Air Quality Monitoring Network Newcastle Summer 2023-24 seasonal newsletter

Newcastle summer 2023–24

Air quality in the Newcastle region[1] was mostly good during summer 2023–24.

- Levels of nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ammonia (NH_3) remained below national benchmarks and assessment goals[2].
- Daily average levels of PM2.5[3] remained below the 25 µg/m^3 benchmark at all stations.
- Daily average levels of PM10 exceeded the 50 µg/m^3 benchmark on 25 days. These occurred on all 25 days at Stockton, 3 days at Mayfield and 2 days at Carrington. Daily average particle levels were below national benchmarks 73% of the time at Stockton, 97% at Mayfield, 98% at Carrington, and 100% of the time at the remaining 3 stations.
- Stockton exceeded the PM10 daily benchmark most often in January (12 days). Elevated PM10 levels at Stockton are influenced by sea salt spray transported under prevailing onshore winds typical in the warmer months[4]. See Stockton section for details.
- Hourly particle levels were in the 'good to fair' air quality categories[5] for 96% of hours at Stockton, and at remaining sites ranged from 99.5% at Carrington and up to 100% at Wallsend.
- The region had average rainfall but much higher temperatures than usual.

Annual air quality trends

Long-term trends in rolling annual average[6] PM10 and PM2.5 levels are at Figure 1 and Figure 2.

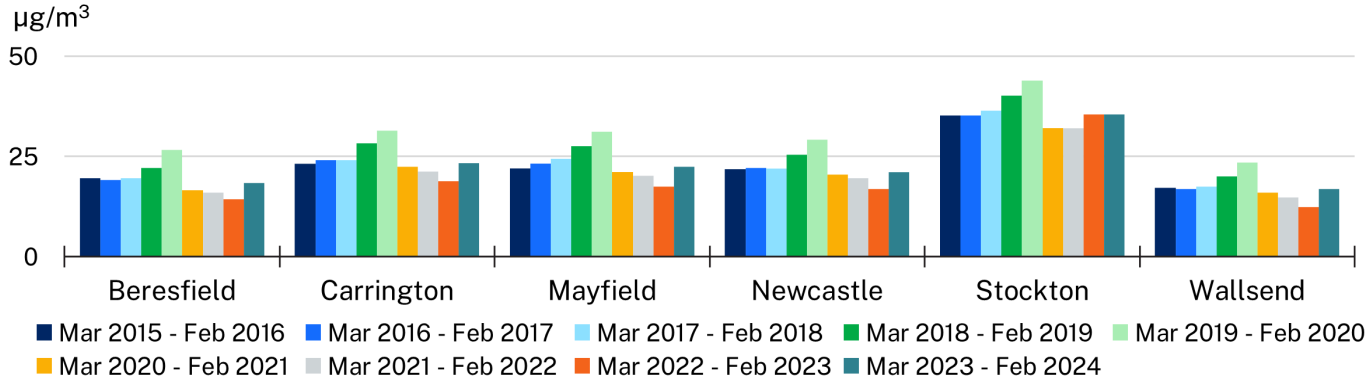

Figure 1 Rolling annual averages[6] to the end of summer 2015–16 to summer 2023–24 for PM10

Note: data in this figure are listed in Table 3, Appendix A: Rolling annual averages.

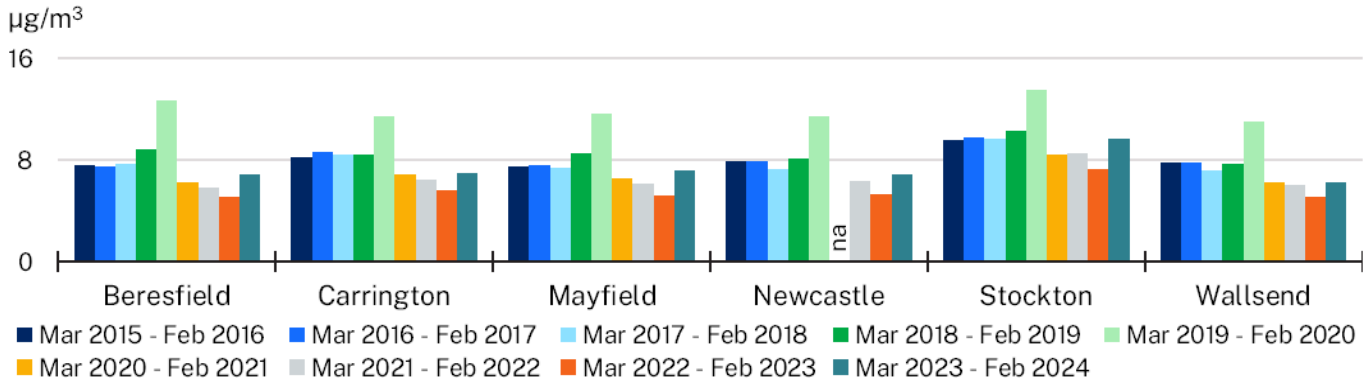

Figure 2 Rolling annual averages[6] to the end of summer 2015–16 to summer 2023–24 for PM2.5

na = rolling annual average unavailable due to insufficient data availability
Note: data in this figure are listed in Table 4, Appendix A: Rolling annual averages.

Rolling annual PM10 and PM2.5 averages for March 2023 to February 2024 were higher than the 3 previous 12-month periods. For all stations, the PM10 and PM2.5 concentrations in the 12 months to the end of February 2024 were the highest or equal highest since the 2019–20 bushfire season (March 2019 to February 2020). This increase reflects a tendency towards drier conditions (Figure 3) following 3 successive years of La Niña conditions.

The higher PM10 and PM2.5 annual averages at Stockton are consistent with the Lower Hunter Particle Characterisation Study[4] finding that PM10 at Stockton was at least twice the levels compared to 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 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).

In the 12 months to the end of February 2024, 45% of New South Wales was in one of the 5 drought categories, including areas of the Upper Hunter and Newcastle (Figure 3)[7]. In previous summers, no areas of New South Wales were affected by drought at the end of summer 2022–23[8], while 3% of New South Wales was drought affected at the end of summer 2021–22[9].

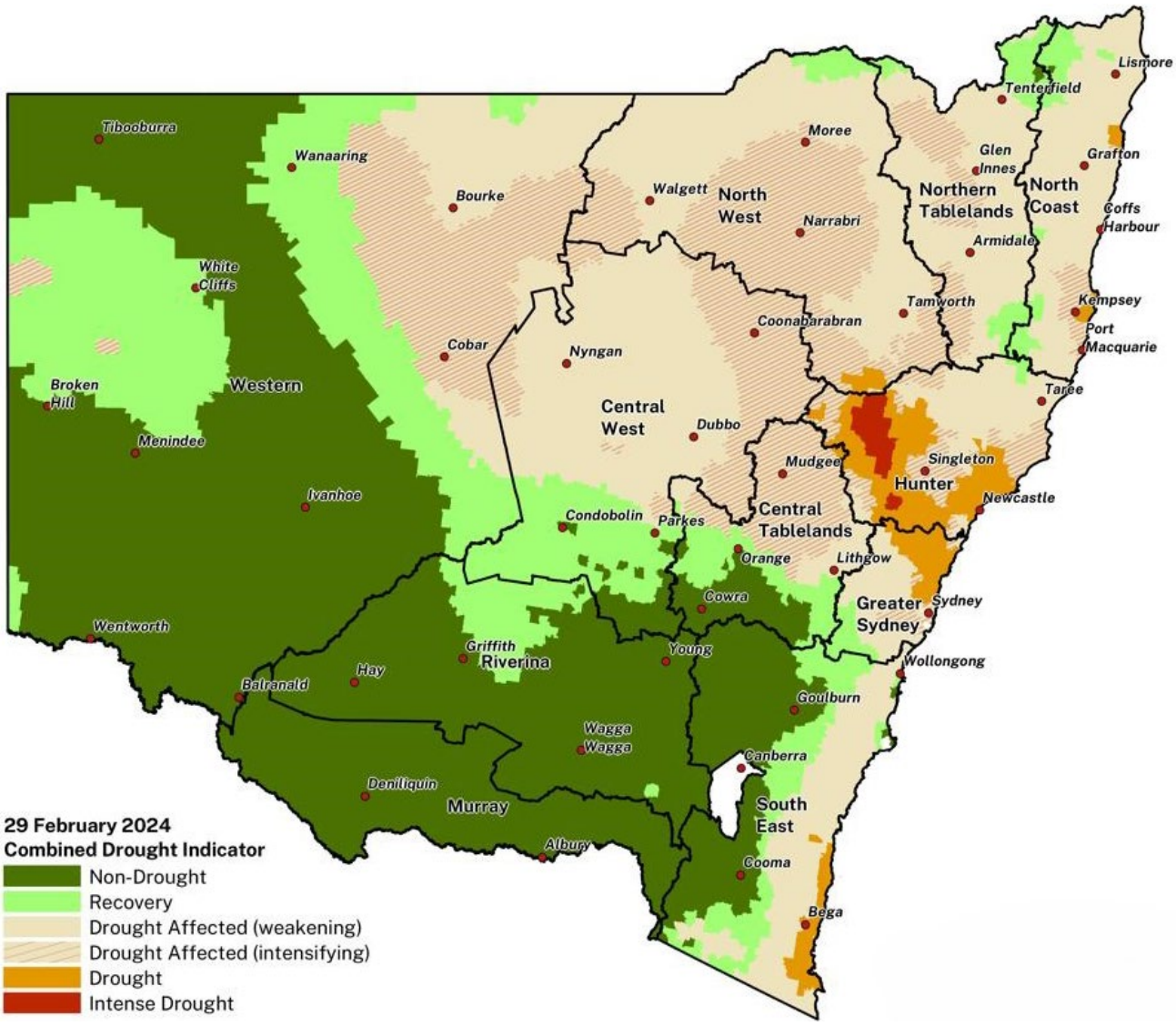

Figure 3 NSW combined drought indicator map for the 12 months to 29 February 2024[7]

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

Days above benchmark concentrations

Concentrations of PM2.5 particles, SO_2, NO_2 and NH_3 were below benchmarks at all stations. Particles as PM10 was the only exceeding pollutant during summer 2023–24 (Table 1). Stockton recorded 25 days over the PM10 daily benchmark, followed by Mayfield (3 days) and Carrington stations (2 days).

Table 1 Number of days above the relevant national benchmarks: summer 2023–24

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

Seasonal trends

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

At Stockton, there have been no days over the NH_3 assessment criterion in summer during the past 11 years.

Figure 4 to Figure 7 compare particle trends in summer 2023–24 with previous summer seasons where data were available[10].

In summer 2023–24, the region had 25 days over the PM10 daily benchmark (Figure 4). This is more than double the 12 days observed in summer 2022–23, though comparable to summer 2021–22 (28 days). Historically, days over the PM10 daily benchmark ranged from 9 days (summer 2013–14) to 43 days (summer 2019–20).

Figure 5 shows the highest number of days over the PM10 daily benchmark historically were recorded at Stockton (43 days) while the remaining stations recorded maximums of 16 to 21 days, all during summer 2019–20. This peak occurred in a season affected by intense drought conditions and extreme bushfires.

The region recorded no days over the PM2.5 daily benchmark during summer 2023–24, the same as the previous 3 summers (Figure 6). Historically, days over the PM2.5 daily benchmark have occurred in 2 summers, with 20 days occurring in summer 2019–20 and one day in summer 2015–2016. All other summer seasons did not record any days over the PM2.5 daily benchmark. Figure 7 shows the highest number of days were recorded at Beresfield (17 days) in summer 2019–20, with all other stations recording 13 days above the benchmark in summer 2019–20.

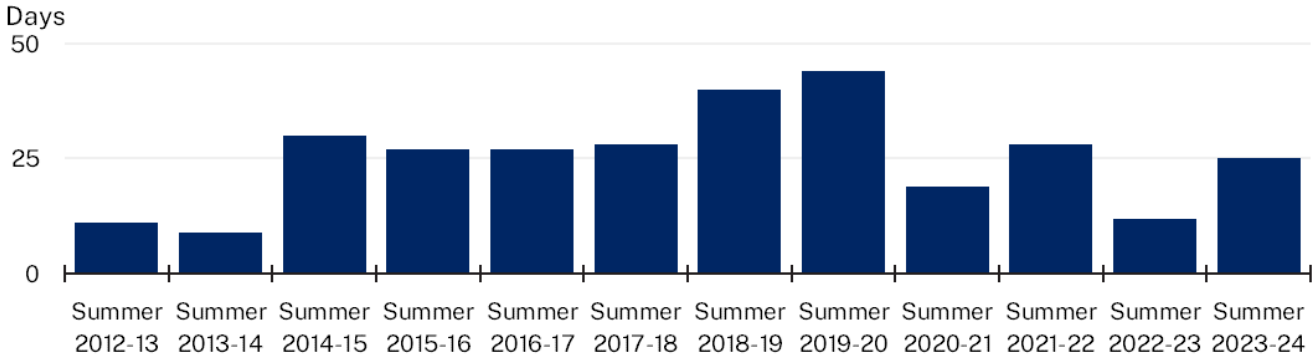

Figure 4 **Number of days above the PM10 daily benchmark in the Newcastle region: summer 2012–13 to summer 2023–24**

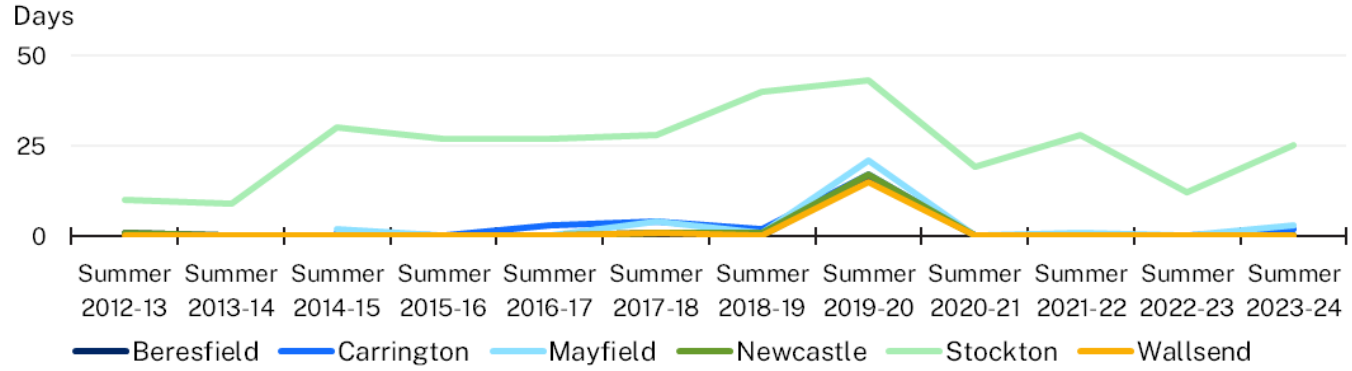

Figure 5 **Number of days above the PM10 daily benchmark at each station: summer 2012–13 to summer 2023–24**

Note: There are no PM10 data for Carrington and Mayfield prior to August 2014. Stockton data prior to 14 October 2014 came from Orica[10].

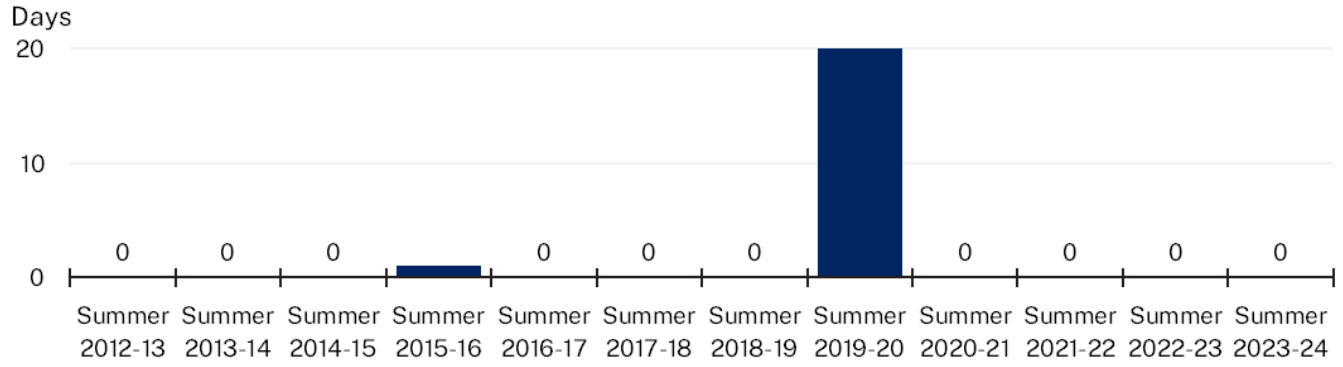

Figure 6 **Number of days above the PM2.5 daily benchmark in Newcastle region: summer 2012–13 to 2023–24**

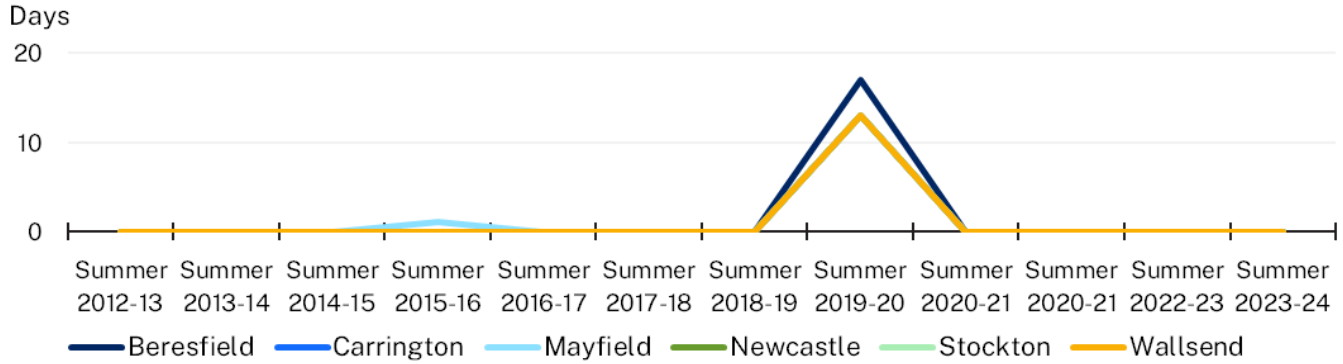

Figure 7 **Number of days above the PM2.5 daily benchmark at each station: summer 2012–13 to 2023–24**

Note: There are no PM2.5 data for Carrington and Mayfield prior to August 2014, or Newcastle prior to December 2013. Data from Stockton prior to 14 October 2014 came from Orica[10].

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 are shown from Figure 8 to Figure 12 for summer 2023–24. Except for PM10 at Stockton, Carrington and Mayfield, all other parameters remained below the benchmarks and assessment criteria.

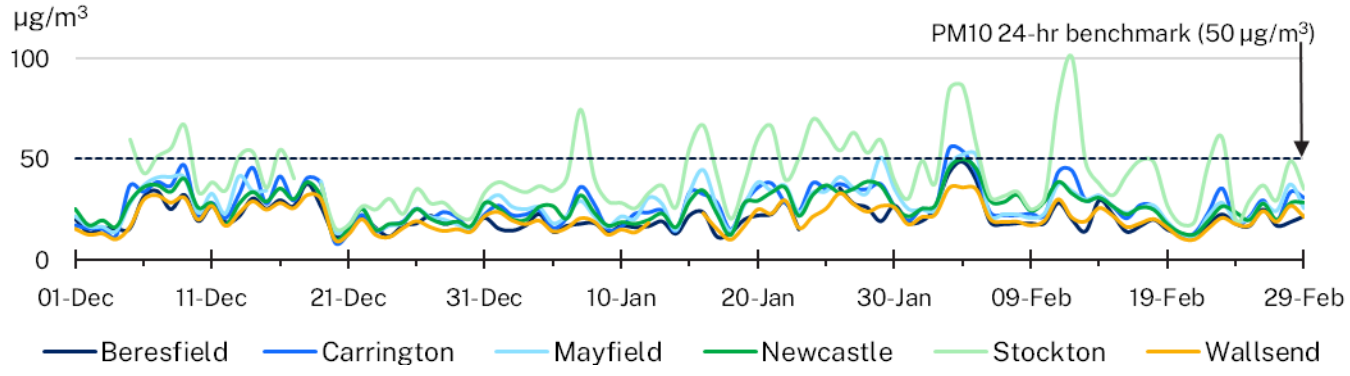

Figure 8 **Daily PM10 averages during summer 2023–24**[11]

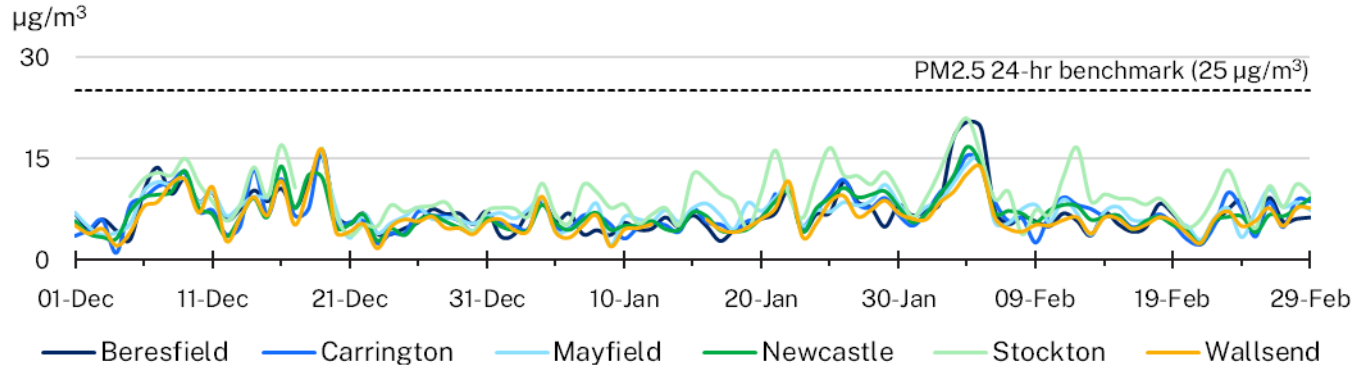

Figure 9 **Daily PM2.5 averages during summer 2023–24**[11]

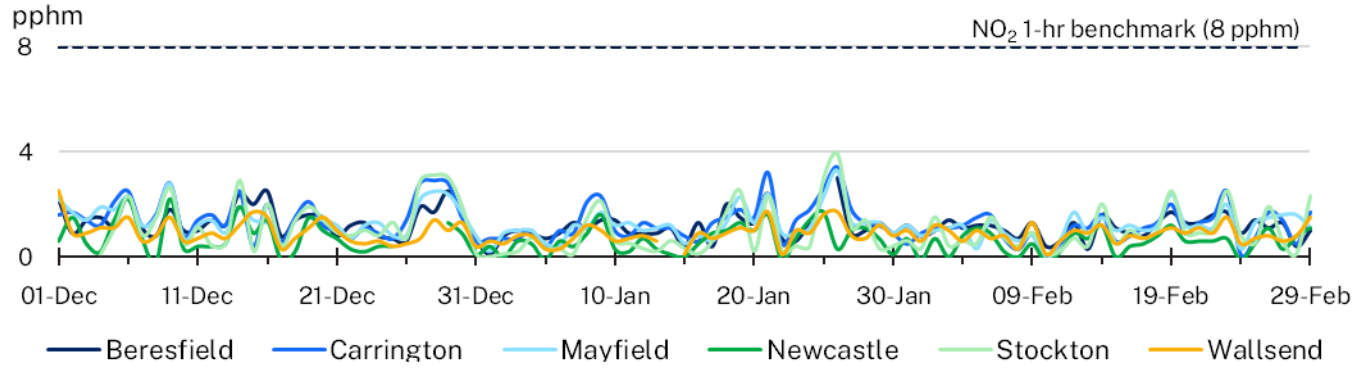

Figure 10 **Daily maximum 1-hr NO_2 during summer 2023–24**[11]

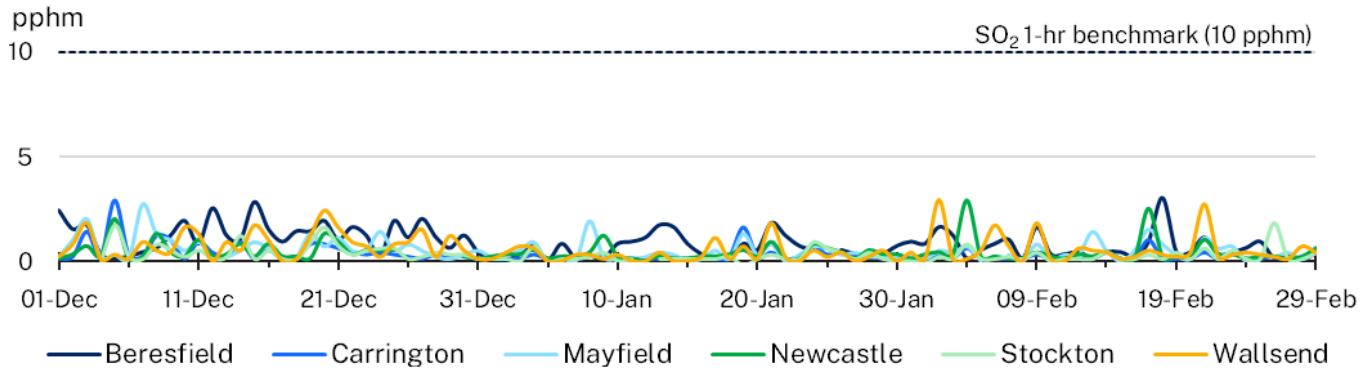

Figure 11 **Daily maximum 1-hr SO_2 during summer 2023–24**[11]

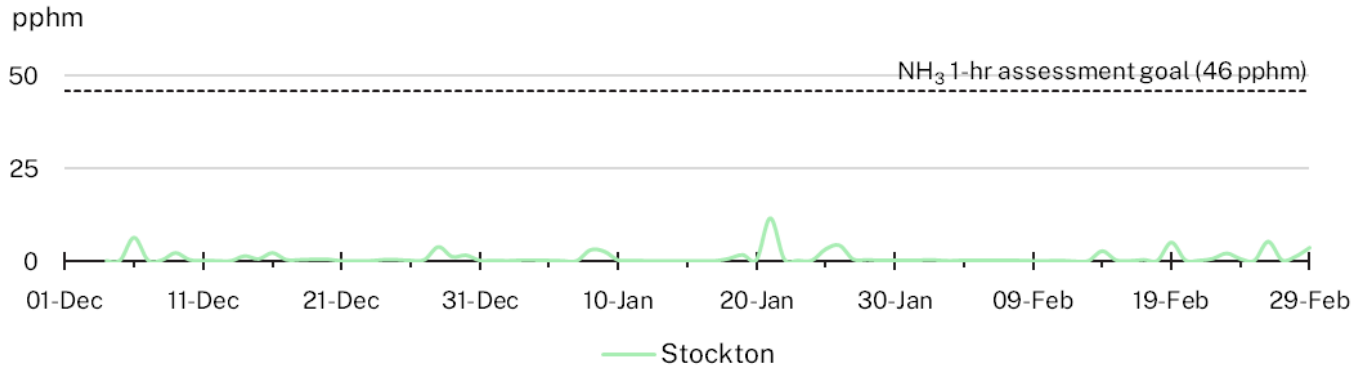

Figure 12 **Daily maximum 1-hr NH_3 during summer 2023–24**[11]

Pollution roses from hourly particle data

The seasonal pollution rose maps[12] (Figure 13 and Figure 14) show hourly PM10 and PM2.5 levels for the region's stations during summer 2023–24, and the associated wind directions when these concentrations were observed.

Hourly PM10 levels were in the 'good to fair' categories[5] (<100 µg/m^3) for 96% of hours at Stockton, 99% of hours at Carrington and 100% of hours at all other stations (Figure 13). Elevated PM10 at Stockton was predominantly recorded during onshore easterly winds (north-east to south-east), indicative of sea salt influence (see Stockton section below for more detail).

Hourly PM2.5 levels were in the 'good to fair' categories[5] (<50 µg/m^3) at all stations, 100% of the time. (Figure 14).

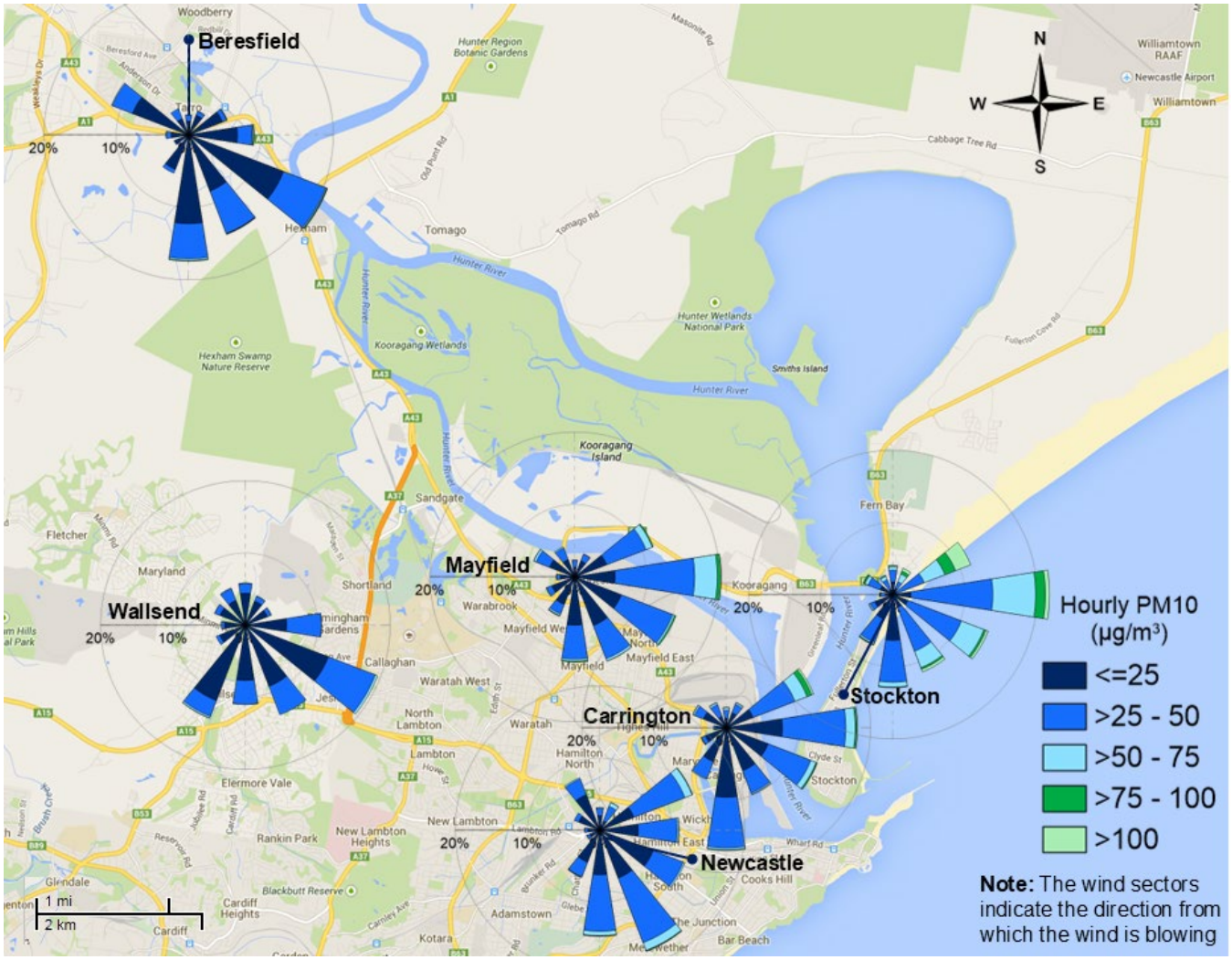

Figure 13 **Hourly PM10 pollution roses for the Newcastle region for summer 2023–24**

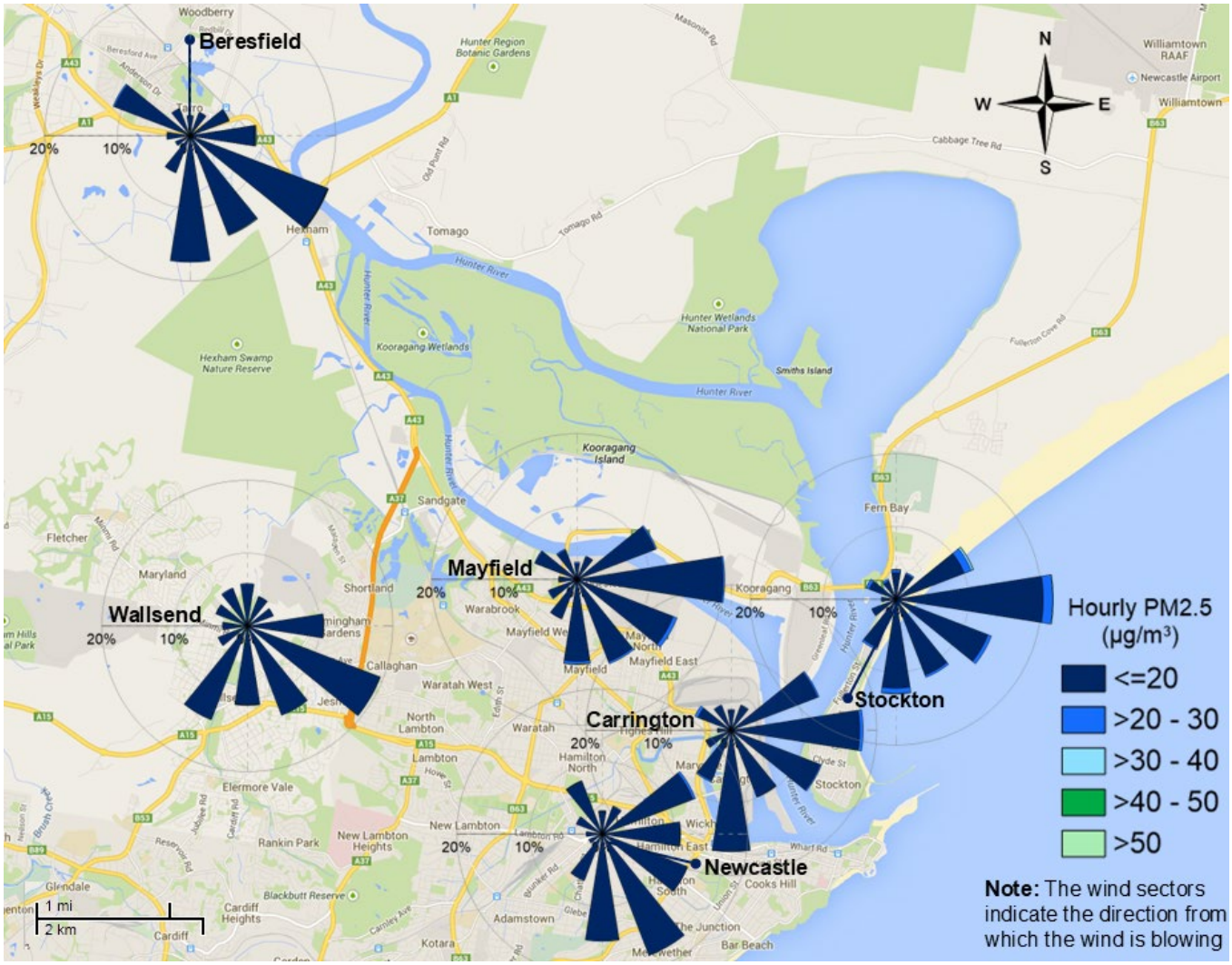

Figure 14 **Hourly PM2.5 pollution roses for the Newcastle region for summer 2023–24**

Particle air quality trends

Figure 15 and Figure 16 compare daily average PM10 levels during summer 2023–24 (blue lines), with historical PM10 levels (shaded blue) at Newcastle and Stockton stations. Both stations were generally within historical ranges, however, some higher levels were seen in early February, following a dry January (Figure 17).

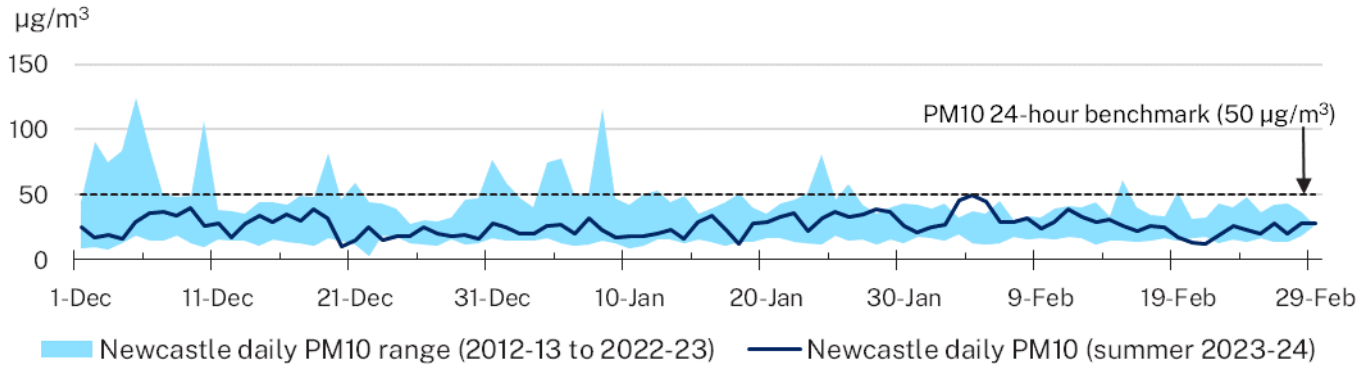

Figure 15 **Newcastle daily average PM10 during summer 2023–24 plotted against the daily maximum and minimum PM10 levels from 2012–13 to 2022–23[11]**

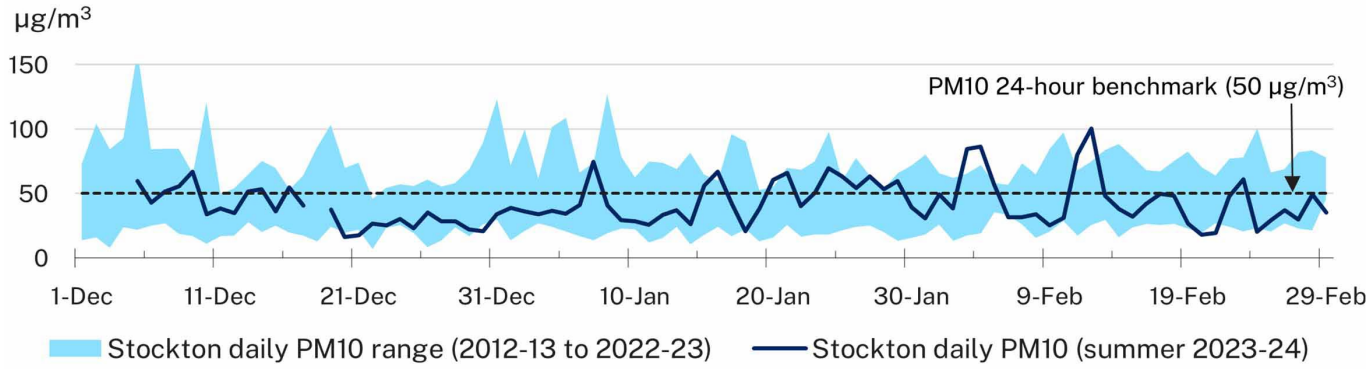

Figure 16 **Stockton daily average PM10 during summer 2023–24 plotted against the daily maximum and minimum PM10 levels from 2012–13 to 2022–23[11]**

Newcastle's Nobbys Signal Station AWS[13] recorded average rainfall for December 2023, below average in January 2024 and above average in February 2024 (Figure 17).

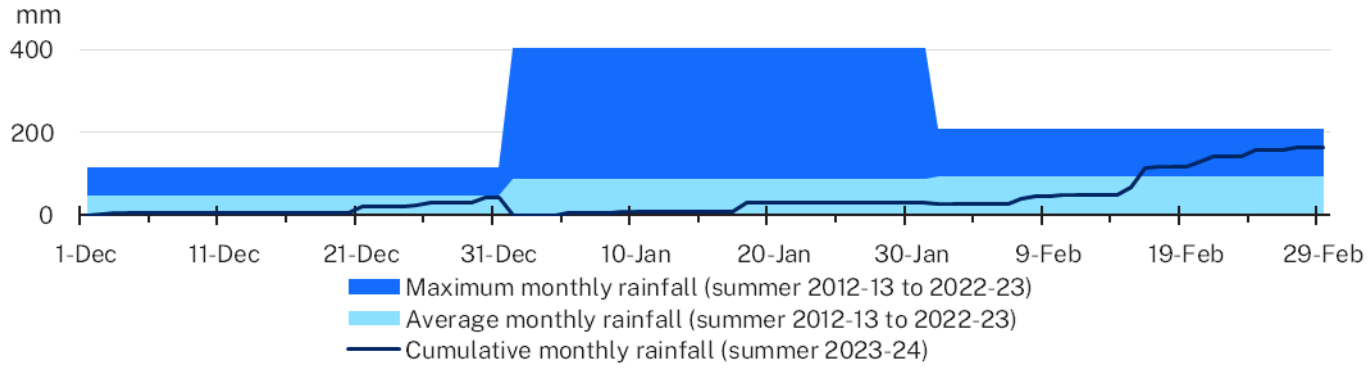

Figure 17 **Bureau of Meteorology Newcastle Nobbys Signal Station AWS[13] cumulative rainfall during summer 2023–24 plotted against maximum and average rainfall from 2012–13 to 2022–23**

Figure 18 and Figure 19 compare daily average PM2.5 levels during summer 2023–24 to historical levels (shaded blue) at Newcastle and Stockton stations. Both stations were mostly within historical ranges during summer 2023–24.

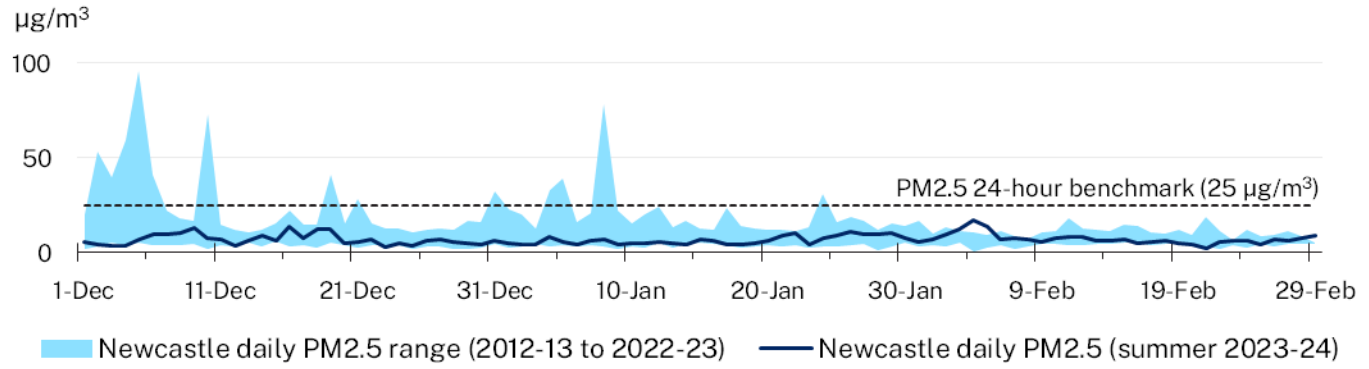

Figure 18 **Newcastle daily average PM2.5 during summer 2023–24 plotted against the daily maximum and minimum PM2.5 levels from 2012–13 to 2022–23**[11]

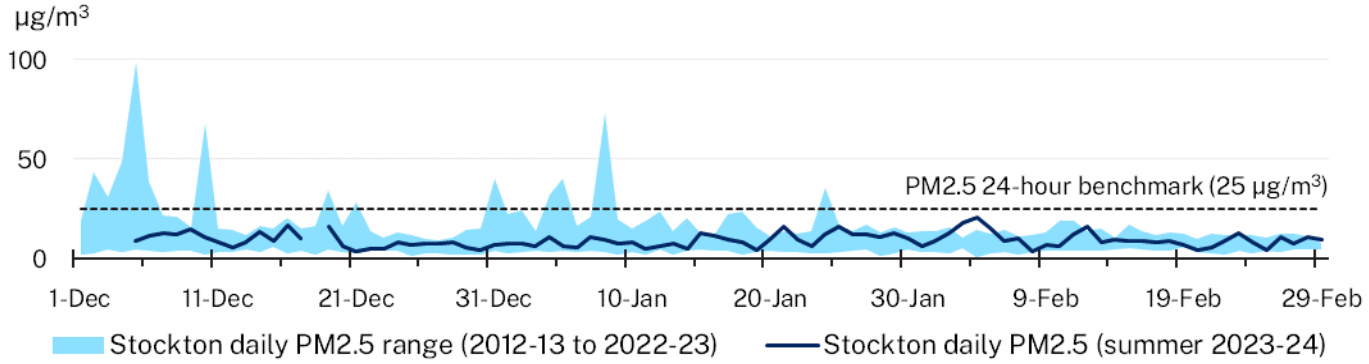

Figure 19 **Stockton daily average PM2.5 during summer 2023–24 plotted against the daily maximum and minimum PM10 levels from 2012–13 to 2022–23**[11]

Meteorological summary

Rainfall and temperature[14]

The Newcastle region experienced average rainfall in summer 2023–24 (Figure 20). Compared to previous summers, summer 2023–24 was up to 50 mm wetter than summer 2022–23, up to 100 mm drier than summer 2021–22 and 100 to 200 mm drier than summer 2020–21.

The Newcastle region experienced warmer-than-average days and nights, with both maximum (Figure 21) and minimum[15] temperatures (not shown) very much above average.

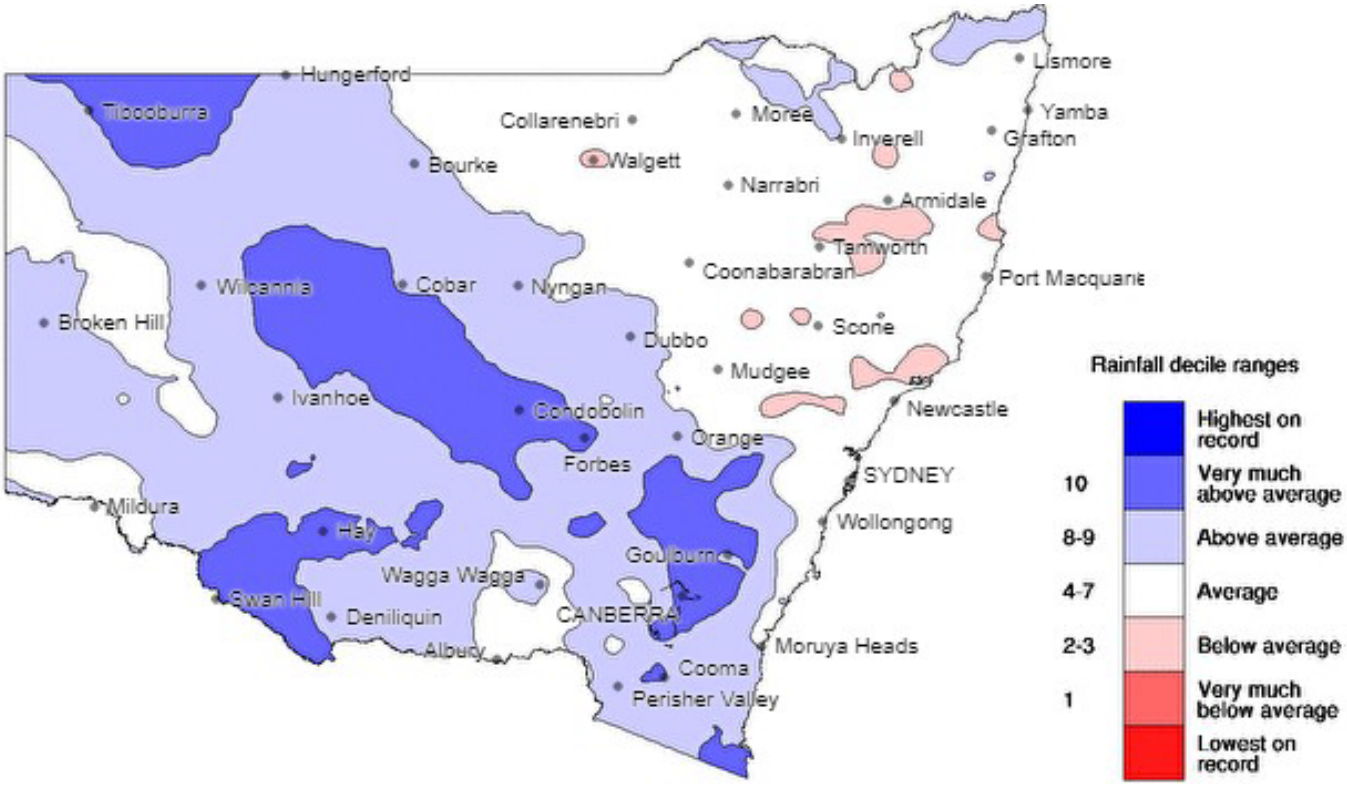

Figure 20 New South Wales rainfall deciles for summer 2023–24[14]

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. Base period: 1900–Feb 2024. Dataset: AGCD v2. Issued 21/03/2024

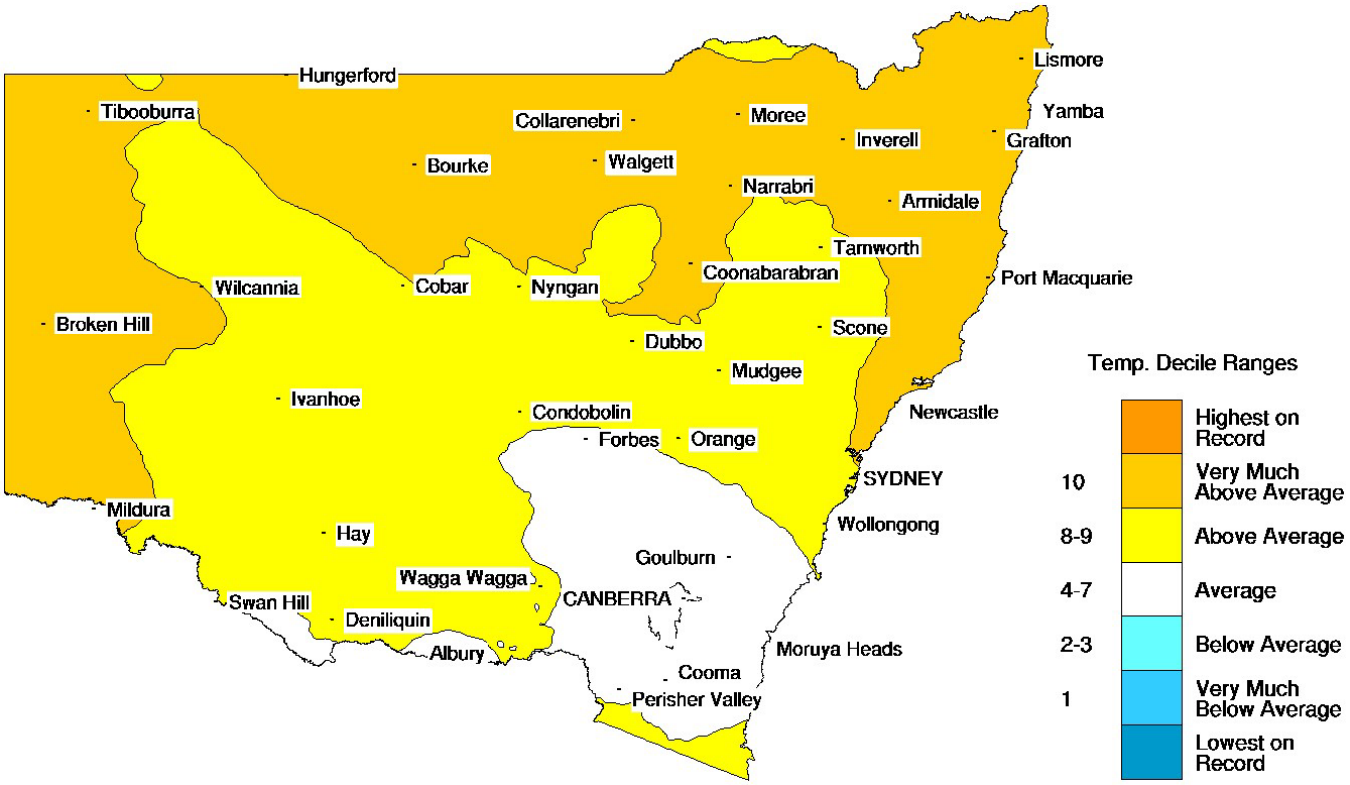

Figure 21 New South Wales maximum temperature deciles for summer 2023–24[14]

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. ID code: AWAP. Issued 21/03/2024

Winds

Figure 22 shows the wind direction and speed at each monitoring station during summer 2023–24[16]. Winds across the region were predominantly from the north-east to south, which is typical for summer. At Stockton for example, north-easterly to south-easterly winds prevailed approximately 57% of the time, with moderate or stronger (>5 metres per second) winds occurring 4.4% of the time during the season.

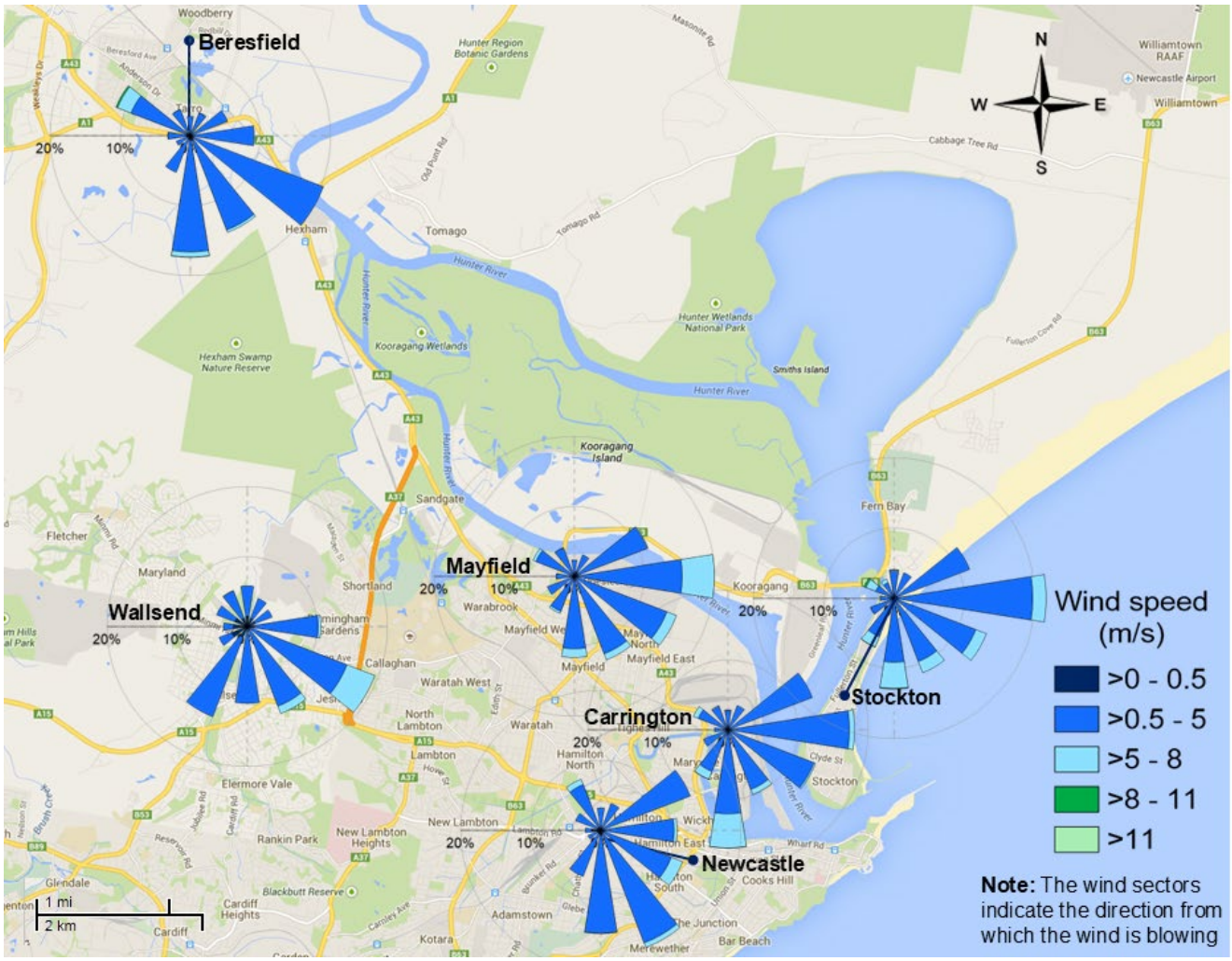

Figure 22 **Wind rose map for the Newcastle region for summer 2023–24**

Stockton

During summer 2023–24, Stockton recorded 25 days over the PM10 daily benchmark (5, 7–9, 13–14 and 16 December 2023; 7, 15–16, 20–21 and 23–29 January 2024; 3–5, 11–12 and 23 February 2024). This is more than double the 12 exceedance days Stockton recorded during previous year summer 2022–23. Historically, from summer 2012–13 to summer 2022–23, Stockon has ranged between 9 days (summer 2013–14) and 43 days (summer 2019–20) over the PM10 daily benchmark (Figure 5).

In summer 2023–24, elevated hourly PM10 levels (>100 µg/m^3)[17] were recorded at Stockton 4.3% (90 hours) of the time (Figure 23). These were observed over 29 days and occurred predominantly under north-easterly winds (82 hours).

Elevated PM10 levels under predominant onshore winds at Stockton indicate the potential contribution of sea salt. The Lower Hunter Particle Characterisation Study[4] found sea salt was a major contributor of particles at the site under onshore winds.

The Stockton monitoring station did not record any days over the PM2.5 daily benchmark or elevated hourly PM2.5 levels (>50 µg/m^3)[17] during summer 2023–24.

Figure 23 **Stockton pollution rose for hourly PM10 levels >75 µg/m^3 during summer 2023–24**

Network performance

The target network performance is at least 95% available data. Due to daily calibrations for the gaseous parameters NO_2, SO_2 and NH_3, the maximum online time that can be attained is 96%. The reduced online time for Newcastle NO_2 and SO_2 was due to instrument faults (Table 2).

Table 2 **Network performance (%) during summer 2023–24**

Station	Particles daily PM10	Particles daily PM2.5	Gases hourly SO_2	Gases hourly NO_2	Gases hourly NH_3	Meteorology hourly
Beresfield	98	100	94	94	–	100
Carrington	100	99	96	96	–	100
Mayfield	97	97	93	91	–	100
Newcastle	100	100	88	82	–	100
Stockton	96	96	90	92	92	96
Wallsend	97	97	93	93	–	98

– = not monitored

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Appendix A: Rolling annual averages

Table 3 **PM10 rolling annual averages (µg/m^3) from the end of summer 2015–16 to the end of summer 2023–24**

Station	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	2022–23	2023–24
Beresfield	19.5	19.1	19.5	22.1	26.6	16.5	16.0	14.3	18.4
Carrington	23.2	24.1	24.1	28.2	31.4	22.4	21.2	18.8	23.3
Mayfield	22.0	23.2	24.3	27.5	31.1	21.0	20.2	17.4	22.4
Newcastle	21.8	22.1	21.9	25.4	29.1	20.4	19.5	16.8	21.1
Stockton	35.2	35.1	36.3	40.1	43.9	32.0	32.0	35.4	35.4
Wallsend	17.1	16.9	17.4	20.0	23.5	15.9	14.7	12.4	16.9

Note: The rolling annual averages are calculated from 1 March to 28/29 February each year.

Table 4 **PM2.5 rolling annual averages (µg/m^3) from the end of summer 2015–16 to the end of summer 2023–24**

Station	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22	2022–23	2023–24
Beresfield	7.6	7.5	7.7	8.9	12.7	6.3	5.9	5.1	6.9
Carrington	8.2	8.7	8.4	8.4	11.5	6.9	6.5	5.6	7.0
Mayfield	7.5	7.6	7.4	8.6	11.7	6.6	6.2	5.2	7.2
Newcastle	7.9	7.9	7.3	8.1	11.5	na	6.4	5.3	6.9
Stockton	9.6	9.8	9.7	10.3	13.5	8.4	8.5	7.3	9.7
Wallsend	7.8	7.8	7.2	7.7	11.0	6.3	6.1	5.1	6.3

Note: The rolling annual averages are calculated from 1 March to 28/29 February each year

na = rolling annual average unavailable due to insufficient data availability

[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 near the Port of Newcastle.

[2] The national benchmarks can be found at National Environment Protection (Ambient Air Quality) Measure.

[3] PM2.5 and PM10 refer to airborne particles, less than or equal to 2.5 and 10 micrometres in diameter respectively, measured in micrograms per cubic metre (µg/m^3).

[4] Lower Hunter Particle Characterisation Study found sea salt contributes significantly to PM10 levels at Stockton station during the warmer months.

[5] Air quality categories.

[6] Rolling annual averages use 12 months of data to the end of the season. These are used indicatively to assess long-term trends using the most up-to-date monitoring data and are not intended for comparison to the calendar year annual benchmarks of 25 µg/m^3 for PM10 and 8 µg/m^3 for PM2.5.

[7] Sourced from Department of Primary Industries NSW State seasonal update – February 2024 (accessed April 2024).

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

[9] Sourced from Department of Primary Industries NSW State seasonal update – February 2022 (accessed April 2024).

[10] 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.

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

[12] 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.

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

[14] Rainfall and temperature information is from the Bureau of Meteorology New South Wales summer 2023-24 climate statement (accessed April 2024) and climate maps (accessed April 2024).

[15] Bureau of Meteorology seasonal minimum temperature deciles map not shown.

[16] 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.

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