# Air quality in Newcastle: Winter 2021

Air quality in the Newcastle region was predominantly good during winter 2021. Daily particle levels were within national benchmarks for 98% of the time at Stockton and 100% of the time at all other stations. Stockton particle levels typically are affected by sea salt due to the station's proximity to the coast[1]. Hourly particle levels were in the good to fair air quality categories for 99.2% to 100% of the time throughout the region.

- Levels of nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$) and ammonia ($NH_3$) were good, all remaining below national benchmark concentrations and assessment goals.
- Daily average levels of fine particulate matter PM2.5 (particles less than or equal to 2.5 microns in diameter) remained below the national benchmark of 25 micrograms per cubic metre (µg/m3).
- Daily average levels of particulate matter PM10 (particles less than or equal to 10 microns in diameter) were above the 50 µg/m$^3$ national benchmark on 2 days (2 June and 9 August 2021), both occurring at Stockton. Regional maximum daily PM10 levels on these days ranged from 53.7 to 60.2 µg/m$^3$.
- At Stockton, elevated hourly PM10 levels (> 75 µg/m$^3$) predominantly occurred under onshore north-easterly to south-easterly winds (67% of the time that levels were elevated). The events on 2 June and 9 August were likely due to sea salt[1] with light winds coming onshore from the north-east on both occasions. See Stockton section for further details.
- Stockton recorded the regional daily PM10 maximum concentration on 86% of winter days in 2021.

# Annual air quality trends in the Newcastle region

A comparison of annual average PM10 and PM2.5 levels shows the long-term trends. The national annual average benchmarks are 25 µg/m$^3$ for PM10 and 8 µg/m$^3$ for PM2.5, based on a calendar year.

Figure 1 shows the PM10 and PM2.5 **rolling** annual averages[2], based on the 12-month periods to the end of winter, for 2015 to 2021.

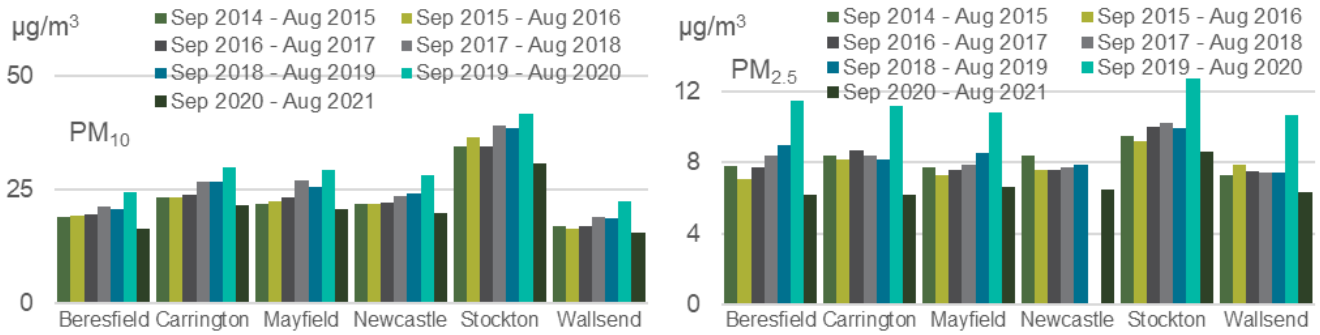


**Figure 1 PM10 and PM2.5 annual averages – 2015 to 2021**

The comparison in Figure 1 shows a large decrease in particle levels throughout the region during the 12-month to the end of winter 2021, compared to the same 12-month period in previous years (especially compared to the end of winter 2020). Annual average PM10 and PM2.5 were the lowest at each station in the region since the network began operation. In contrast, particle levels across the region during the 12-months to the end of winter 2020 were the highest since the network began due to the extended and intense NSW bushfire period in spring–summer 2019–20.

[1] Lower Hunter Particle Characterisation Study.

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

The lowest particle levels on record resulted from cooler, wetter conditions in 2020 and early 2021, which reduced impact from dust storms and likelihood of bushfires. At the end of winter 2021, 7% of New South Wales was drought affected (Figure 2), compared to 35% of the State drought declared by the end of winter 2020[3].

The higher PM10 and PM2.5 annual averages at Stockton were consistent with findings of the Lower Hunter Particle Characterisation Study. This study found that PM10 at Stockton was 2 and a half times higher than Mayfield, mainly due to fresh sea salt. It also found 40% more PM2.5 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).

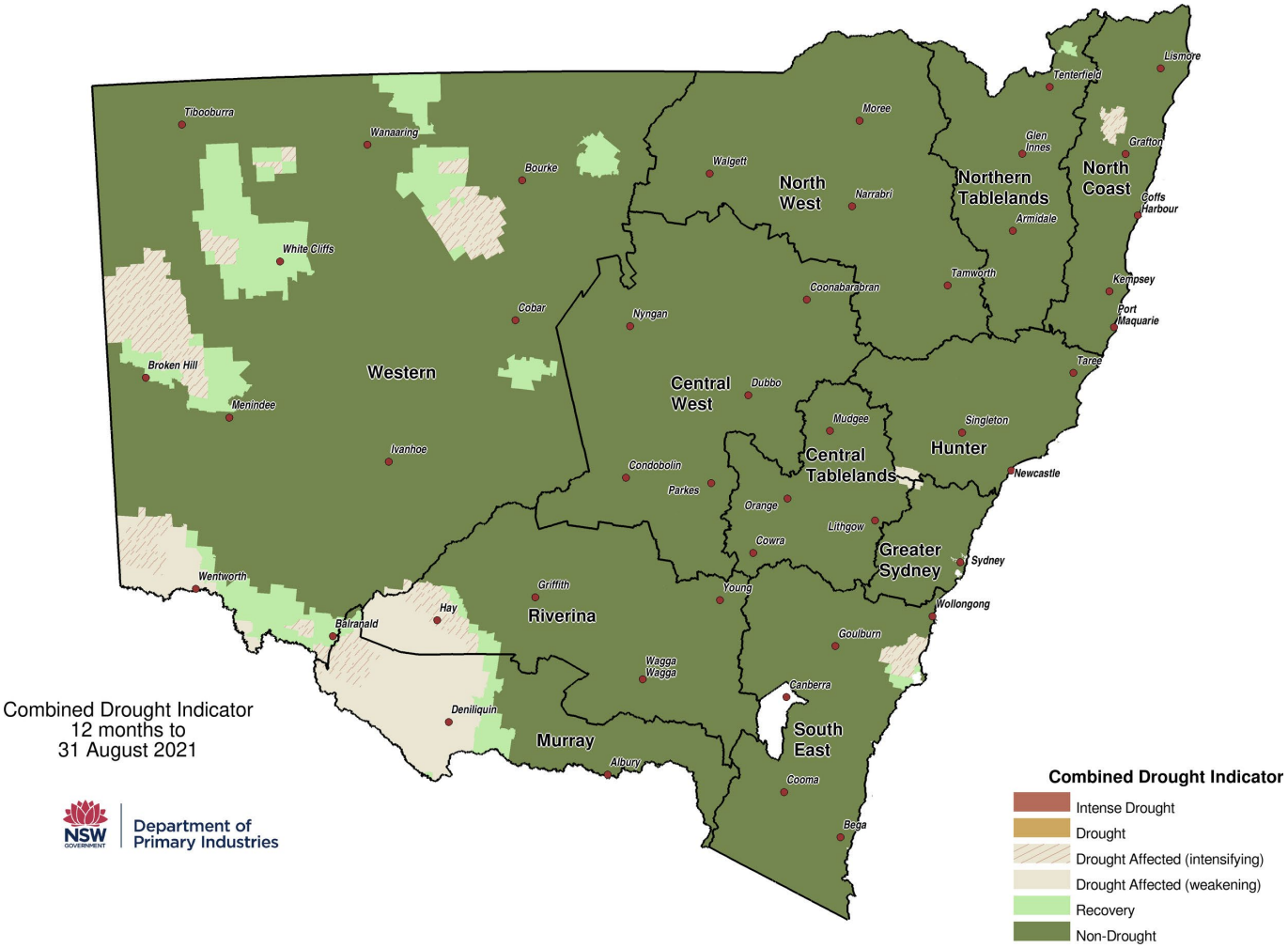


**Figure 2** **Department of Primary Industries NSW Combined Drought Indicator to 31 August 2021[4]**

[3] Sourced from Department of Primary Industries NSW State seasonal update – May 2020 (accessed October 2021).

[4] Sourced from Department of Primary Industries Monthly State Seasonal Update Figures (accessed October 2021).

## Days above benchmark concentrations

There were 2 days over the PM10 daily benchmark in winter 2021, 2 June and 9 August 2021, both occurring at Stockton. Concentrations of PM2.5, $SO_2$, $NO_2$ and $NH_3$ remained below relevant benchmarks in winter 2021.

**Table 1 Number of days above the relevant benchmarks – winter 2021**

| Station | PM10 daily [50 µg/m$^3$ benchmark] | PM2.5 daily [25 µg/m$^3$ benchmark] | $SO_2$ hourly[5] [10 pphm benchmark] | $SO_2$ daily[5] [2 pphm benchmark] | $NO_2$ hourly[5] [8 pphm benchmark] | $NH_3$ hourly [46 pphm benchmark] |
|---|---|---|---|---|---|---|
| **Beresfield** | 0 | 0 | 0 | 0 | 0 | - |
| **Carrington** | 0 | 0 | 0 | 0 | 0 | - |
| **Mayfield** | 0 | 0 | 0 | 0 | 0 | - |
| **Newcastle** | 0 | 0 | 0 | 0 | 0 | - |
| **Stockton** | 2 | 0 | 0 | 0 | 0 | 0 |
| **Wallsend** | 0 | 0 | 0 | 0 | 0 | - |

µg/m$^3$ = micrograms per cubic metre
pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air)
- = not monitored

[5] Note: The National Environment Protection (Ambient Air Quality) Measure (Air NEPM) was updated on 18 May 2021. New national benchmarks were introduced for hourly $SO_2$ (now 10 pphm), daily $SO_2$ (now 2 pphm) and hourly $NO_2$ (now 8 pphm).

## Daily time series plots

Daily average time series plots for PM10 and PM2.5 and daily one–hour maximum plots for $NO_2$, $SO_2$ and $NH_3$ show the concentrations throughout the winter season (Figure 3 to Figure 7).

Levels of PM2.5, $NO_2$, $SO_2$ and $NH_3$ remained below the benchmarks[5] and assessment criteria throughout the season.

PM10 levels remained below the benchmark at most stations, except for 2 days at Stockton. Stockton PM10 levels were most likely affected by sea salt on 2 June and 9 August, due to its proximity to the coast. See Stockton section for further details.

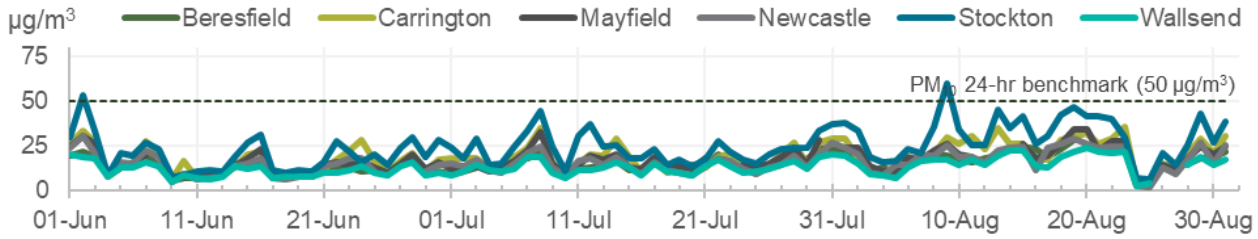


**Figure 3** **Daily average PM10 during winter 2021**

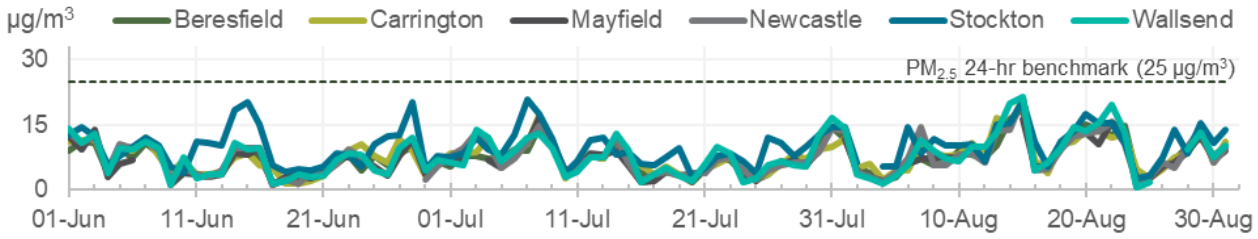


**Figure 4** **Daily average PM2.5 during winter 2021**

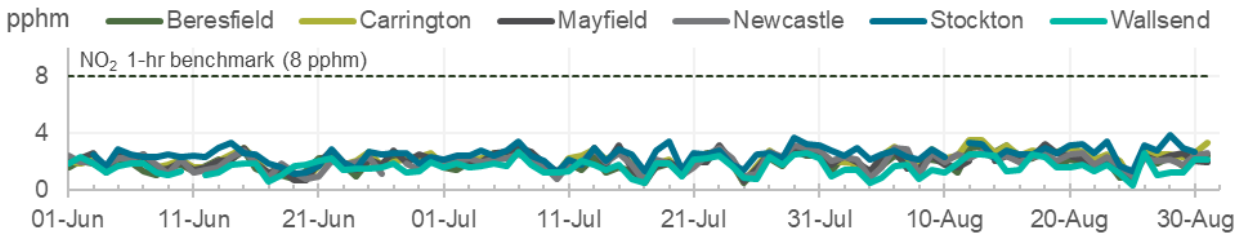


**Figure 5** **Daily maximum 1-hr $NO_2$ during winter 2021**

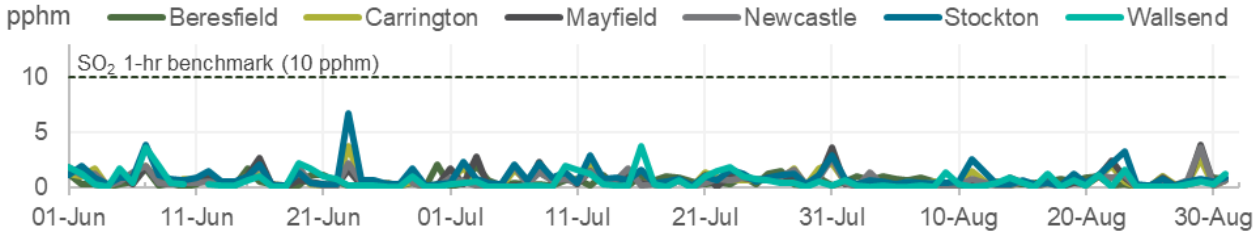


**Figure 6** **Daily maximum 1-hr $SO_2$ during winter 2021**

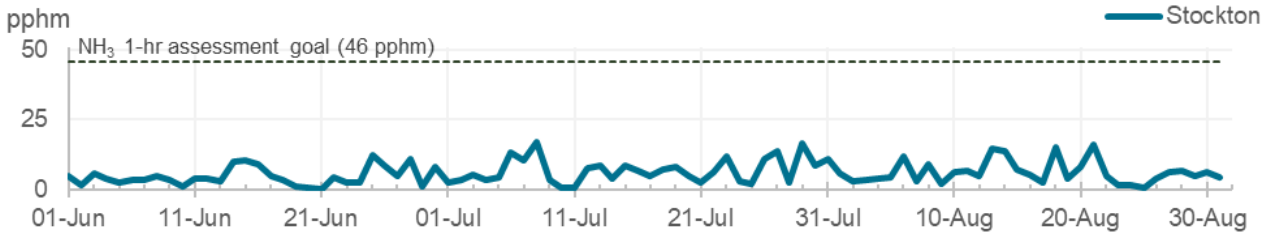


**Figure 7** **Daily maximum 1-hr $NH_3$ during winter 2021**

# Pollution roses from hourly particle data

The seasonal pollution rose maps[6] (Figure 8 and Figure 9) show that hourly[7] PM10 and PM2.5 levels generally remained low during the season.

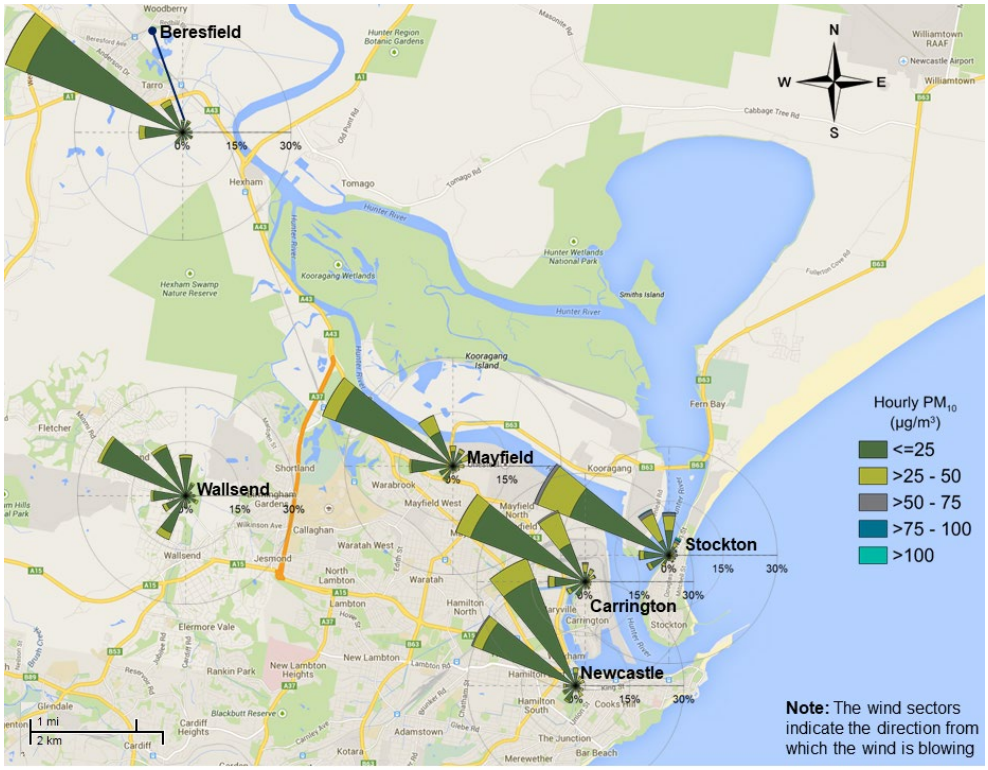


**Figure 8** **Hourly PM10 pollution roses for the Newcastle region for winter 2021**

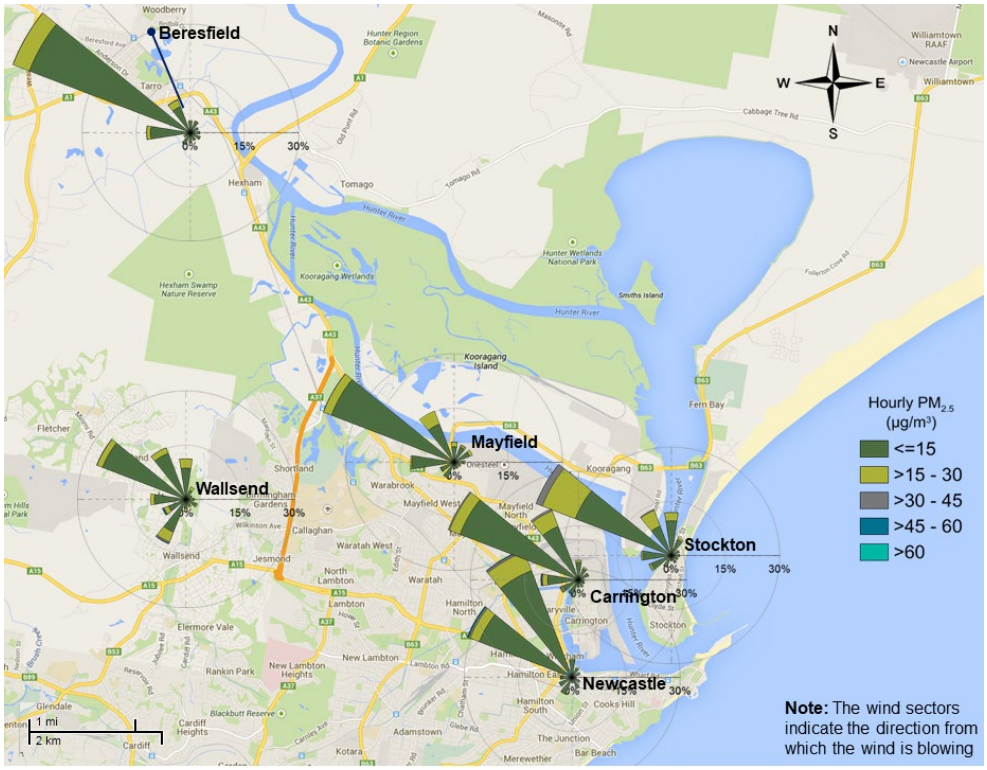


**Figure 9** **Hourly PM2.5 pollution roses for the Newcastle region for winter 2021**

[6] 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.

[7] There are no standards for hourly PM10 or PM2.5 in the Air NEPM.

## Seasonal comparisons

This section compares air quality levels in winter 2021 with previous winter seasons, where data were available[8].

All days were below benchmark concentrations for $NO_2$ and $SO_2$ in winter during the past 9 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 winter during the past 9 years.

There were no days above the PM2.5 benchmark during winter 2021. In earlier years, there were 3 over the PM2.5 benchmark at Stockton in 2013; 5 days in 2015, at Beresfield, Carrington, Mayfield and Newcastle (one day each) and Stockton (3 days). There was one day over the benchmark at Stockton in 2019 and one at Newcastle in 2020.

There were 2 days over the PM10 benchmark during winter 2021, both at Stockton. This was the same number of days over the benchmark as in 2020. There were fewer winter days above the PM10 benchmark in 2020 and 2021, compared with recent winters, with 5 days above the benchmark in winter 2019 and 8 days in winter 2018.

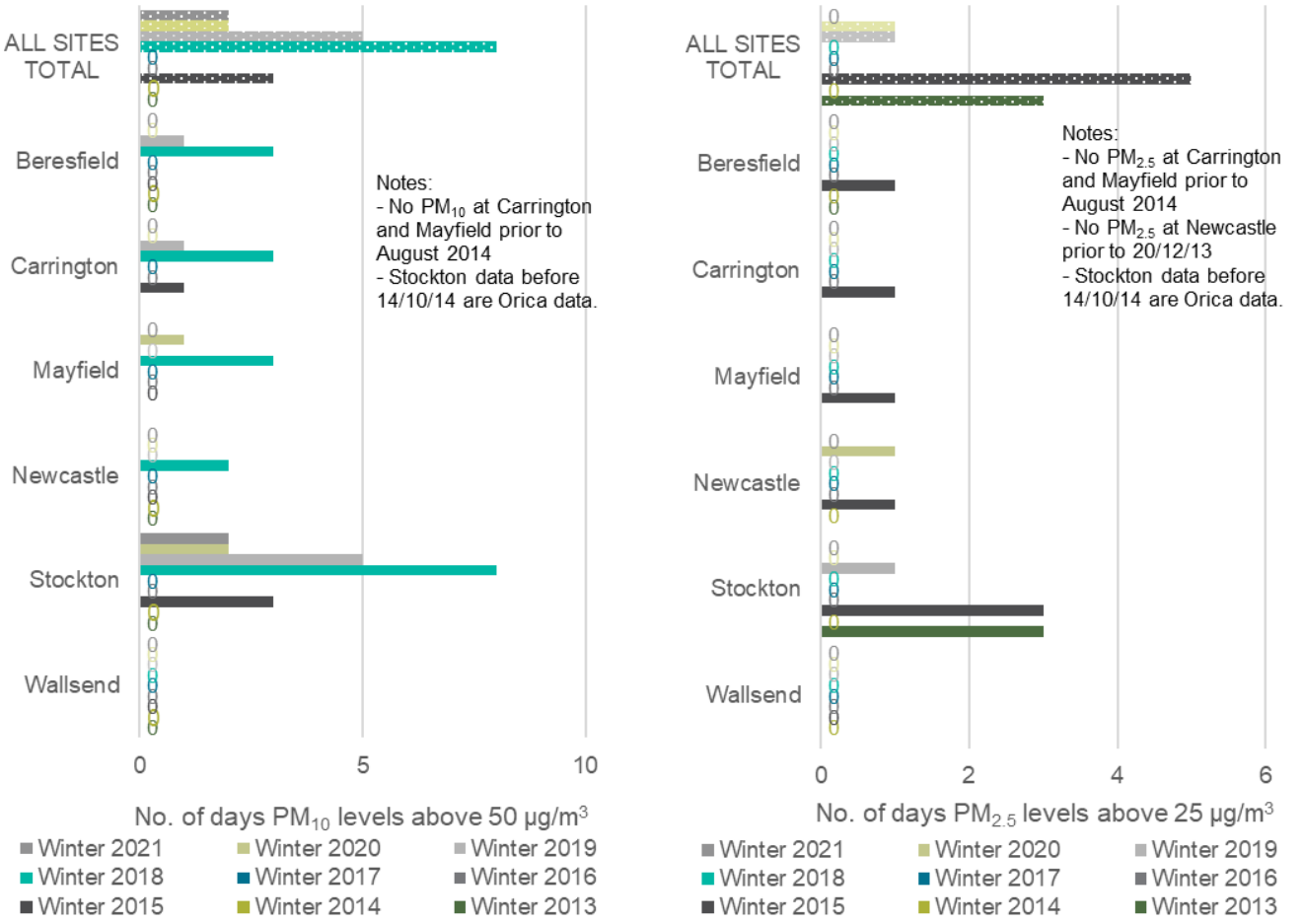


**Figure 10 Number of days above the PM10 and PM2.5 daily benchmarks: winter 2013 to 2021**

[8] Monitoring at Stockton commenced in October 2012 and at Mayfield and Carrington in August 2014. Monitoring of PM2.5 at Newcastle commenced in December 2013. Stockton air quality monitoring was undertaken by Orica from October 2012 to October 2014. From October 2014 it was undertaken by the NSW government as part of the Newcastle Local Air Quality Monitoring Network.

# Particle air quality trends in the Newcastle region

Figure 11 and Figure 12 show daily average PM10 during winter 2021, compared to the daily maximum and minimum PM10 levels (i.e. shaded range) from winter 2013 to 2020, at Stockton and Newcastle. Daily PM10 levels were generally within the historical range throughout the season, and often towards the lower end of the range, especially in June and July. Rainfall at Newcastle was near average in July, but was relatively low in July and August.

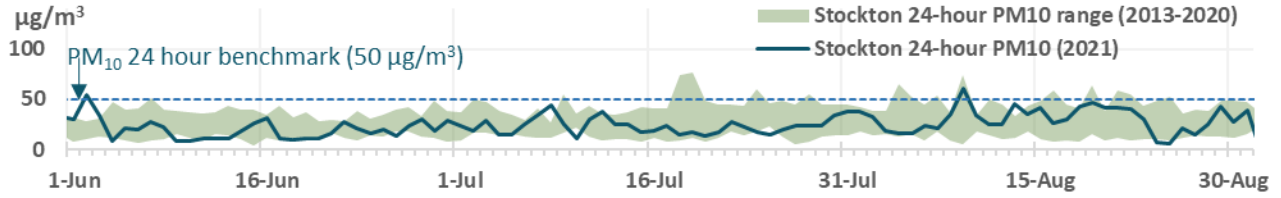


**Figure 11** **Stockton daily average PM10 during winter 2021 plotted against the daily maximum and minimum PM10 levels from 2013 to 2020**

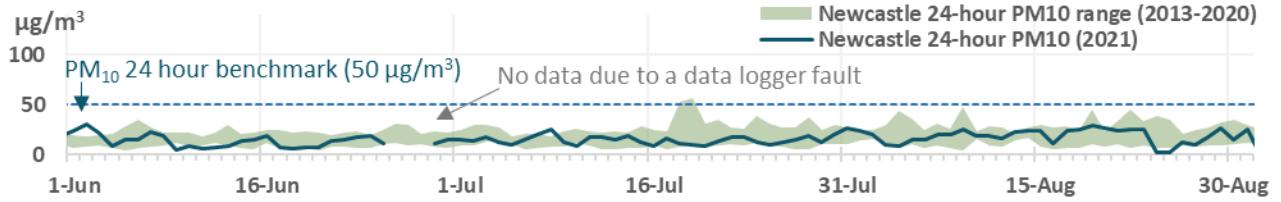


**Figure 12** **Newcastle daily average PM10 during winter 2021 plotted against the daily maximum and minimum PM10 levels from 2013 to 2020**

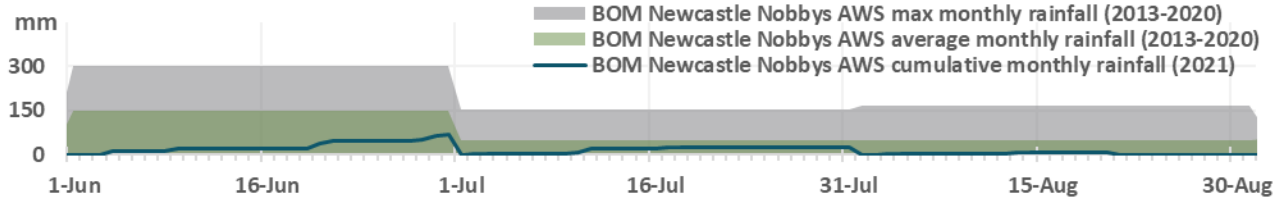


**Figure 13** **Bureau of Meteorology Newcastle Nobbys Signal Station AWS[9] cumulative rainfall during winter 2021 plotted against maximum and average rainfall from 2013 to 2020**

Figure 14 and Figure 15 show daily average PM2.5 during winter 2021, compared to the daily maximum and minimum PM2.5 levels (shaded range) from 2014 to 2020, at Stockton and Newcastle. Daily PM2.5 levels were generally within the historical range throughout the season, and often at the lower levels.

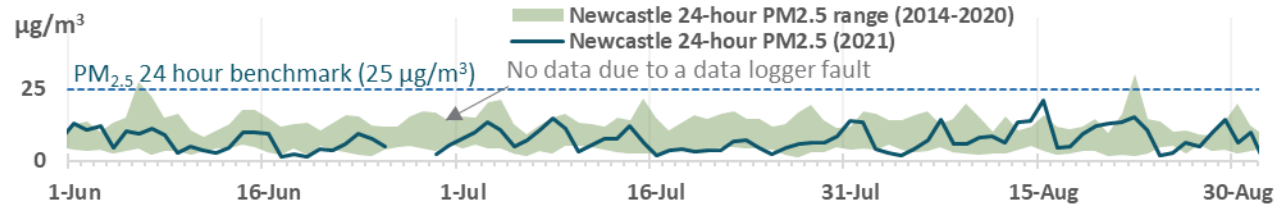


**Figure 14** **Newcastle daily average PM2.5 during winter 2021 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2020**

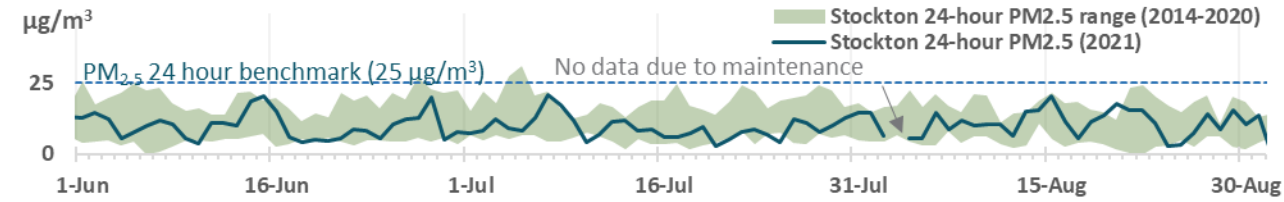


**Figure 15** **Stockton daily average PM2.5 during winter 2021 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2020**

[9] Data from Bureau of Meteorology Newcastle Nobbys Signal Station AWS monthly rainfall page (accessed October 2021).

# Meteorological summary

## Rainfall and temperature[10]

The Newcastle region experienced below average rainfall overall during winter 2021 compared to long-term records (Figure 16).

Winter 2021 was dryer than the 3 previous winters, with 100 to 200 millimetres less rain than winters in 2020 and 2019 and 50 to 200 millimetres less than winter 2018.

Maximum and minimum temperatures were above average during the season (Figure 17).

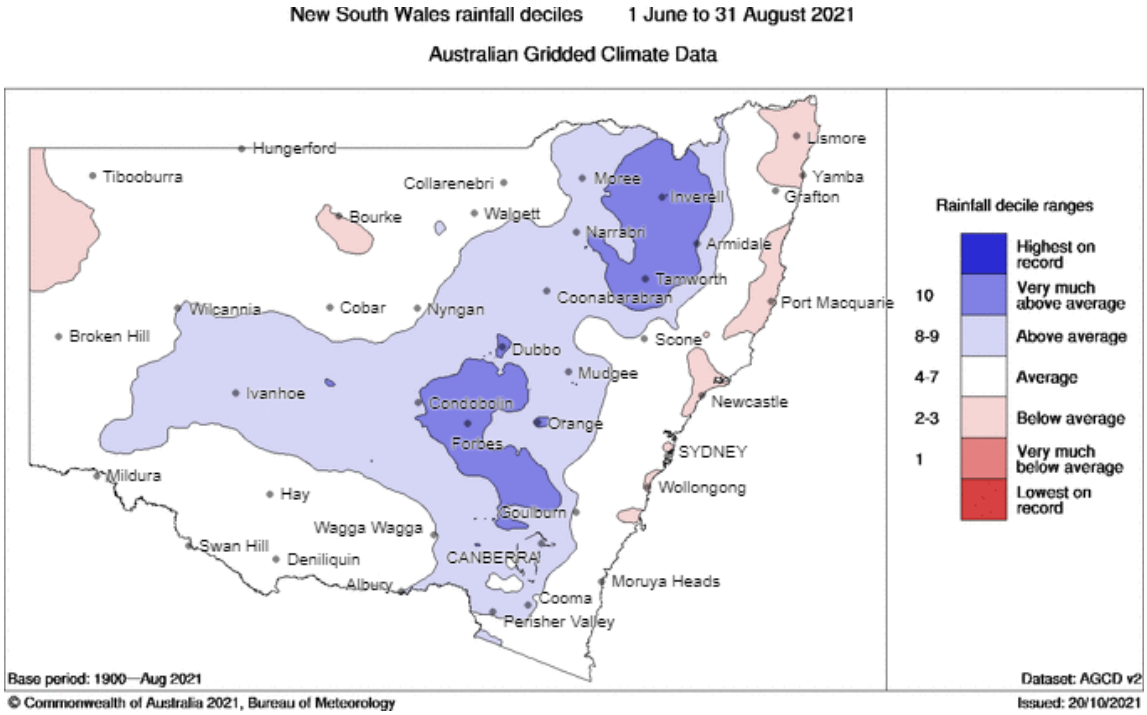


**Figure 16 NSW rainfall deciles – winter 2021**

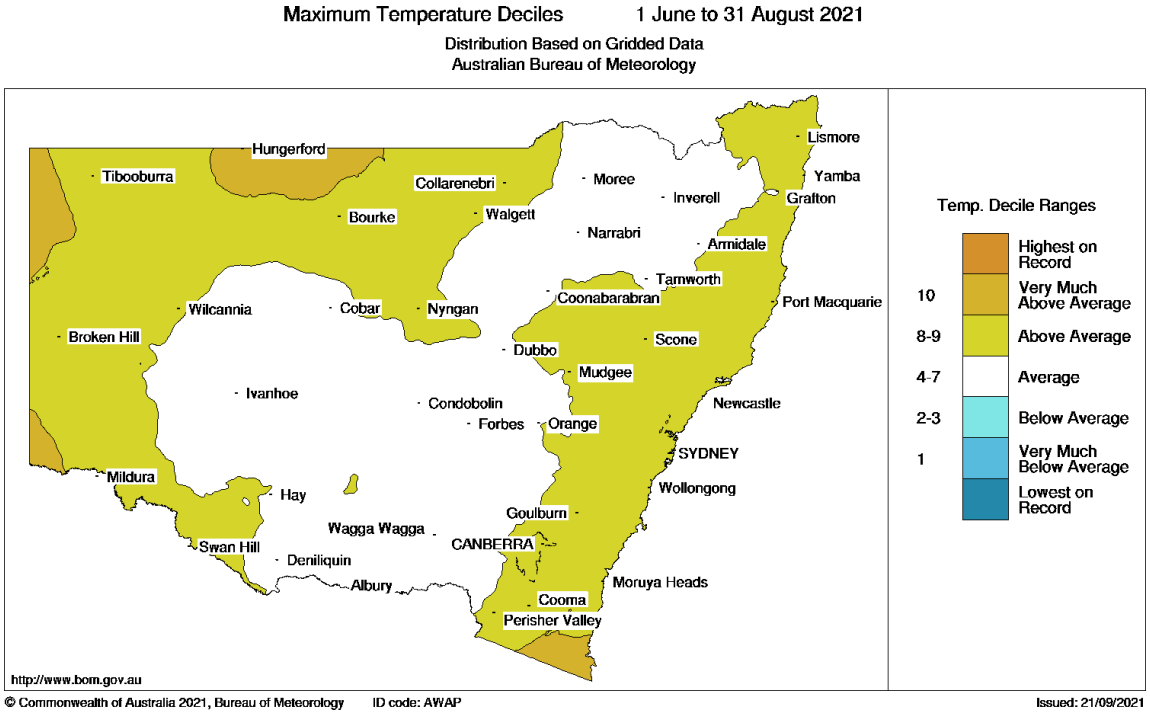


**Figure 17 NSW maximum temperature deciles – winter 2021**

[10] Rainfall and temperature information is from the Bureau of Meteorology New South Wales winter 2021 climate statement (access October 2021) and climate maps (accessed October 2021).

## Wind

Winds were predominately from the north-west region during winter 2021, which was typical for this time of year. For example, Figure 18 shows that north-west winds prevailed 43% of the time at Stockton, with these moderate or stronger winds (above 5 metres per second) 17% of the time. The duration of prevailing north-west winds was similar to previous winters, with more frequent moderate to strong winds in 2021, 2020 and 2018, compared to 2019.

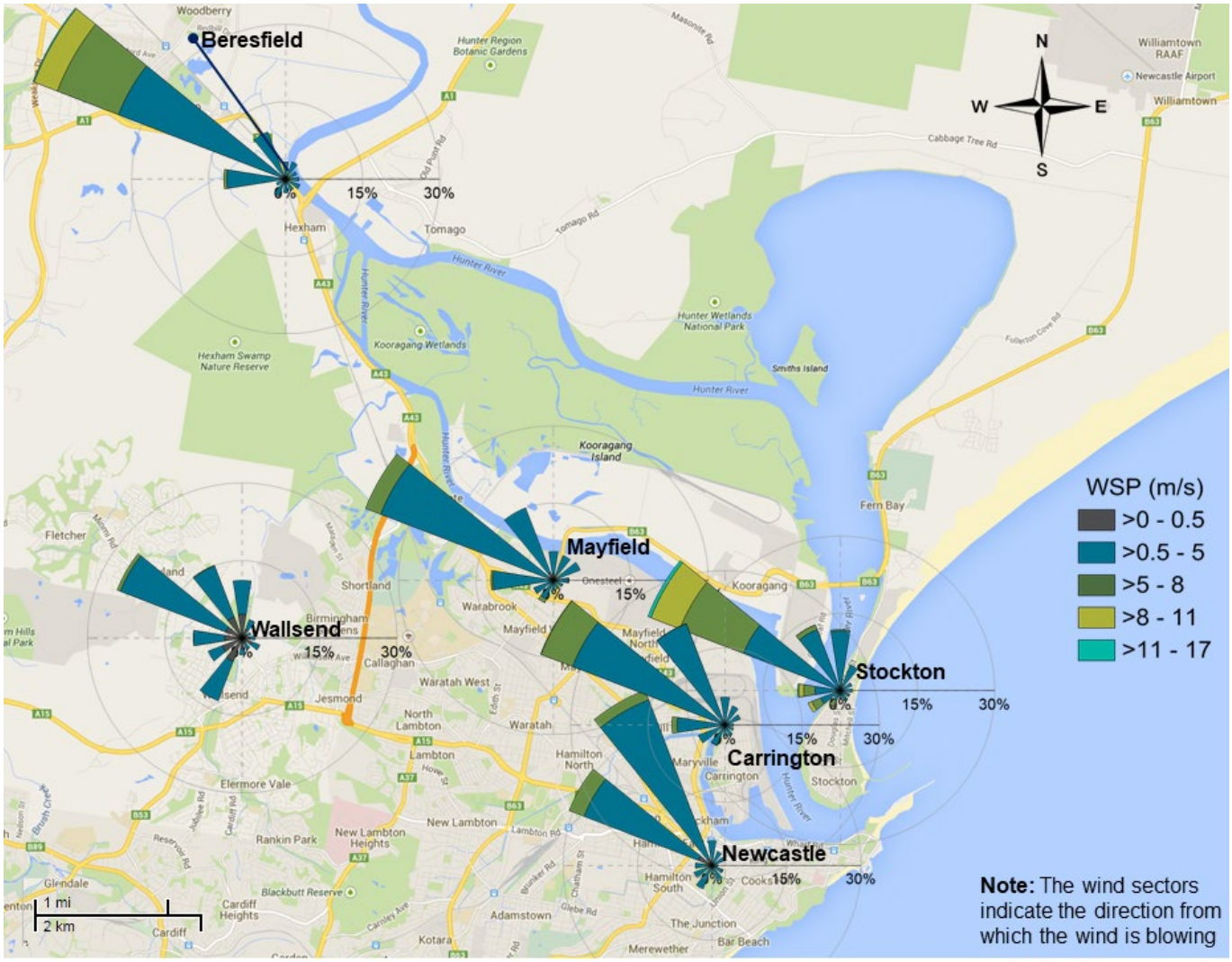


**Figure 18** **Wind rose map[11] for the Newcastle region for winter 2021**

[11] 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

## Particles at Stockton in winter 2021

Stockton recorded 2 days over the PM10 daily benchmark during winter 2021 (2 June and 9 August 2021). This was the same number of days over the PM10 benchmark as in winter 2020. In previous years, up to 8 winter days were over the PM10 benchmark, with 3 days in 2015, 8 days in 2018 and 5 days in 2019 (Figure 10).

In winter 2021, elevated hourly PM10 levels (>75 µg/m$^3$)[12] were recorded at Stockton 1.9% of the time (Figure 19). These occurred under:

- onshore north-easterly to south-easterly winds 67% of the time (28 hours, 1.3% total for winter)
- north-westerly winds 7% of the time (7 hours, 0.3% total for winter).

Elevated hourly PM10 levels under predominant onshore winds at Stockton indicate the potential contribution of sea salt, as was observed during the 2 June and 9 August events. The Lower Hunter Particle Characterisation Study found sea salt was a major contributor of particles at the station under onshore winds.

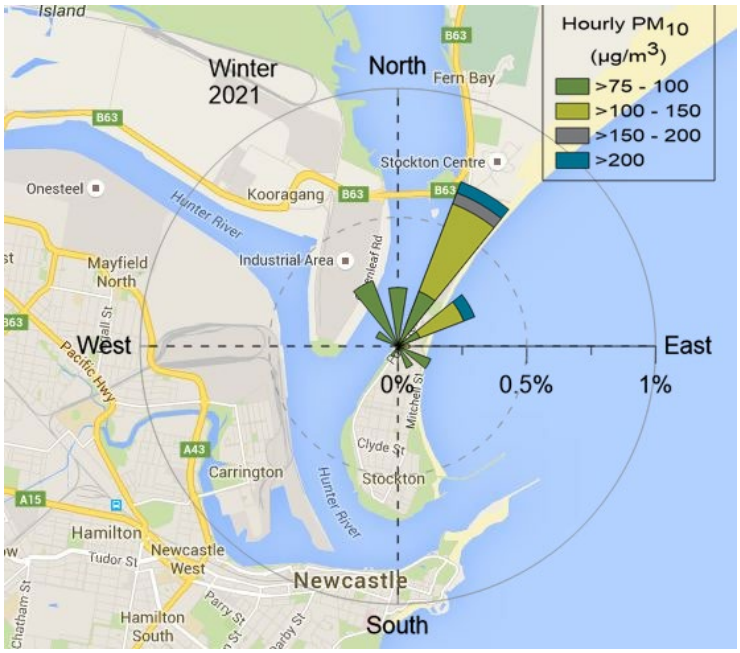


**Figure 19 Stockton winter 2021 PM10 pollution rose – proportion of hourly averaged PM10 levels >75 µg/m$^3$ by wind direction**

The Stockton monitoring station did not record any days over the PM2.5 daily benchmark during winter 2021. This was the same as all previous years (Figure 10). Elevated levels of hourly PM2.5 (>40 µg/m$^3$)[12] occurred 0.5% of the time (10 hours) during winter from the west to north-west (Figure 20).

[12] There are no standards for hourly PM10 or PM2.5 in the Air NEPM.

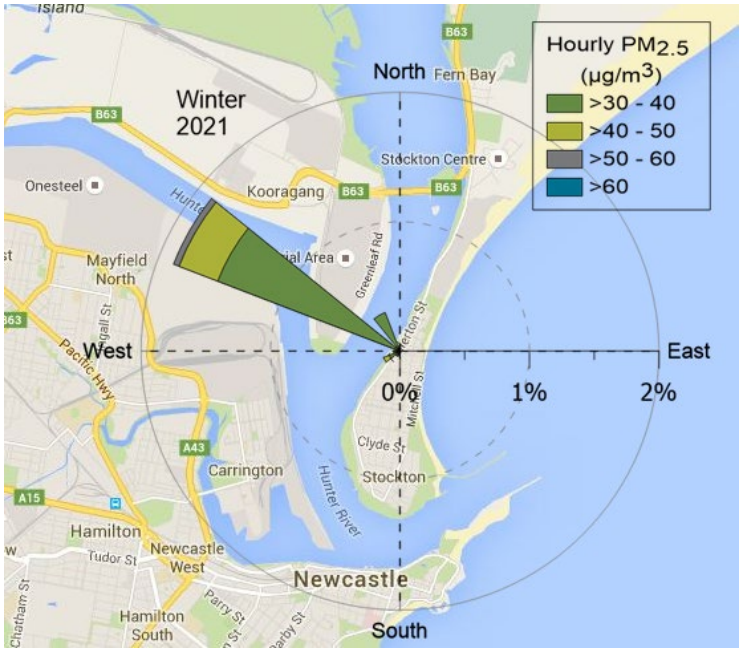


**Figure 20** **Stockton winter 2021 PM2.5 pollution rose – proportion of hourly averaged PM2.5 levels >30 µg/m3 by wind direction**

## Ammonia at Stockton in autumn and winter 2021

There were no days over the hourly $NH_3$ assessment goal of 46 pphm at Stockton during autumn and winter 2021.

$NH_3$ levels at Stockton follow a seasonal pattern with levels increasing in cooler months (when winds are predominantly from the north-west) and decreasing in warmer months (when winds are predominantly onshore easterly) (Figure 21). The primary ammonia source at Stockton is Orica's ammonium nitrate manufacturing facility on Kooragang Island, located to the north-west of the station[1].

Figure 21 shows that the maximum 1-hour average $NH_3$ concentrations from 2013 to 2021, were highest in 2013 and lowest in 2016 and 2019.

Figure 22 shows the daily $NH_3$ 1-hour maximum concentrations in 2021, plotted against the daily minimum and maximum levels from 2013 to 2020. This shows that daily 1-hour maximum $NH_3$ levels in autumn and winter 2021 were generally within the range of autumn and winter periods in earlier years.

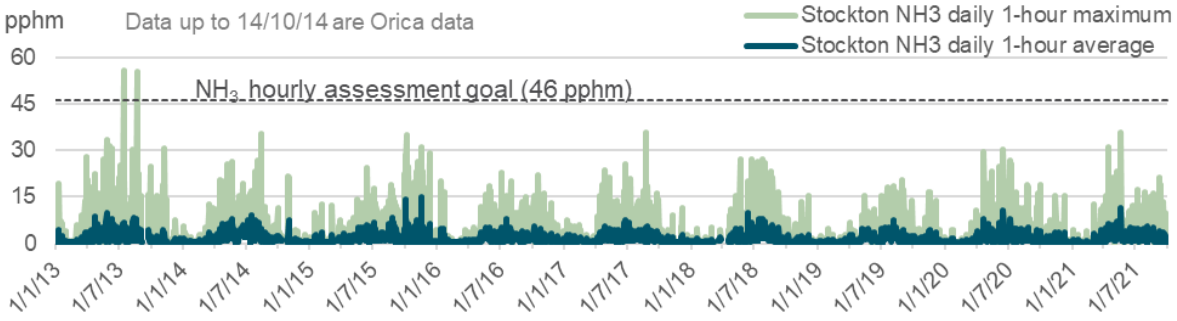


**Figure 21** **Stockton daily 1-hour maximum and average $NH_3$ from 2013 to 2021**

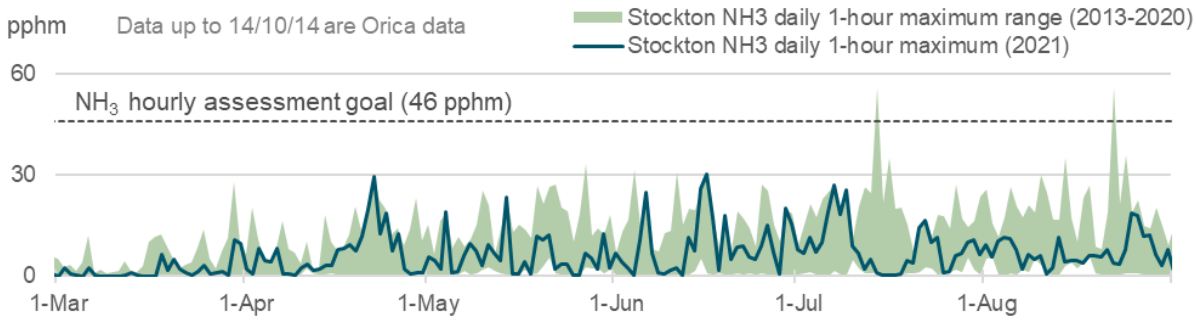


**Figure 22** **Stockton daily 1-hour maximum $NH_3$ for autumn and winter 2021 compared to daily levels from autumn and winter 2013 to 2020**

# Network performance

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

**Table 2 Online performance (%) during winter 2021**

| Station | Particles PM10 daily | Particles PM2.5 daily | Gases $SO_2$ Hourly | Gases $NO_2$ hourly | Gases $NH_3$ hourly | Meteorology Wind hourly |
|---|---|---|---|---|---|---|
| **Beresfield** | 100 | 100 | 95 | 95 | | 100 |
| **Carrington** | 100 | 99 | 92 | 95 | | 100 |
| **Mayfield** | 92 | 89 | 92 | 92 | | 96 |
| **Newcastle** | 97 | 97 | 93 | 94 | | 98 |
| **Stockton** | 100 | 99 | 95 | 91 | 93 | 100 |
| **Wallsend** | 98 | 98 | 94 | 94 | | 100 |

- = not monitored

The overall reduced online times were mainly due to:

- Mayfield PM10 – instrument fault (7 days)
- Mayfield PM2.5 – instrument fault (9 days) and scheduled maintenance (one day)



This document was prepared by Sean Watt and reviewed by Dr Upma Dutt, David Salter and Dr Leanne Graham.

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