# Air Quality Monitoring Network

## Newcastle spring 2023

Air quality in the Newcastle region[1] was generally good during spring 2023 despite the intensifying drought conditions. Daily particle levels were below national benchmarks 75% of the time at Stockton, 97% at Carrington, and 100% at all other stations. Hourly particle levels were in the good to fair air quality categories between 96% of time at Stockton to 100% at Beresfield and Wallsend.

- Levels of nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$) and ammonia ($NH_3$) were good, remaining below national benchmarks and assessment goals.
- Daily average levels of PM2.5[2] fine particles remained below the 25 µg/m$^3$ [3] benchmark.
- Daily average levels of PM10[4] particles were above the 50 µg/m$^3$ benchmark on 24 days. These occurred on 3 days at Carrington and 23 days at Stockton. Regional maximum daily PM10 levels on these days ranged from 50.8 to 92.6 µg/m$^3$.
- Elevated particle levels occurred predominantly during onshore winds at Stockton[5]. Particle levels at Stockton are influenced by sea salt spray transported by onshore winds[6], which prevail during the warmer months. Elevated particle levels at Carrington occurred under varying north-westerly to north-easterly winds, likely due to local or regional sources.
- Annual average particle levels were below benchmarks at all stations in 2023, except Stockton.
- The area had normal rainfall but much higher than usual daytime temperatures.

# Annual air quality trends

Long-term trends in annual average PM10 and PM2.5 levels are compared in Figure 1 and Figure 2.

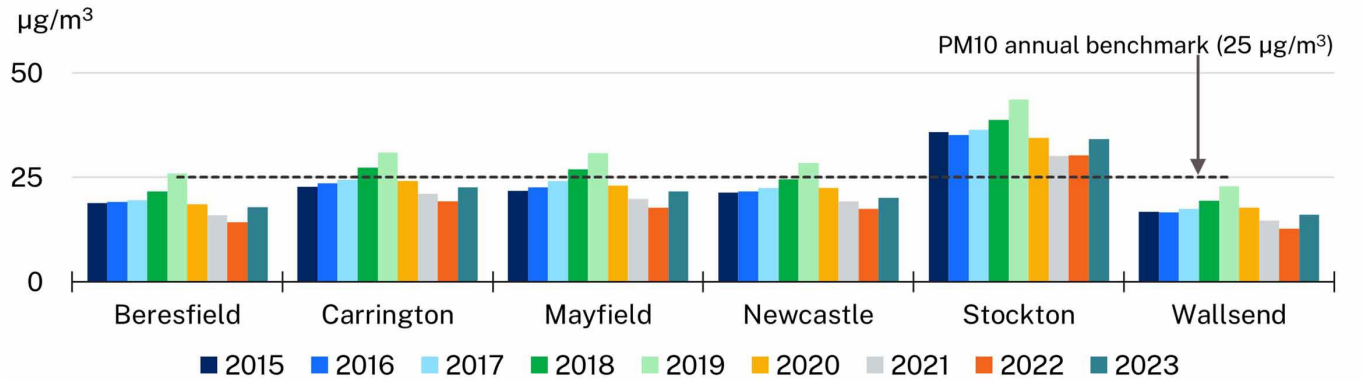


**Figure 1** **Annual average PM10 – 2015 to 2023**

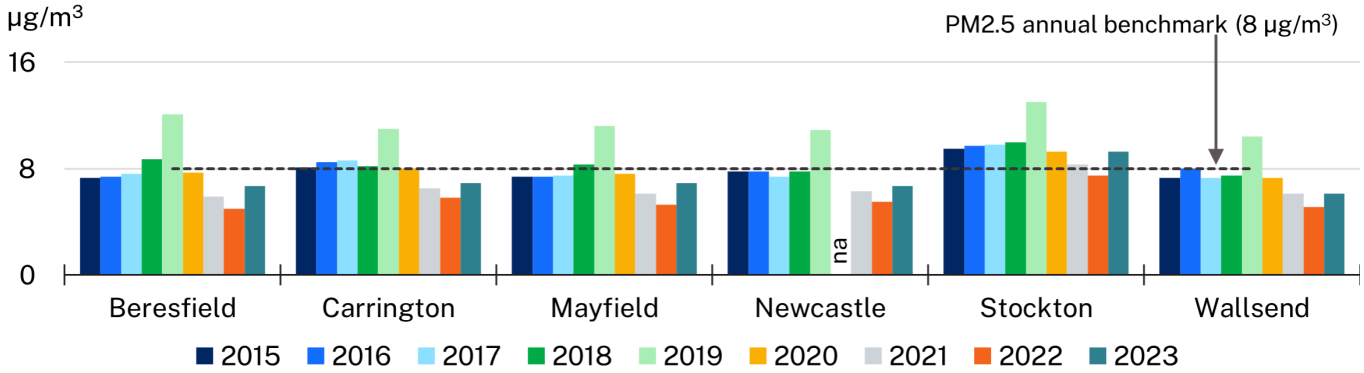


**Figure 2 Annual average PM2.5 – 2015 to 2023**

na = Newcastle 2020 annual average unavailable due to insufficient data availability

The comparisons in Figure 1 and Figure 2 show that particle levels increased at all stations in 2023, compared to recent record low years (2022 was the NSW best year for air quality on record[7]).

Annual average PM10 and PM2.5 levels were within the benchmarks at all stations in 2023, except Stockton:

- Stockton annual PM2.5 levels were 9.3 µg/m$^3$, exceeding the benchmark of 8 µg/m$^3$
- Stockton annual PM10 levels were 34.2 µg/m$^3$, exceeding the benchmark of 25 µg/m$^3$.

The higher PM10 and PM2.5 annual averages at Stockton were consistent with the Lower Hunter Particle Characterisation Study. The study found that PM10 levels in Stockton were 2.5 times higher than in Mayfield, mainly because of 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).

At the end of spring 2023, 65% of New South Wales was in one of 3 drought categories[8] (Figure 3), compared to 0% at the end of spring 2022[9], and 5% at the end of spring 2021[10].

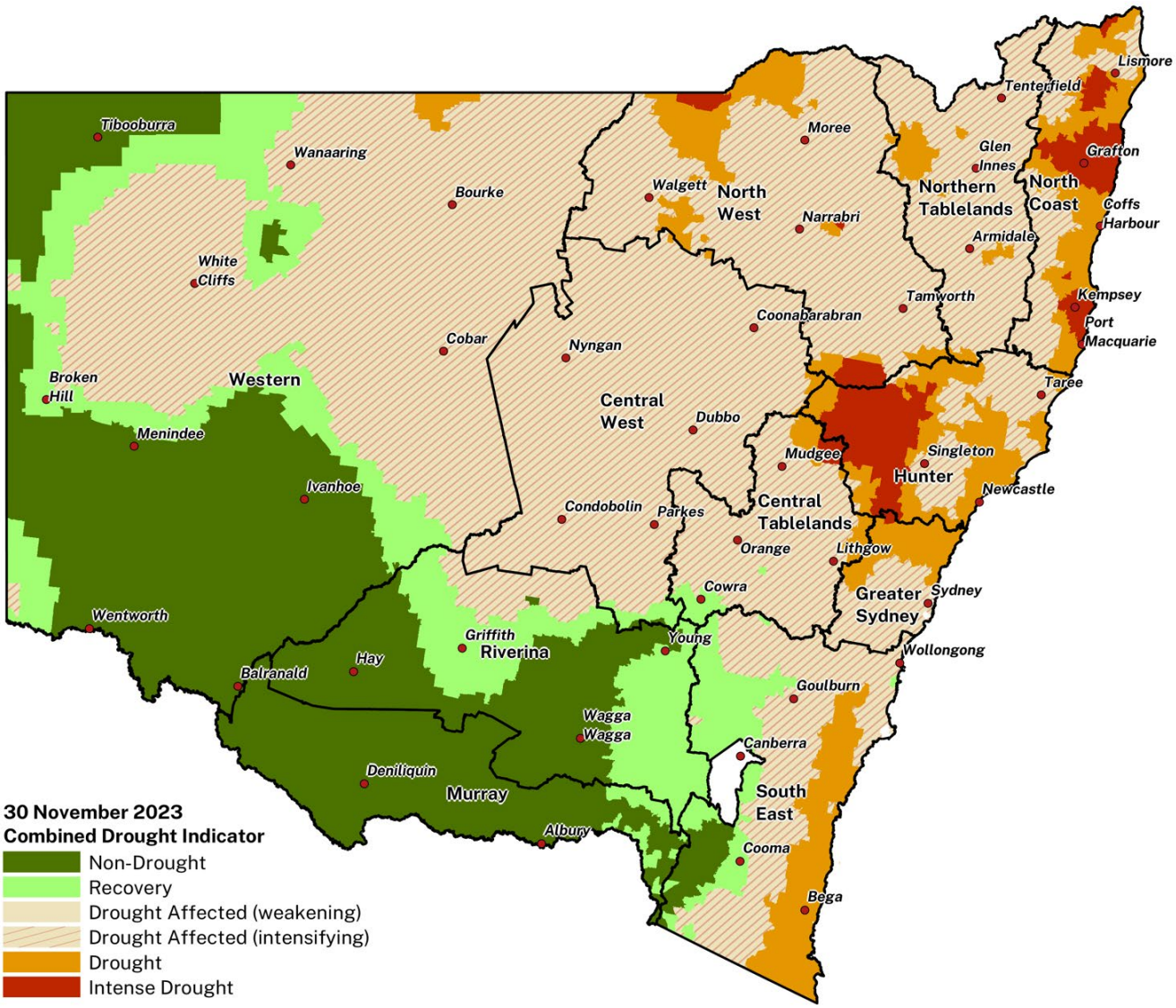


**Figure 3 Department of Primary Industries NSW combined drought indicator to 30 November 2023**[8]

Figure produced by NSW Department of Primary Industries © State of New South Wales EDIS v2.2

# Days above benchmark concentrations

In spring 2023, there were 23 days over the PM10 benchmark at Stockton (14–19 September; 2–3, 9, 11–12, 19, 21–25 and 31 October; 3 and 11–14 November) and 3 days over the benchmark at Carrington (18–20 September), compared to 3 days and 0 days respectively in spring 2022 (Table 1). Sea salt was the primary contributor to PM10 exceedance days at Stockton during onshore winds, while elevated levels at Carrington occurred under varying north-westerly to north-easterly winds.

Levels of PM2.5, $SO_2$, $NO_2$ and $NH_3$ remained below relevant benchmarks during the season.

**Table 1 Number of days above the relevant benchmarks – spring 2023**

| Station | PM10 daily [50 µg/m³ benchmark] | PM2.5 daily [25 µg/m³ benchmark] | $SO_2$ hourly [10 pphm benchmark] | $SO_2$ daily [2 pphm benchmark] | $NO_2$ hourly [8 pphm benchmark] |
|---|---|---|---|---|---|
| **Beresfield** | 0 | 0 | 0 | 0 | 0 |
| **Carrington** | 3 | 0 | 0 | 0 | 0 |
| **Mayfield** | 0 | 0 | 0 | 0 | 0 |
| **Newcastle** | 0 | 0 | 0 | 0 | 0 |
| **Stockton** | 23 | 0 | 0 | 0 | 0 |
| **Wallsend** | 0 | 0 | 0 | 0 | 0 |

µg/m³ = micrograms per cubic metre
pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air)

# Seasonal trends

Air quality levels in spring 2023 are compared with previous spring seasons (Figure 4 to Figure 7)[11].

There were no days above $NO_2$ and $SO_2$ benchmarks in spring during the past 11 years at Beresfield, Newcastle, Stockton and Wallsend, or since monitoring began in 2014 at Carrington and Mayfield.

At Stockton, there were no days over the $NH_3$ assessment criterion in spring during the past 11 years.

In spring 2023, Stockton recorded the second highest number of days over the PM10 benchmark on record, with 23 days above the national benchmark (behind 39 days recorded in 2019) (Figure 5). There were also 3 days over the PM10 daily benchmark at Carrington, the highest since 2019.

There were no days over the PM2.5 daily benchmark during spring 2023 (Figure 6). This is the same as spring 2022, 2021 and 2020.

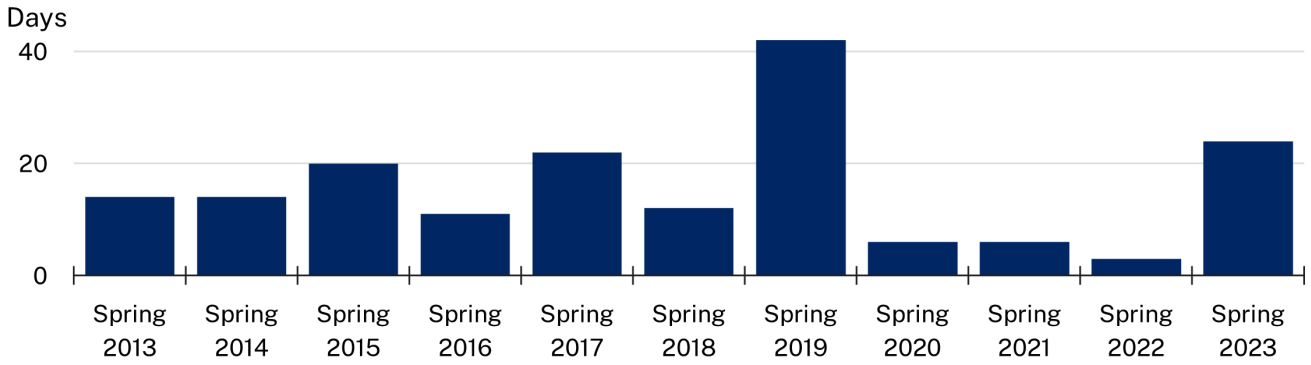

**Figure 4** **Number of days above the PM10 daily benchmark in the Newcastle region: spring 2013 to 2023**

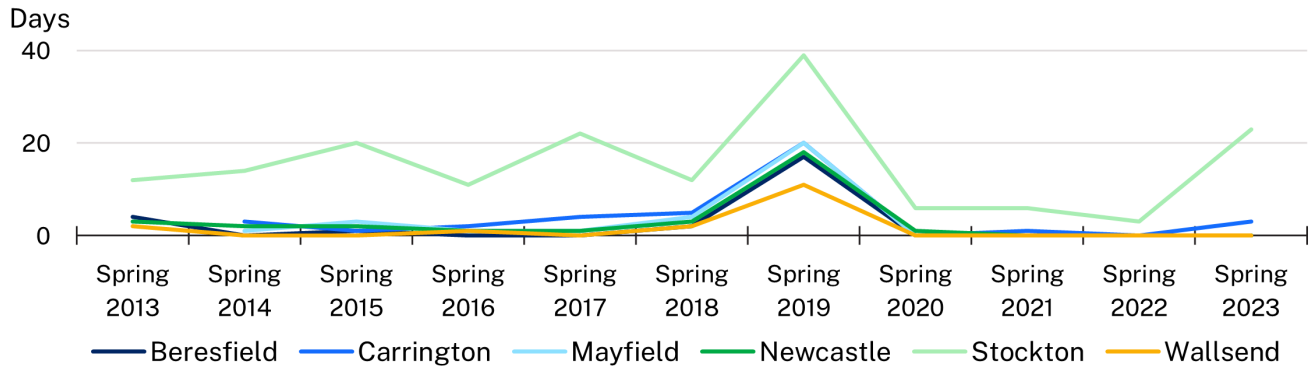


**Figure 5** **Number of days above the PM10 daily benchmark at each station: spring 2013 to 2023**

Note: There are no PM10 data for Carrington and Mayfield before August 2014. Data from Stockton before 14 October 2014 came from Orica.

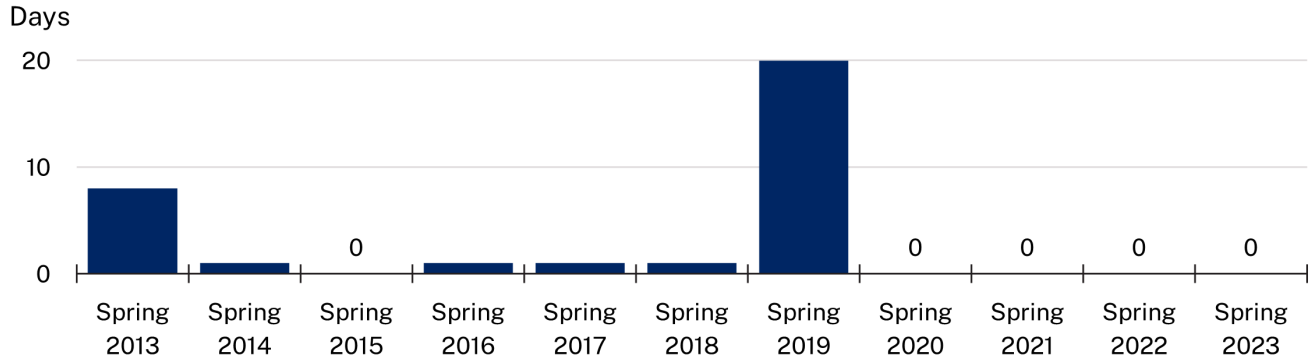


**Figure 6** **Number of days above the PM2.5 daily benchmark in the Newcastle region: spring 2013 to 2023**

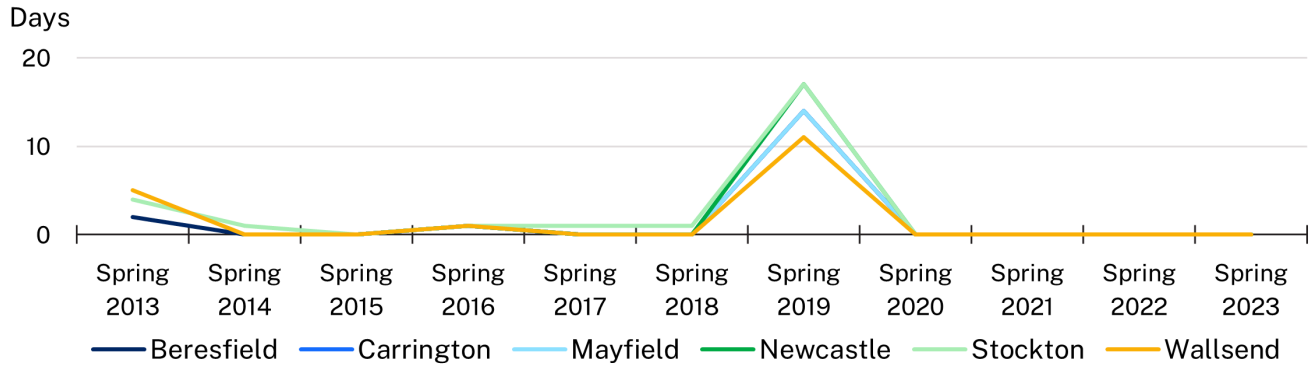


**Figure 7** **Number of days above the PM2.5 daily benchmark at each station: spring 2013 to 2023**

Note: There are no PM2.5 data for Carrington and Mayfield before August 2014, or Newcastle before December 2013. Data from Stockton before 14 October 2014 came from Orica.

# Daily time series plots

Daily average time series plots for PM10 and PM2.5 and daily 1–hour maximum plots for $NO_2$, $SO_2$ and $NH_3$ show the concentrations throughout the spring season (Figure 8 to Figure 12).

All parameters except PM10 remained below the benchmarks throughout the season. Stockton and Carrington PM10 exceeded the daily benchmark on 23 and 3 days, respectively. Stockton was predominantly affected by sea salt on these days due to its proximity to the ocean. See Stockton section for further details.

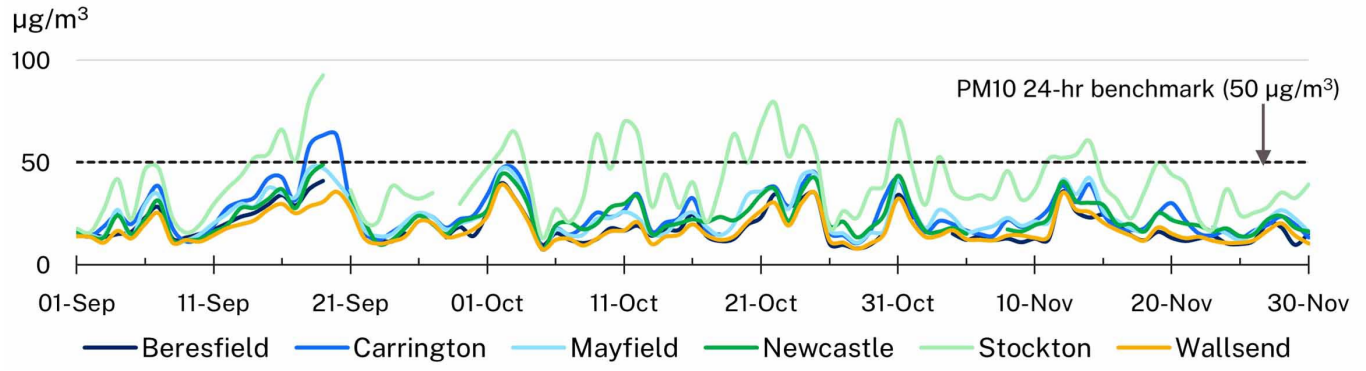


**Figure 8 Daily average PM10 during spring 2023[12]**

Note: Stockton daily PM10 data missing on 20 September 2023 due to data logger issue.

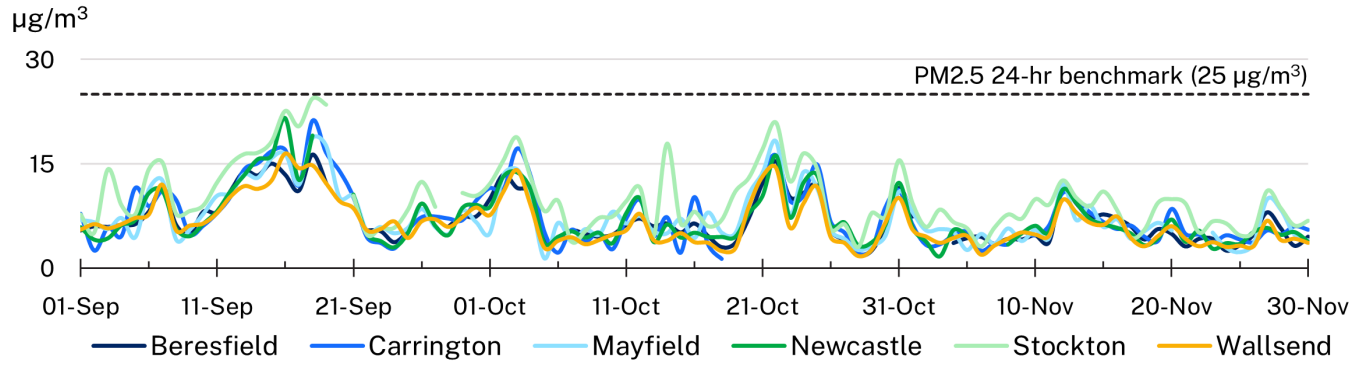


**Figure 9 Daily average PM2.5 during spring 2023[12]**

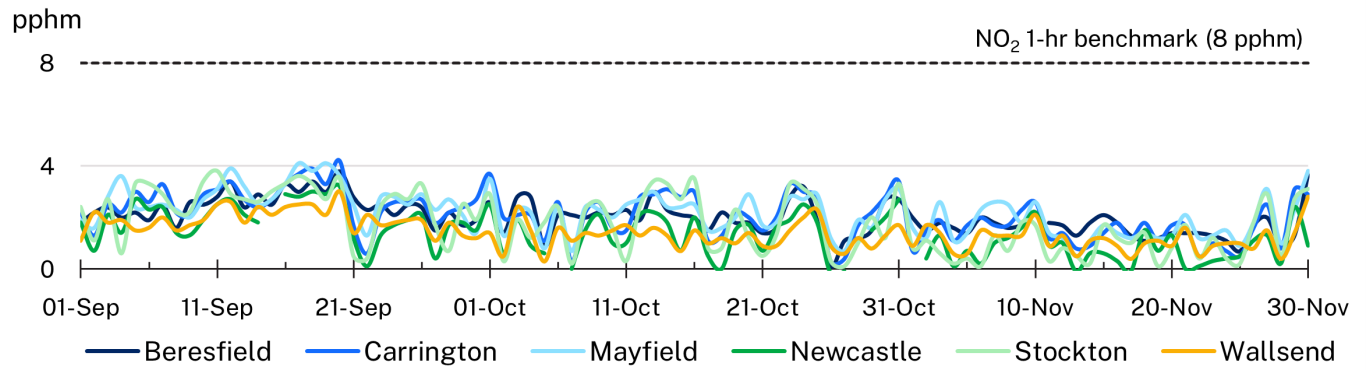


**Figure 10 Daily maximum 1-hr $NO_2$ during spring 2023[12]**

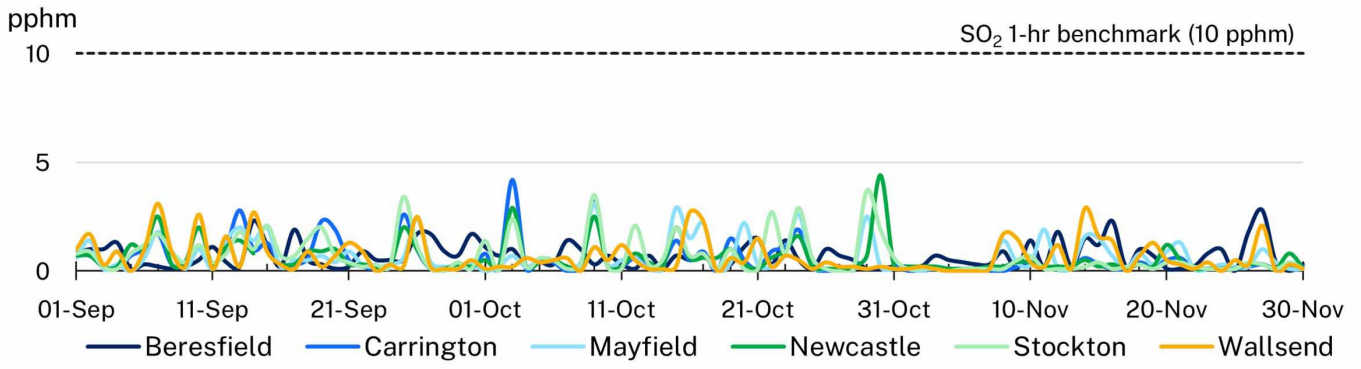


**Figure 11** **Daily maximum 1-hr $SO_2$ during spring 2023**[12]

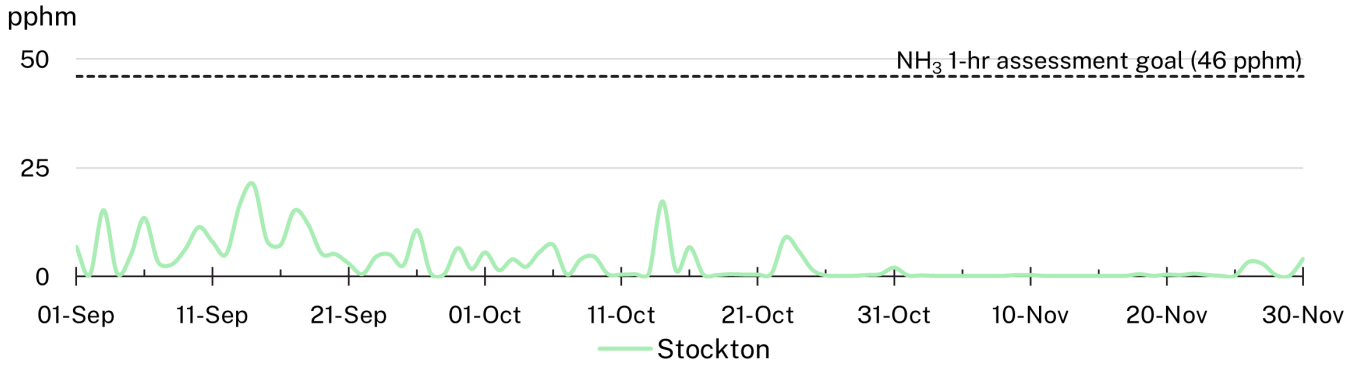


**Figure 12** **Daily maximum 1-hour $NH_3$ during spring 2023**

# Pollution roses from hourly particle data

The seasonal pollution rose maps[13] (Figure 13 and Figure 14) show that hourly[14] PM10 levels were periodically elevated, mainly at Stockon. PM2.5 levels generally remained low during the season. The majority (82%) of hours of elevated PM10 (>100 µg/m$^3$) at Stockton were recorded during onshore easterly winds, indicative of sea salt influence (see Stockton section for more detail).

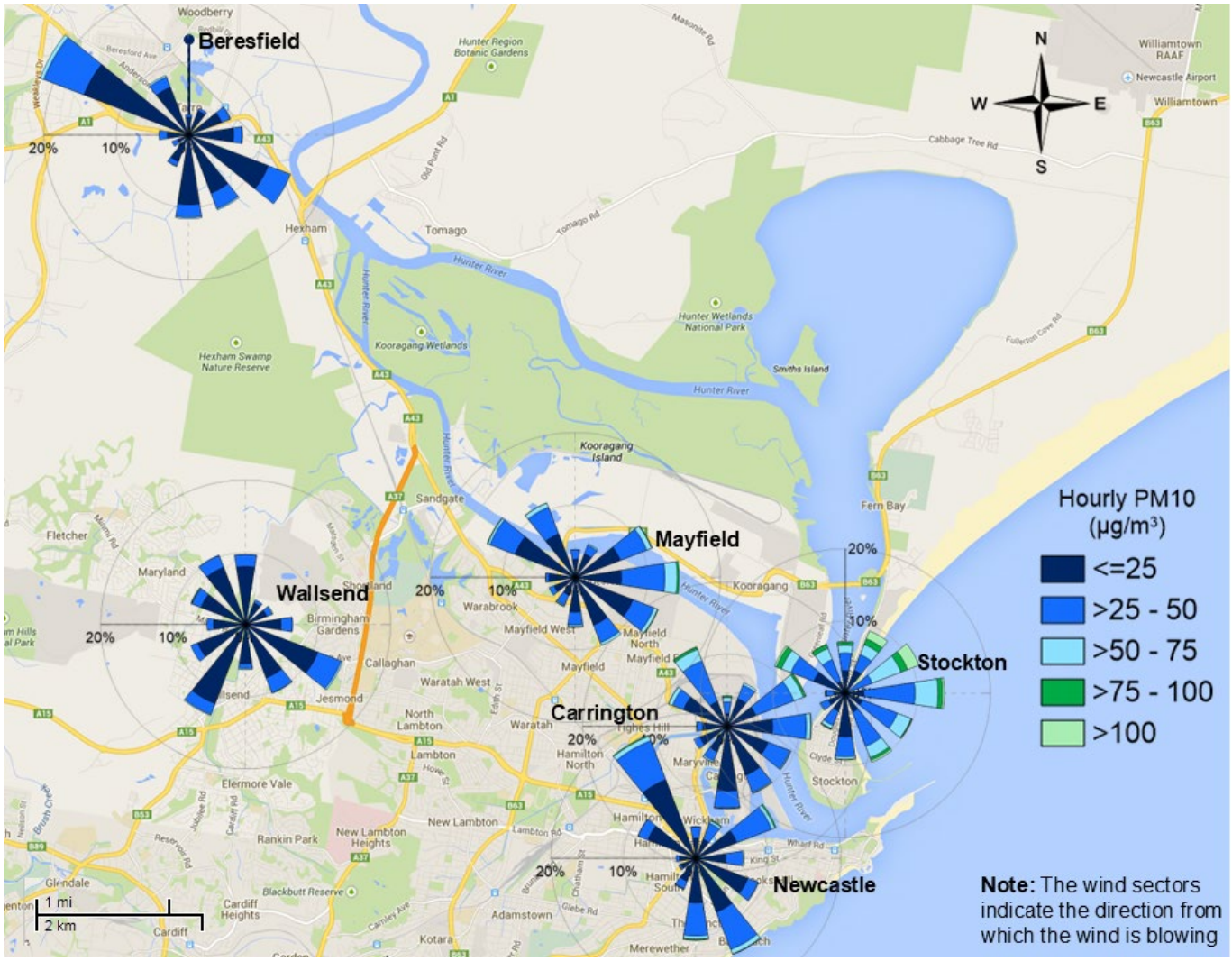


**Figure 13** **Hourly PM10 pollution roses for the Newcastle region for spring 2023**

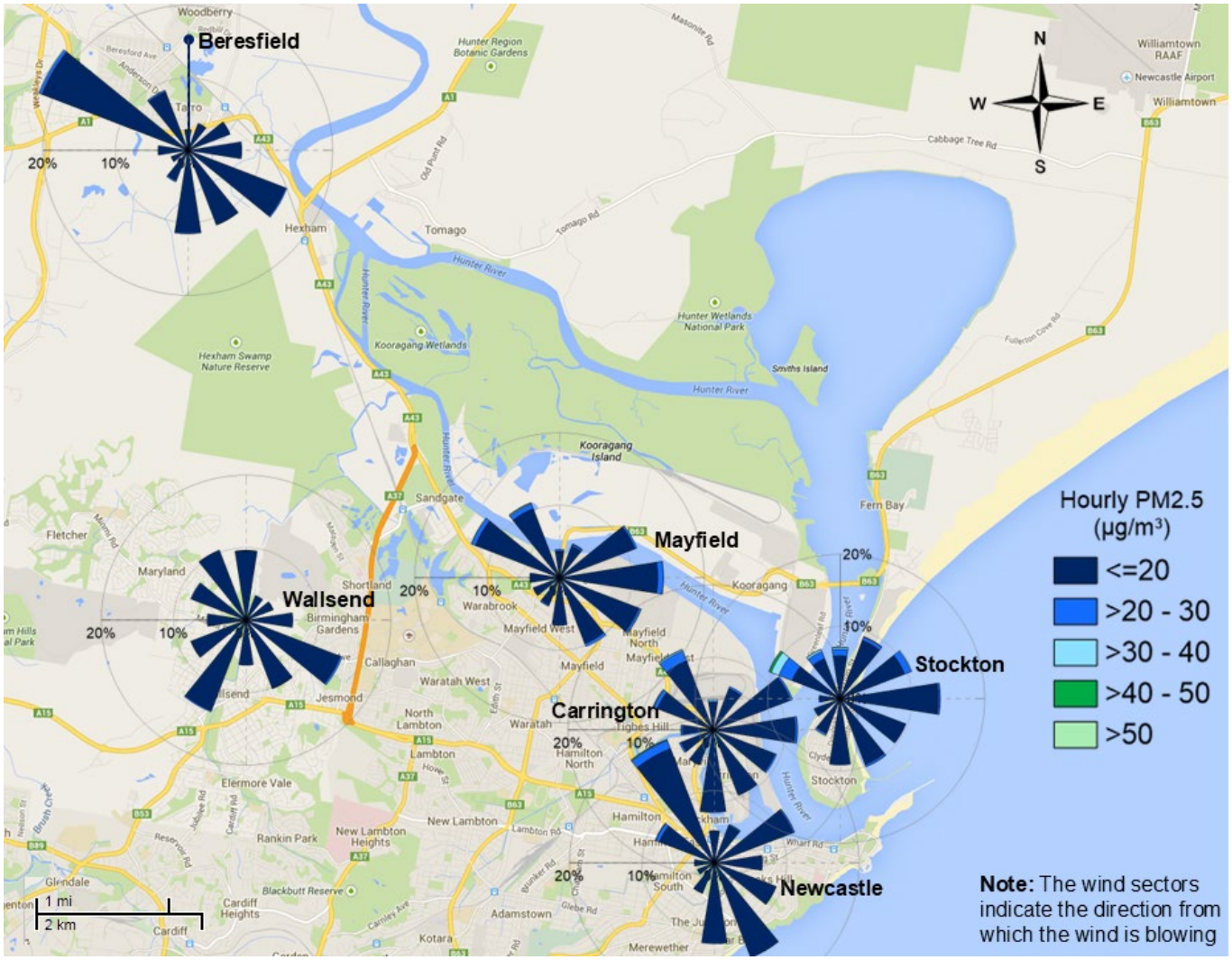


**Figure 14** **Hourly PM2.5 pollution roses for the Newcastle region for spring 2023**

# Particle air quality trends

Figure 15 and Figure 16 show daily average PM10 during spring 2023, compared to the daily maximum and minimum PM10 levels (shaded range) from 2013 to 2022, at Stockton and Newcastle. Daily PM10 levels were generally within the historical range throughout the season. Exceptions include peaks in late September and October during onshore breezes indicative of sea salt.

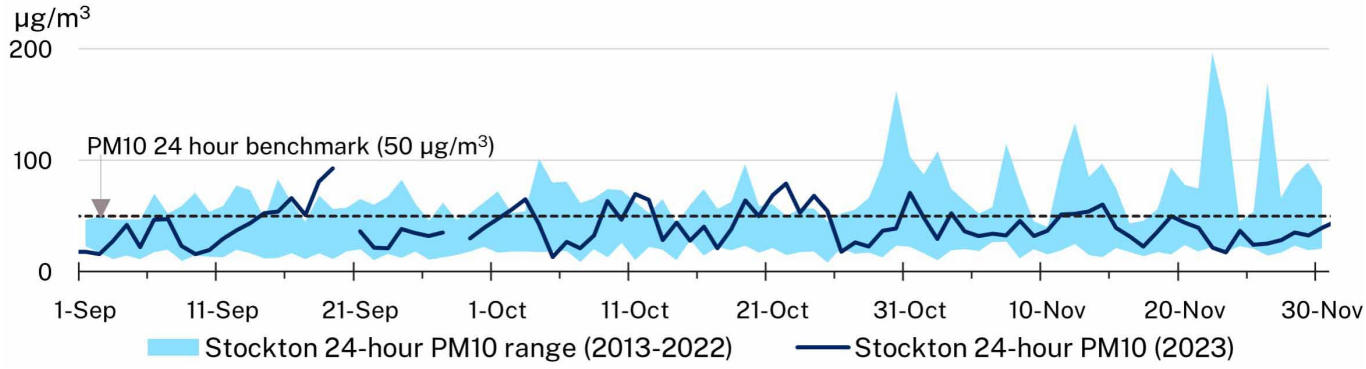


**Figure 15** **Stockton daily average PM10 during spring 2023 plotted against the daily maximum and minimum PM10 levels from 2013 to 2022[12]**

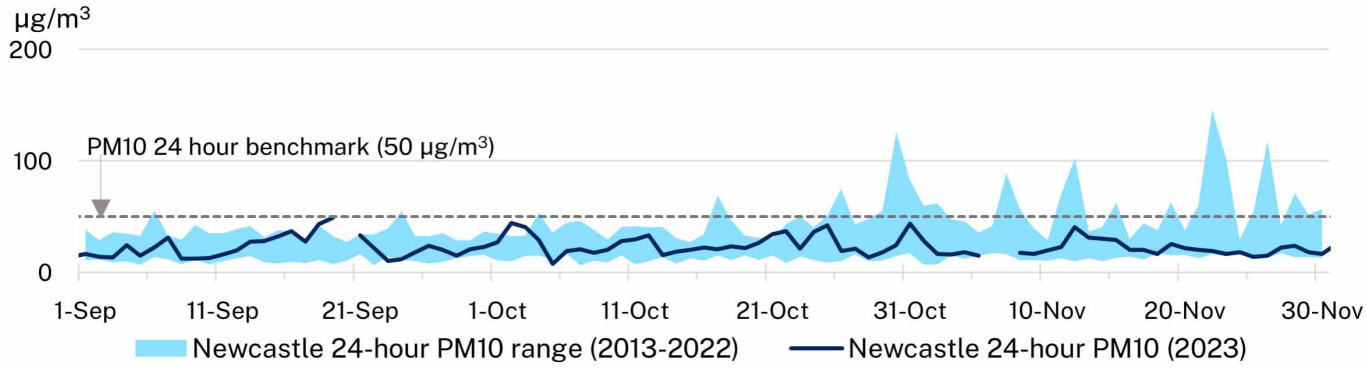


**Figure 16** **Newcastle daily average PM10 during spring 2023 plotted against the daily maximum and minimum PM10 levels from 2013 to 2022[12]**

Rainfall in Newcastle was generally average during spring (Figure 17), with below-average levels in September and above-average in November.

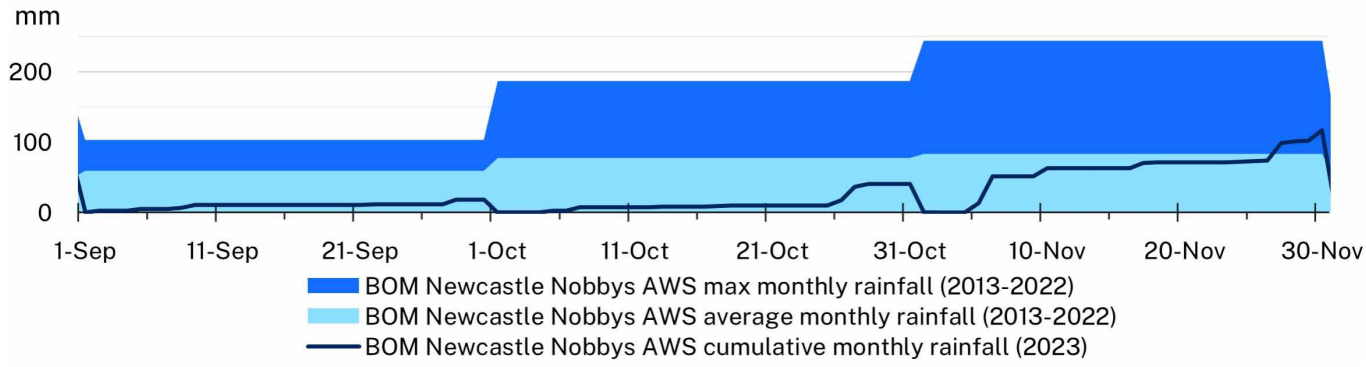


**Figure 17** **Bureau of Meteorology Newcastle Nobbys Signal Station aviation weather service (AWS)[15] cumulative rainfall during spring 2023 plotted against maximum and average rainfall from 2013 to 2023**

Figure 18 and Figure 19 show daily average PM2.5 during spring 2023, compared to the daily maximum and minimum PM2.5 levels (shaded range) from 2014 to 2022, at Stockton and Newcastle. Daily PM2.5 levels were generally within the historical range throughout the season except during some days in late September and October during onshore breezes (indicative of sea salt contributions).

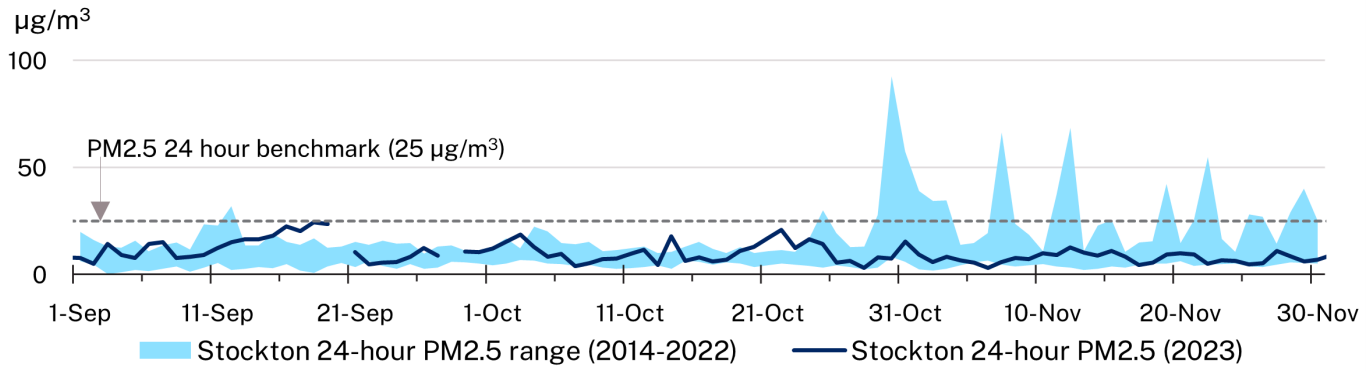


**Figure 18** **Stockton daily average PM2.5 during spring 2023 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2022[12]**

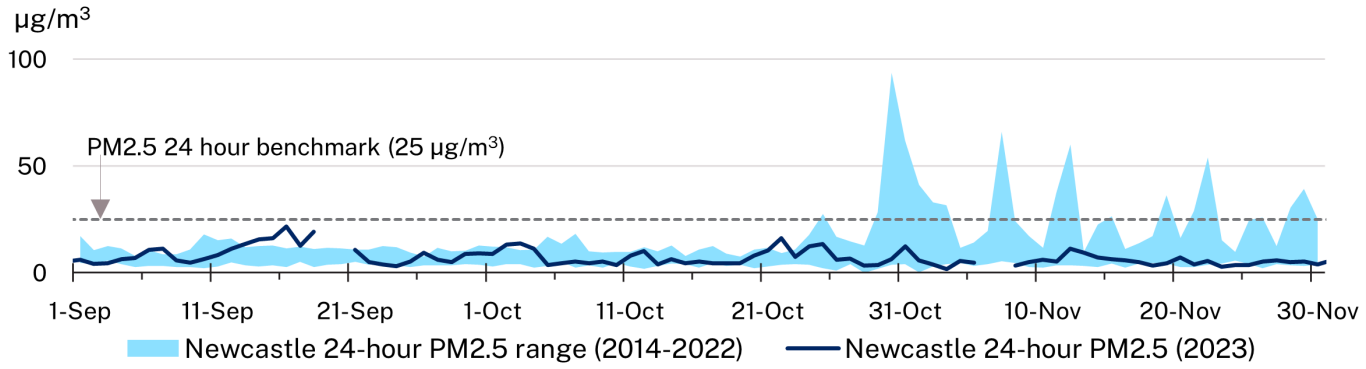


**Figure 19** **Newcastle daily average PM2.5 during spring 2023 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2022**[12]

# Meteorological summary

## Rainfall[16]

The Newcastle region experienced average rainfall during spring 2023 compared to long-term records (Figure 20). Monthly rainfall levels were below average in September, average in October and above average in November due to heavy rainfall in late spring.

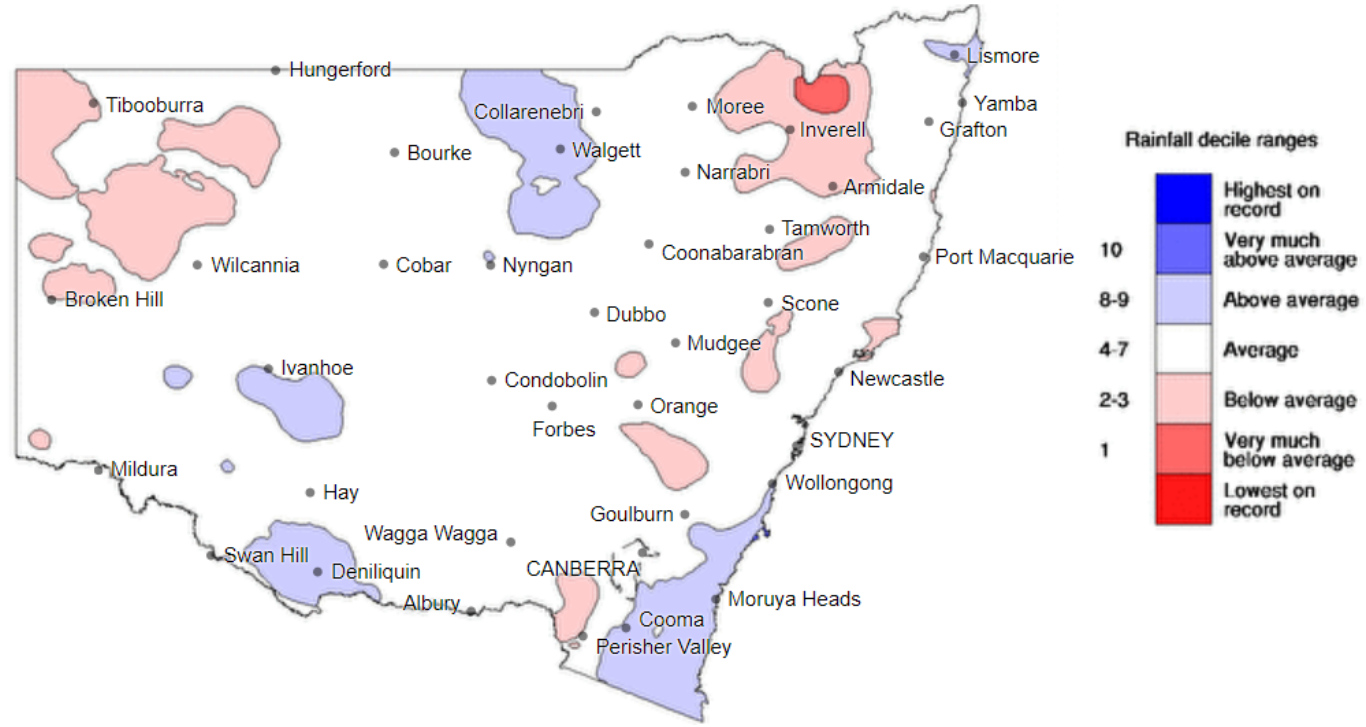


**Figure 20** **NSW rainfall deciles – spring 2023**

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology.
Base period: 1900-Nov 2023. Dataset: AGCD v2. Issued 20/09/2024.

## Temperatures [16]

Maximum temperatures were very-much-above-average in Newcastle during the season (Figure 21), while minimum temperatures were above average for the region.

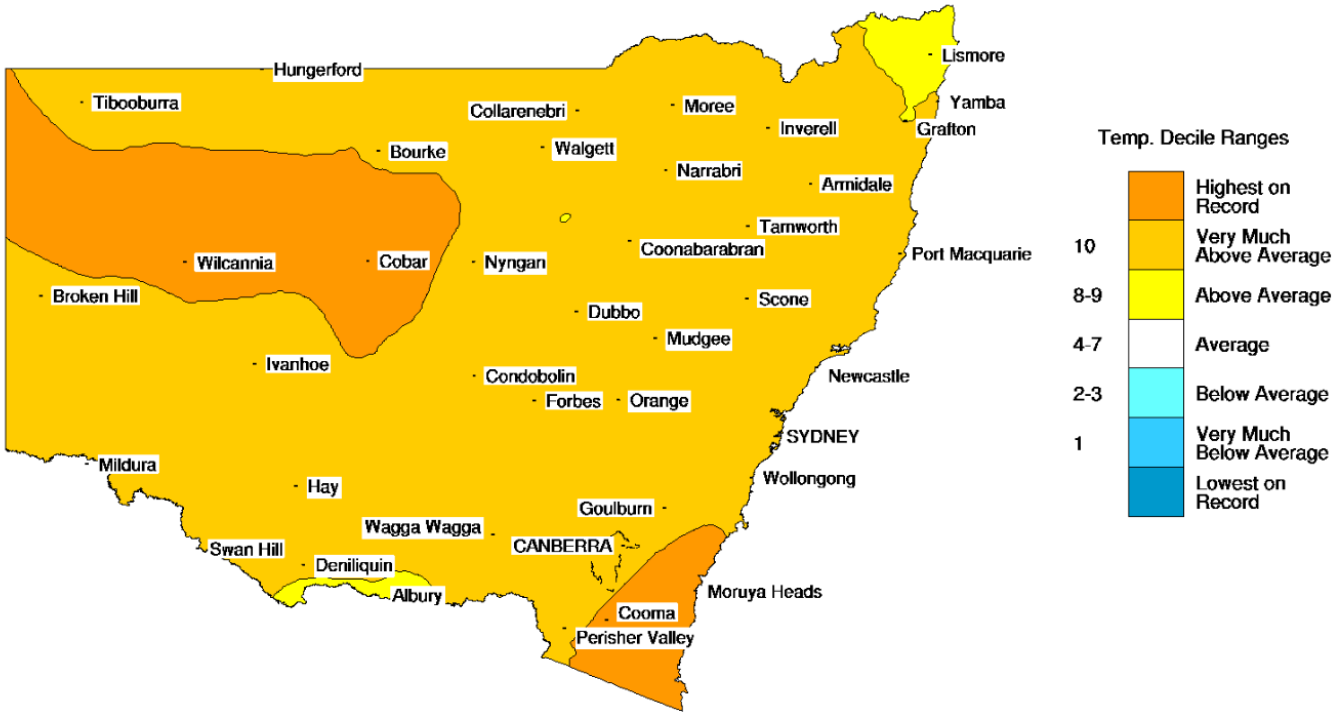


**Figure 21 NSW maximum temperature deciles – spring 2023**

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. ID code: AWAP. Issued 29/05/2024.

## Winds

Winds were variable in the region during spring 2023, which was typical for this transitional season, where predominant winds change from north-westerly in winter to south-easterly in summer.

Figure 22 shows that north-west winds prevailed 15% of the time at Stockton, with these moderate or stronger (above 5 metres per second) 34% of the time.

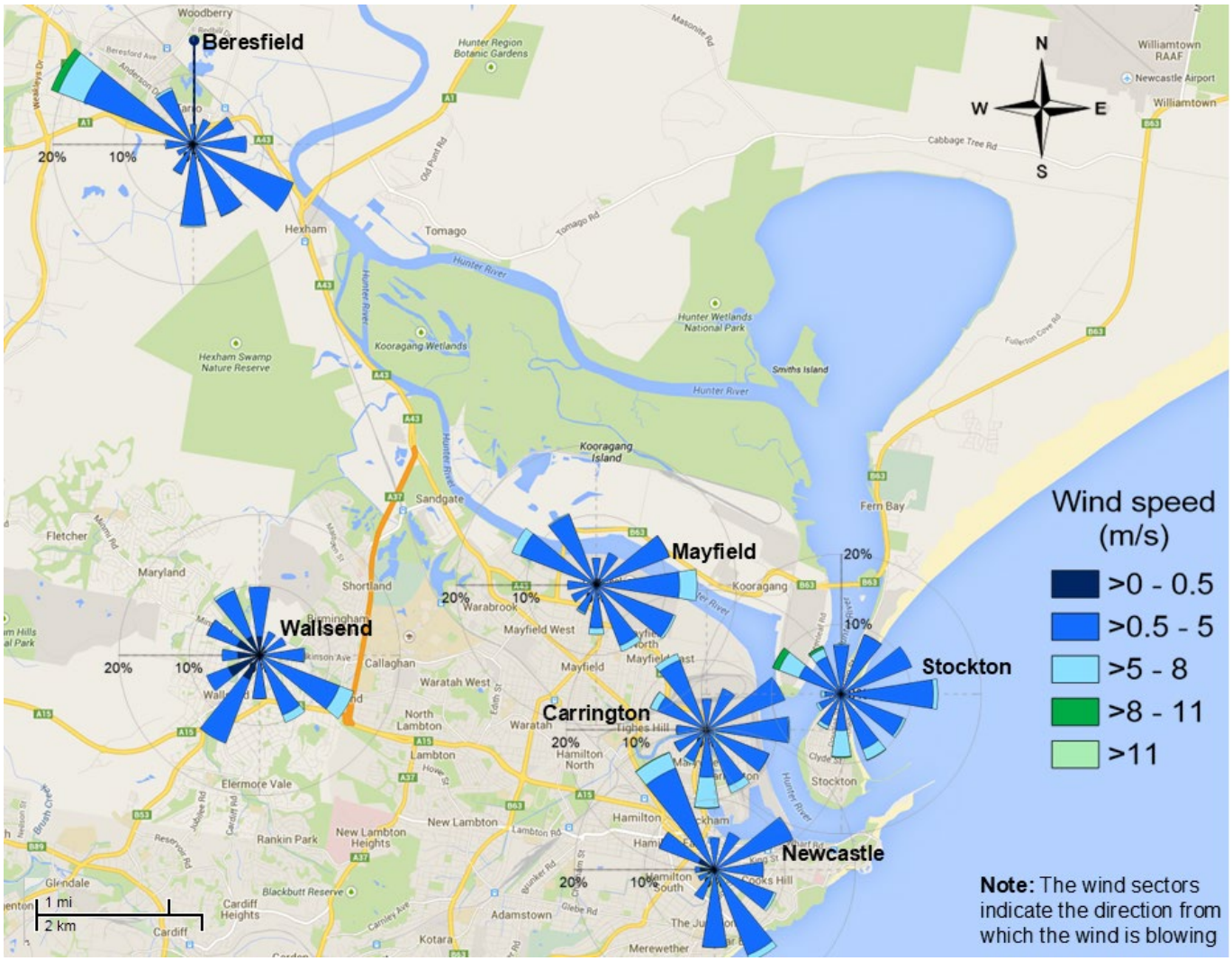


**Figure 22** **Wind rose map for the Newcastle region for spring 2023**

# Stockton

The Stockton monitoring station recorded 23 days over the PM10 daily benchmark during spring 2023. This is the second-highest number of days over the PM10 benchmark during spring since Orica began monitoring in October 2012. This represents an increase of 20 days compared to spring 2022 (the NSW best year for air quality on record[7]). From 2013 to 2023, Stockton recorded between 3 days (spring 2022) and 39 days (spring 2019) over the PM10 daily benchmark (Figure 5).

In spring 2023, elevated hourly PM10 levels (>100 µg/m$^3$)[17] were recorded at Stockton 4.2% of the time (Figure 23). These occurred under onshore north-easterly to south-easterly winds 82% of the time (74 hours, 3.5% total for spring). There were 6 hours with elevated hourly PM10 under north-westerly winds, likely from local sources.

Elevated PM10 levels under predominant onshore winds at Stockton indicate the likely contribution of sea salt. The Lower Hunter Particle Characterisation Study found sea salt was a major contributor of particles at the station under onshore winds.

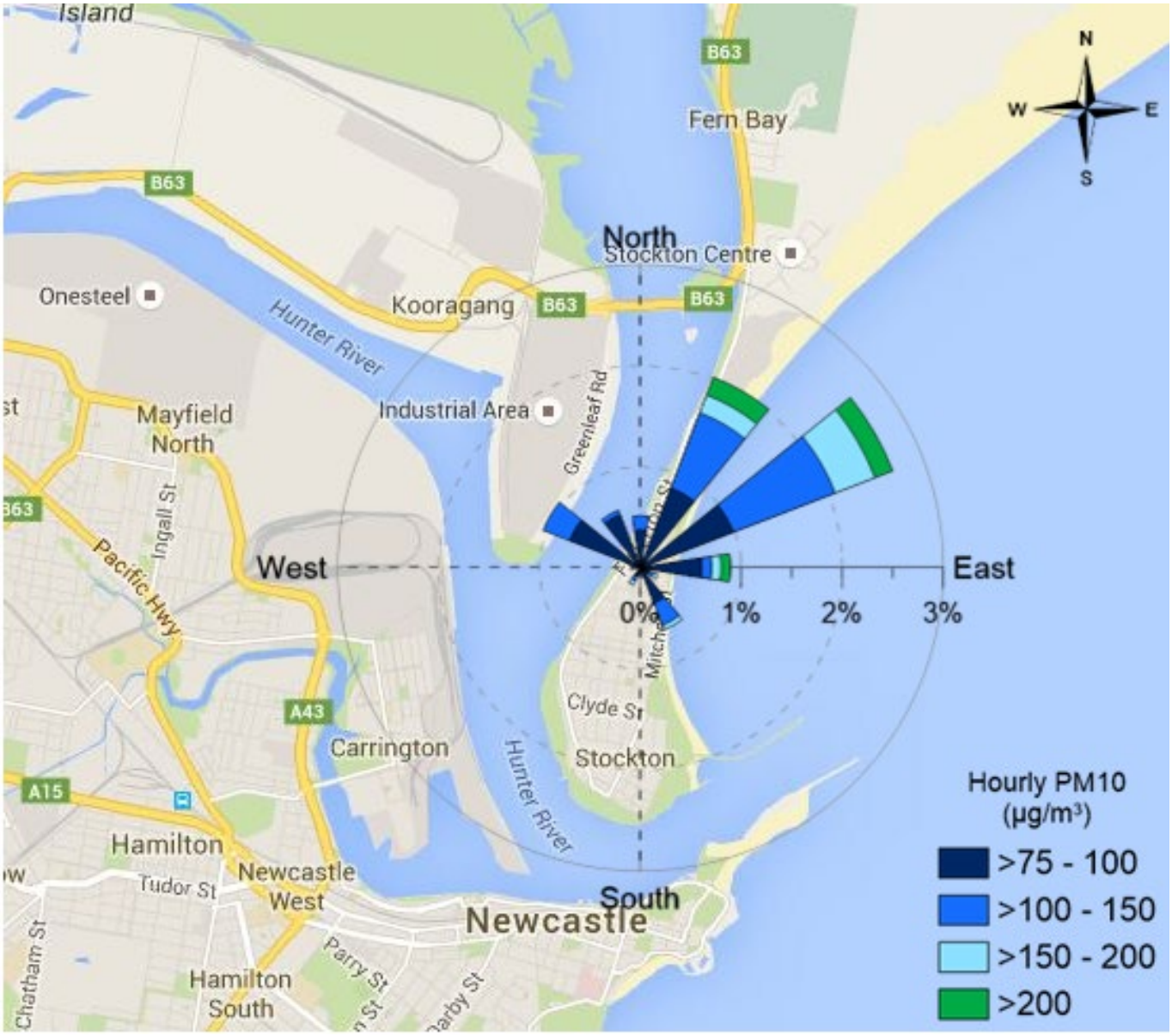


**Figure 23 Stockton spring 2023 PM10 pollution rose for hourly PM10 levels over 75 µg/m³**

The Stockton monitoring station did not record any days over the PM2.5 daily benchmark during spring 2023. From 2013 to 2023, there were from 0 days (springs 2015, 2020-2023) to 17 days (spring 2019) over the PM2.5 daily benchmark (Figure 7).

There were 3 hours with elevated hourly PM2.5 levels (>50 µg/m³) during spring 2023 (Figure 24). The maximum hourly PM2.5 level was 60.9 µg/m³ which occurred under a north-westerly wind.

There were no days with elevated $NH_3$ during spring 2023 (pollution rose not shown).

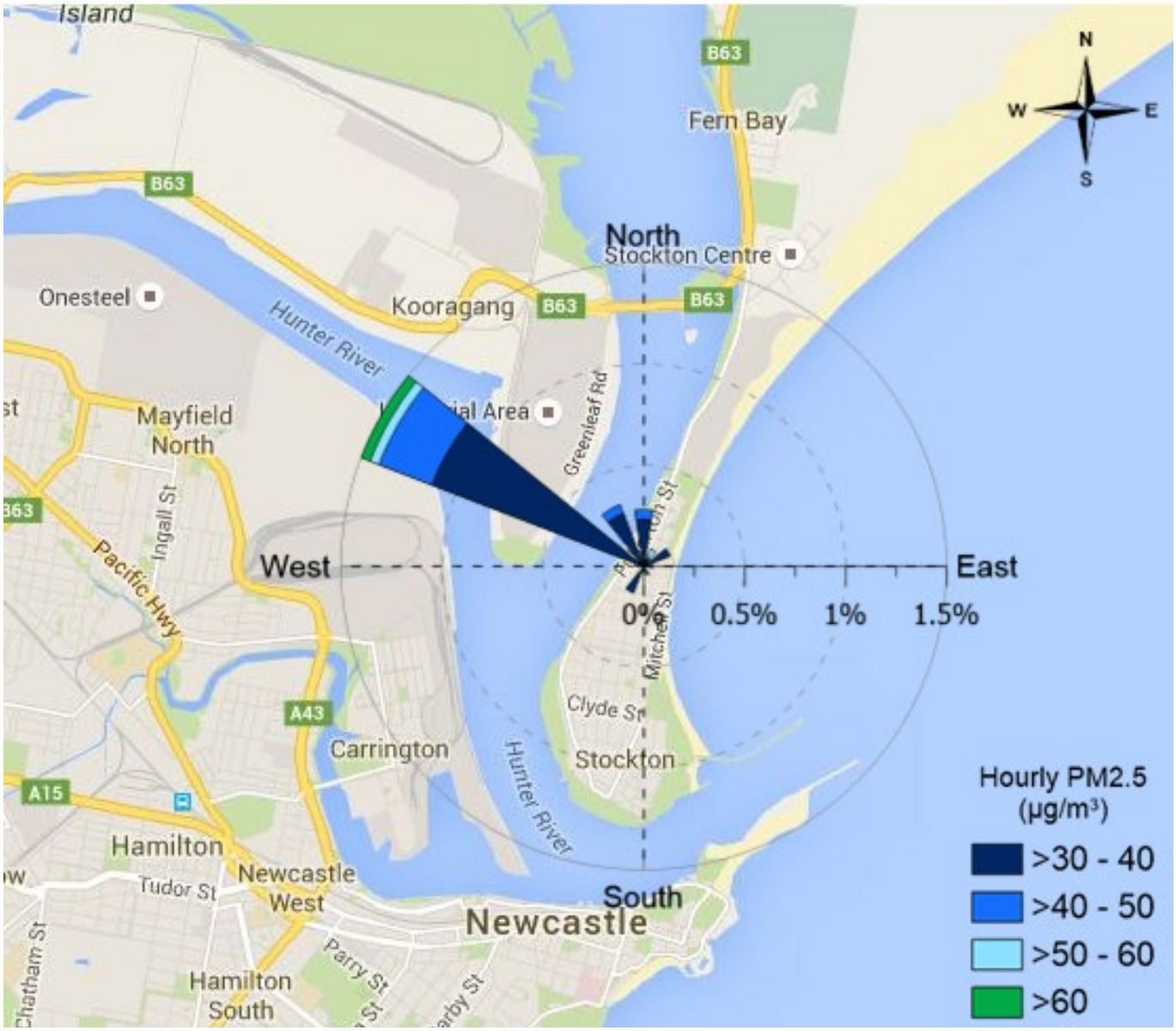


**Figure 24** **Stockton spring 2023 PM2.5 pollution rose for hourly PM2.5 levels over 30 µg/m³**

# Network performance

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

**Table 2** **Online performance (%) during spring 2023**

| Station | Particles PM10 daily | Particles PM2.5 daily | Gases $SO_2$ hourly | Gases $NO_2$ hourly | Gases $NH_3$ hourly | Meteorology wind hourly |
|---|---|---|---|---|---|---|
| **Beresfield** | 93 | 93 | 94 | 92 | — | 99 |
| **Carrington** | 98 | 98 | 92 | 95 | — | 100 |
| **Mayfield** | 98 | 98 | 94 | 95 | — | 99 |
| **Newcastle** | 97 | 96 | 91 | 80 | — | 99 |
| **Stockton** | 98 | 98 | 93 | 94 | 94 | 99 |
| **Wallsend** | 100 | 100 | 95 | 95 | — | 100 |

The reduced online time for Newcastle $NO_2$ was mainly due to instrument faults and maintenance, along with some data logger issues.



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[1] 'Newcastle region' includes the 3 Lower Hunter air quality region stations (Beresfield, Newcastle, Wallsend), and 3 stations in the Newcastle local air quality region (Carrington, Mayfield, Stockton) located nearby the Port of Newcastle.

[2] Particles less than or equal to 2.5 microns in diameter.

[3] Micrograms per cubic metre.

[4] Particles less than or equal to 10 microns in diameter.

[5] See Stockton section for further details.

[6] Lower Hunter Particle Characterisation Study.

[7] NSW annual air quality statement 2022.

[8] Sourced from Department of Primary Industries NSW State seasonal update – November 2023 (accessed January 2024).

[9] Sourced from Department of Primary Industries NSW State seasonal update – November 2022 (accessed February 2023).

[10] Sourced from Department of Primary Industries NSW State seasonal update – November 2021 (accessed February 2023).

[11] 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.

[12] Data gaps at Newcastle region stations this season were predominantly due to data logger and power issues, on top of maintenance checks.

[13] 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.

[14] There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

[15] Data from Bureau of Meteorology Newcastle Nobbys Signal Station AWS monthly rainfall page (accessed January 2024).

[16] Rainfall and temperature information is from the Bureau of Meteorology New South Wales spring 2023 climate statement (accessed February 2023) and climate maps (accessed January 2024).

[17] There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure.