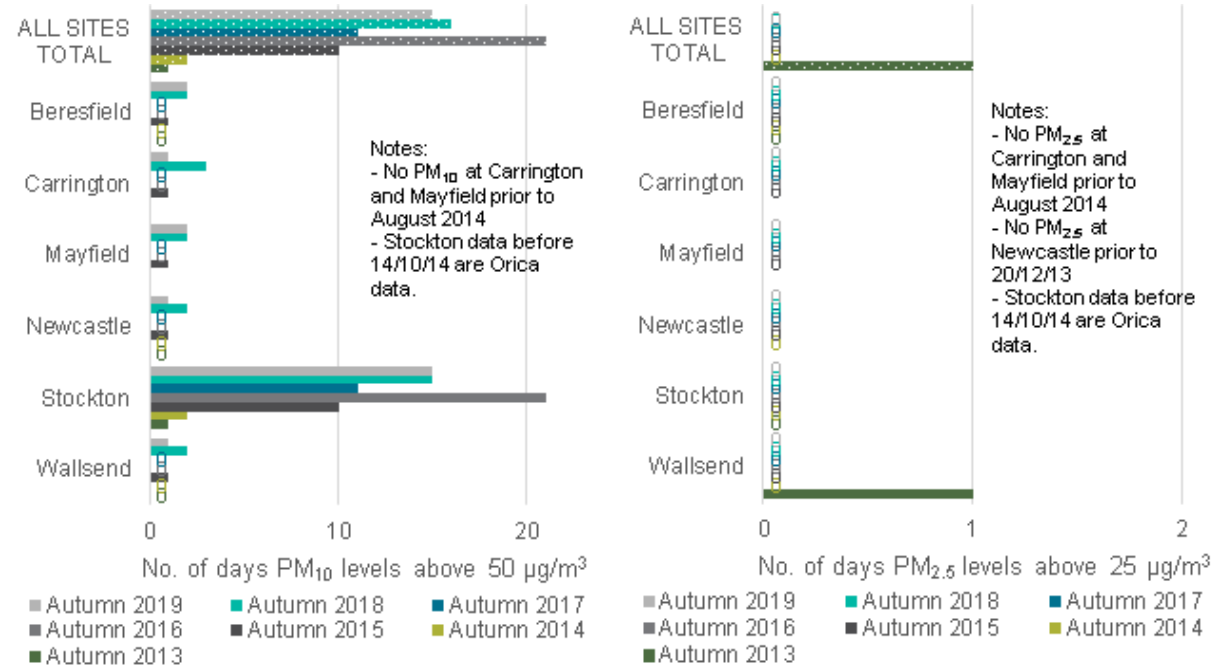

Figure 11 Number of days above the PM_{10} and $PM_{2.5}$ benchmarks: autumns 2013 to 2019

[7] Stockton air quality monitoring was undertaken by Orica from October 2012 to October 2014. From October 2014 it was undertaken by the former Office of Environment and Heritage as part of the Newcastle Local Air Quality Monitoring Network.

Particle air quality trends in the Newcastle region

Figure 12 and Figure 13 show daily average PM_{10} during autumn 2019, compared to the daily maximum and minimum (i.e. shaded range) of PM_{10} levels for the autumn periods from 2013 to 2018, at Stockton and Newcastle. These show that daily PM_{10} levels varied compared to the data range identified from earlier years, with a peak on 6 March due to a widespread dust storm. Rainfall totals were low, particularly in early March, late April and most of May (Figure 14). Variability during the season may also be partly due to the low number of years of historical data available for comparison.

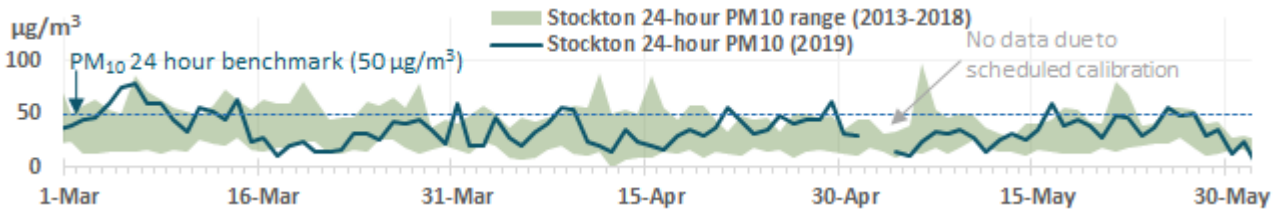

Figure 12 Stockton daily average PM_{10} during autumn 2019 plotted against the daily maximum and minimum PM_{10} levels recorded from autumn 2013 to 2018

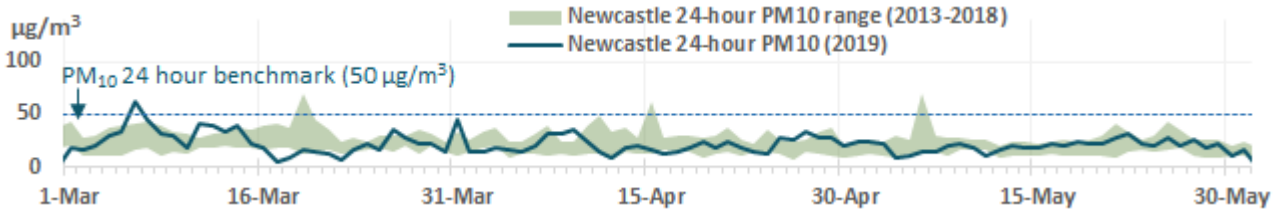

Figure 13 Newcastle daily average PM_{10} during autumn 2019 plotted against the daily maximum and minimum PM_{10} levels recorded from autumn 2013 to 2018

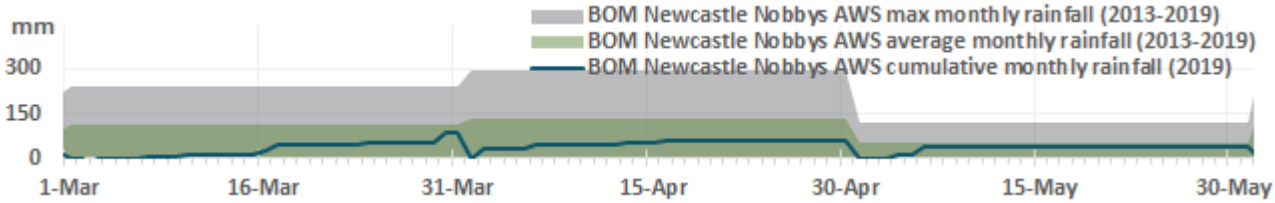

Figure 14 Bureau of Meteorology Newcastle Nobbys Signal Station AWS[8] cumulative rainfall during autumn 2019 plotted against maximum and average rainfall from 2013 to 2019

Figure 15 and Figure 16 show daily average $PM_{2.5}$ during autumn 2019, compared to the daily maximum and minimum levels (shaded range) from autumn 2014 to 2018, at Stockton and Newcastle. These show that daily $PM_{2.5}$ levels were generally within the range of earlier years. Variability during the season may also be partly due to the low number of years of historical data available for comparison.

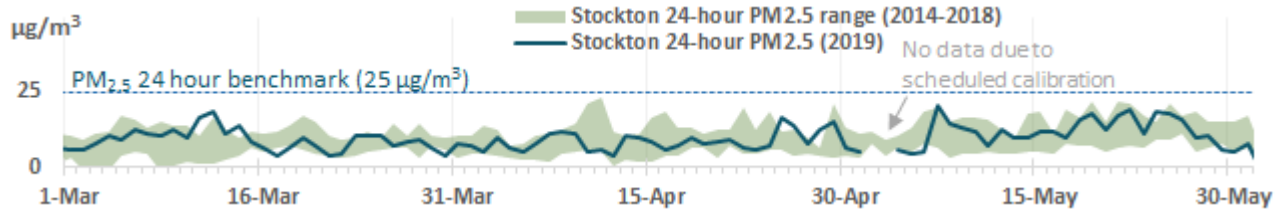

Figure 15 Stockton daily average $PM_{2.5}$ during autumn 2019 plotted against the daily maximum and minimum $PM_{2.5}$ levels recorded from autumn 2014 to 2018

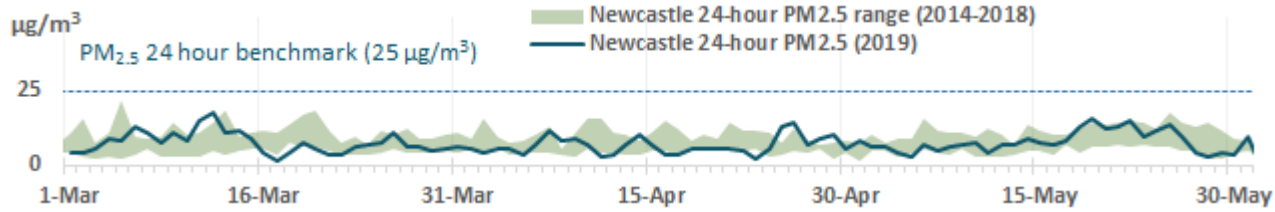

Figure 16 Newcastle daily average $PM_{2.5}$ during autumn 2019 plotted against the daily maximum and minimum $PM_{2.5}$ levels recorded from autumn 2014 to 2018

[8] Data from Bureau of Meteorology Newcastle Nobbys Signal Station AWS monthly rainfall page (accessed July 2019)

Meteorological summary

Rainfall and temperature[9]

The Newcastle region experienced below average rainfall during autumn 2019 compared to long-term records, with below average rainfall in April and May. Autumn 2019 rainfall totals varied compared to the three previous autumn seasons, with similar rainfall levels to autumn 2018, 100 to 200 millimetres less than autumn 2017, and around 50 to 100 millimetres more than autumn 2016.

Maximum temperatures in Newcastle were very much above average and minimum temperatures were above average during the season.

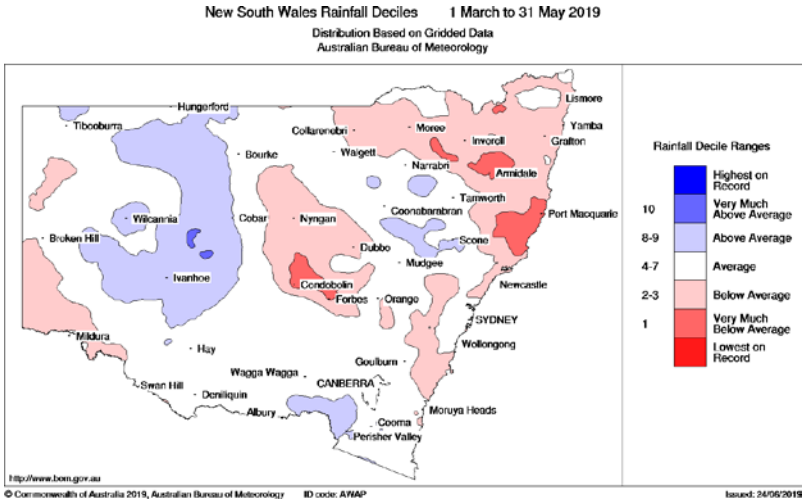

Figure 17 NSW rainfall deciles – autumn 2019

Wind

The winds were variable in the region during autumn 2019, with increasing north-westerly winds. Winds typically change from onshore easterly flows during the warmer months to offshore westerly flows as conditions cool. As an example, Figure 18 shows that at Stockton, north west winds prevailed 25% of the time and these were fresh or stronger (above eight metres per second) 3% of the time.

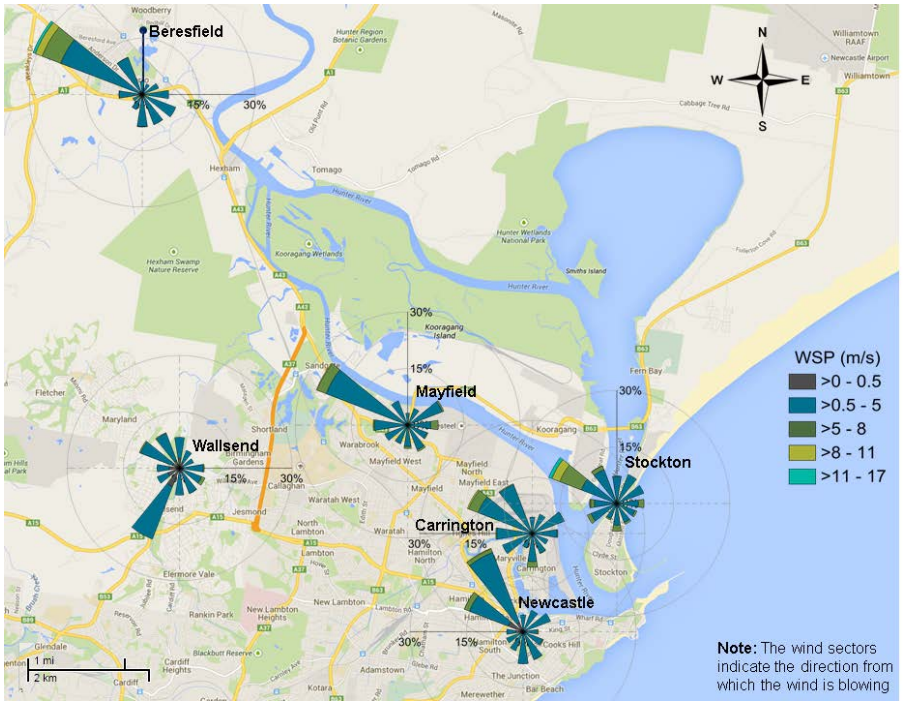

Figure 18 Wind rose map[10] for the Newcastle region for autumn 2019

[9] Rainfall and temperature information are from the Bureau of Meteorology New South Wales autumn 2019 climate statement and climate maps (accessed June 2019).

[10] Wind roses show the wind direction and speed at a location. The length of each bar around the circle in these wind roses shows the percentage of time the wind blows from a particular direction. The colours along the bars indicate the wind speeds.

Stockton

The Stockton monitoring site continued to record a higher number of days over the PM_{10} benchmark (15 days) compared to other sites in the region (one to two days). This was the same number of days over the benchmark as autumn 2018.

In autumn 2019, elevated hourly PM_{10} levels (>75 µg/m^3)[11] were recorded at Stockton 6.3% of the time (Figure 19). These occurred under:

- onshore easterly winds 52% of the time (72 hours, 3.3% total for autumn). This indicates the potential contribution of sea salt, with the Lower Hunter Particle Characterisation Study finding sea salt to be a major contributor of particles at the site.
- north-westerly winds 20% of the time (27 hours, 1.2% total for autumn), mainly as a result of widespread dust storms on 6 and 31 March (10 hours). There may also have been influence from external dust on 27 May (4 hours), when all sites in the region recorded elevated PM_{10} from the north west. Local sources may have potentially contributed during the remaining hours when PM_{10} levels were elevated and winds were from the north west (from one to two hours on varying days).

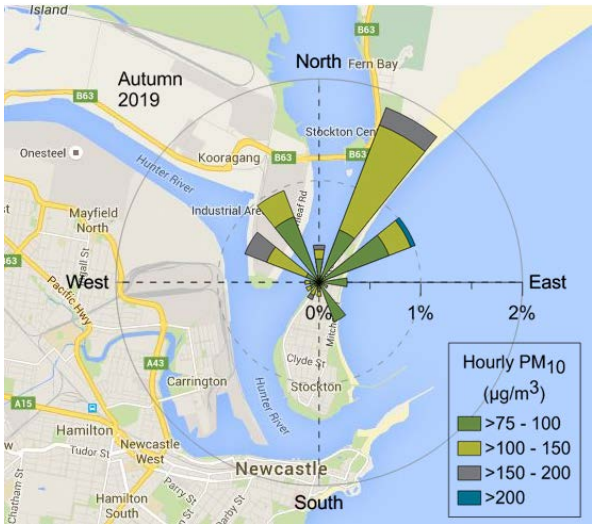

Figure 19 Stockton autumn 2019 pollution rose – proportion of hourly averaged PM_{10} levels >75 µg/m^3 by wind direction

Elevated hourly $PM_{2.5}$ levels (>40 µg/m^3)[11] occurred 0.4% of the time (8 hours) during autumn, with only three of these hours from the north west.

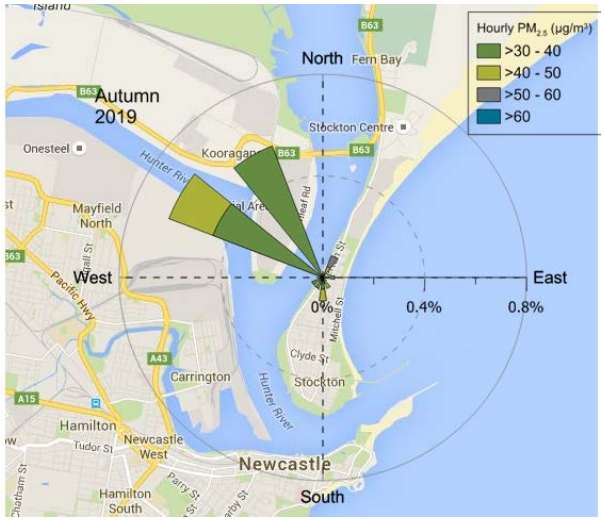

Figure 20 Stockton autumn 2019 pollution rose – proportion of hourly averaged $PM_{2.5}$ levels >30 µg/m^3 by wind direction

[11] Note: There are no standards for hourly PM_{10}/$PM_{2.5}$ in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

Network performance

The target network performance is at least 95% available data for all parameters. For NO_2, SO_2 and NH_3, due to daily calibrations, the maximum online time that can be attained is 96%.

Table 2 Online performance (%) during autumn 2019

Station	Particles PM_{10} daily	Particles $PM_{2.5}$ daily	Gases SO_2 hourly	Gases NO_2 hourly	Gases NH_3 hourly	Meteorology Wind hourly
Beresfield	98	95	95	87	-	99
Carrington	100	99	94	92	-	100
Mayfield	98	95	91	94	-	99
Newcastle	100	100	95	95	-	100
Stockton	98	98	93	95	95	100
Wallsend	100	99	95	95	-	100

- = not monitored

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