Air Quality Monitoring Network

Upper Hunter Winter 2023

Air quality in the Upper Hunter was generally good during winter 2023, despite the region experiencing dry conditions and the warmest maximum winter temperatures on record.

- Muswellbrook and Singleton population centres met national daily benchmarks for particles 100% of the time, with 99.9% of hourly particle levels in the good to fair air quality categories.
- Across the Upper Hunter, daily average PM10[i] levels exceeded the benchmark on 4 days (26 June, 29 July, and 12 and 30 August). This occurred at 4 stations (one day each at Mount Thorley, Muswellbrook NW and Singleton South and 2 days at Warkworth). The regional maximum daily PM10 on these days ranged from 50.7 to 57.1 µg/m^3.
- Meanwhile, PM2.5[i] and gaseous pollutants nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) all met national benchmarks at all stations.

Annual air quality trends

Figure 1 shows the rolling annual averages[ii] for PM10 and PM2.5 particles for the 12-month periods from winter 2013 to winter 2023. Consistent with the 2 most recent winter seasons, particle levels remained below the annual benchmarks at most stations during winter 2023 (Figure 1).

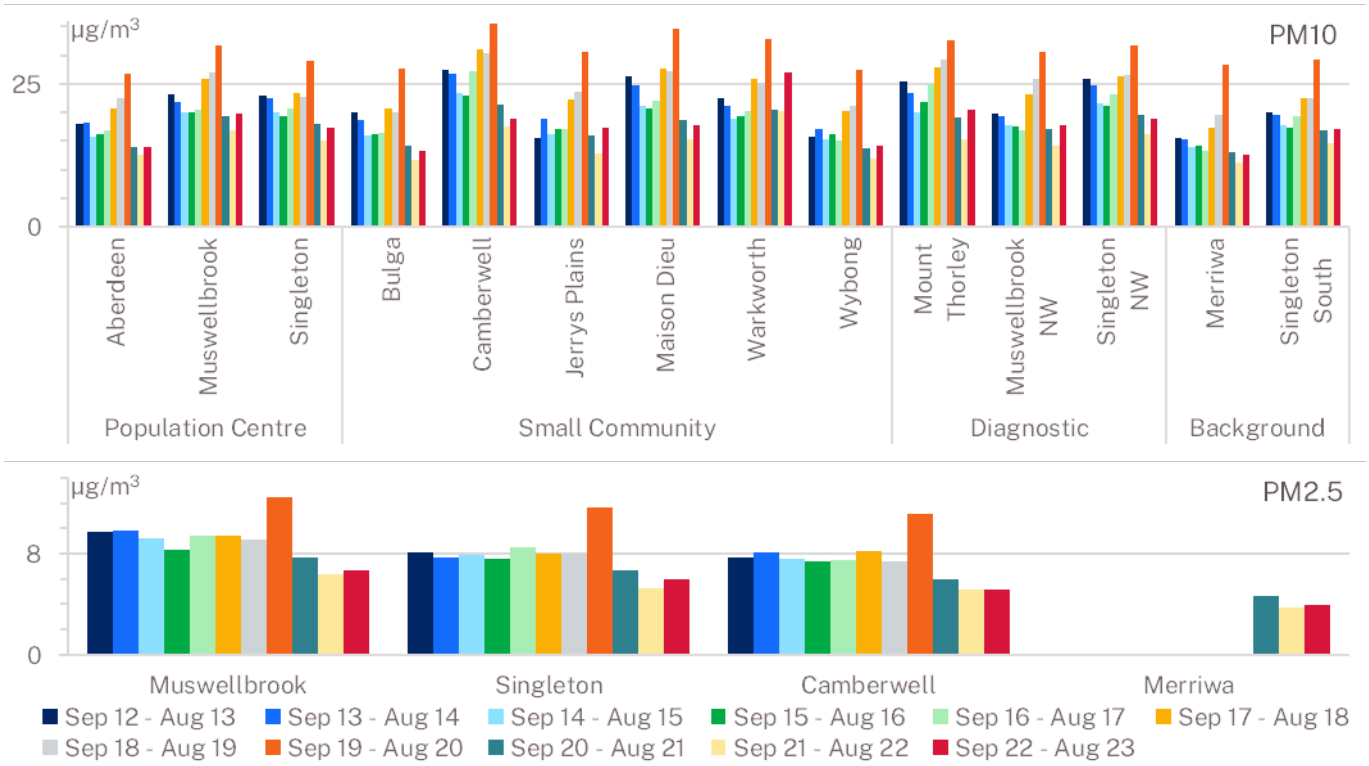

Figure 1 **Rolling annual averages to the end of winter 2013 to winter 2023 for PM10 (top) and PM2.5 (bottom)**

Note: The Merriwa background station was upgraded in July 2020 to also monitor PM2.5.

About 9% of New South Wales was drought-affected by the end of winter 2023[iii] (Figure 2). In 2022, there were no drought-affected areas at the end of winter season[iv], while 7% of the state was drought-affected in 2021, mostly in the western regions[v]. In contrast, drought-affected areas at the end of winter 2023 were distributed along the state's east coast, including parts of the Upper Hunter. As a result, the annual PM10 levels this winter increased compared to winter 2022 at all stations, but most evident at the Warkworth station (Figure 1).

The Warkworth station and its neighbouring Mount Thorley station recorded the 2 highest 12-month PM10 rolling averages for winter 2023. Both stations are located near open cut coal mines, and were likely impacted by emissions from mining operations, which the drying conditions have exacerbated.

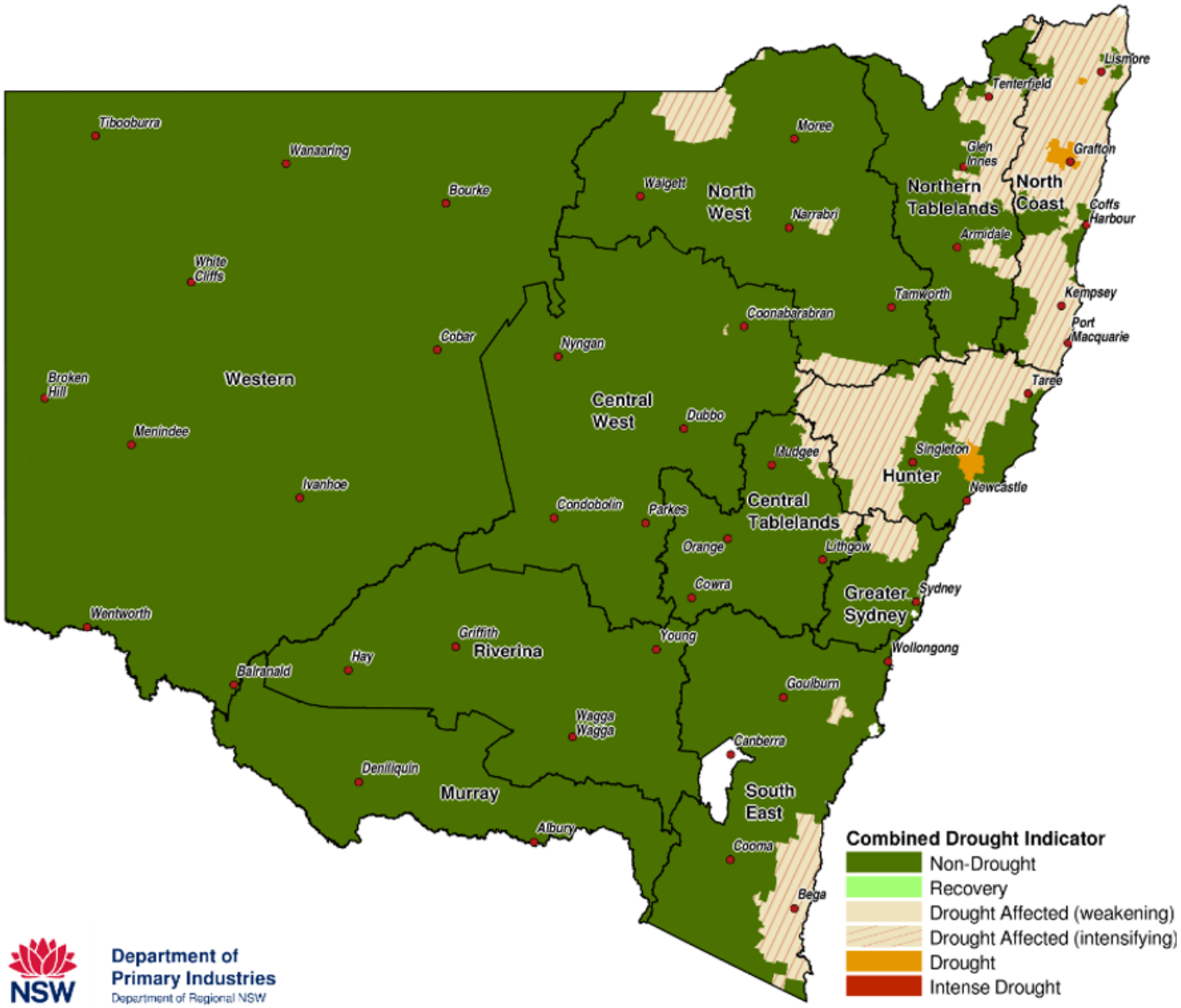

Figure 2 **Department of Primary Industries NSW Combined Drought Indicator for the 12 months to 31 August 2023[iii]**

Days above benchmark concentrations

PM10 was the only parameter that recorded days above the national benchmark during winter 2023, with 4 stations exceeding the PM10 daily benchmark (Table 1), occurring on 4 days. PM2.5, SO_2 and NO_2 levels remained below relevant benchmarks during the season.

Table 1 Number of days above the relevant national benchmarks – winter 2023

Station type*	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]
Population centre	Aberdeen	0	-	-	-	-
Population centre	Muswellbrook	0	0	0	0	0
Population centre	Singleton	0	0	0	0	0
Smaller community	Bulga	0	-	-	-	-
Smaller community	Camberwell	0	0	-	-	-
Smaller community	Jerrys Plains	0	-	-	-	-
Smaller community	Maison Dieu	0	-	-	-	-
Smaller community	Warkworth	2	-	-	-	-
Smaller community	Wybong	0	-	-	-	-
Diagnostic	Mount Thorley	1	-	-	-	-
Diagnostic	Muswellbrook NW	1	-	-	-	-
Diagnostic	Singleton NW	0	-	-	-	-
Background	Merriwa	0	0	0	0	0
Background	Singleton South	1	-	-	-	-

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.

* For explanation, refer to 'Definitions: Upper Hunter monitoring station types' at the end of the report

Seasonal comparison

This section compares days above air quality benchmarks in winter 2023 with previous winters.

- **PM10:** the daily benchmark was exceeded on 4 days during winter 2023 (Figure 3). Historically, there were between zero days (winters 2016, 2021 and 2022) and 29 days (winter 2018) over the PM10 benchmark. Highest frequency of days occurred during drought conditions of 2018 to 2019.
- **PM2.5:** there were no days over the PM2.5 daily benchmark during winter 2023 (Figure 3). From 2012 to 2022, the region recorded between zero days (winters 2013, 2021 and 2022) and 3 days (winters 2015 and 2020) over the PM2.5 benchmark.
- **Gaseous pollutants NO_2 and SO_2:** there were no days over the national benchmarks in winter 2023. If assessing historical levels against the tighter standards in effect since May 2021, there would have been one exceedance over the current 10 pphm 1-hour SO_2 standard, in winter 2020.

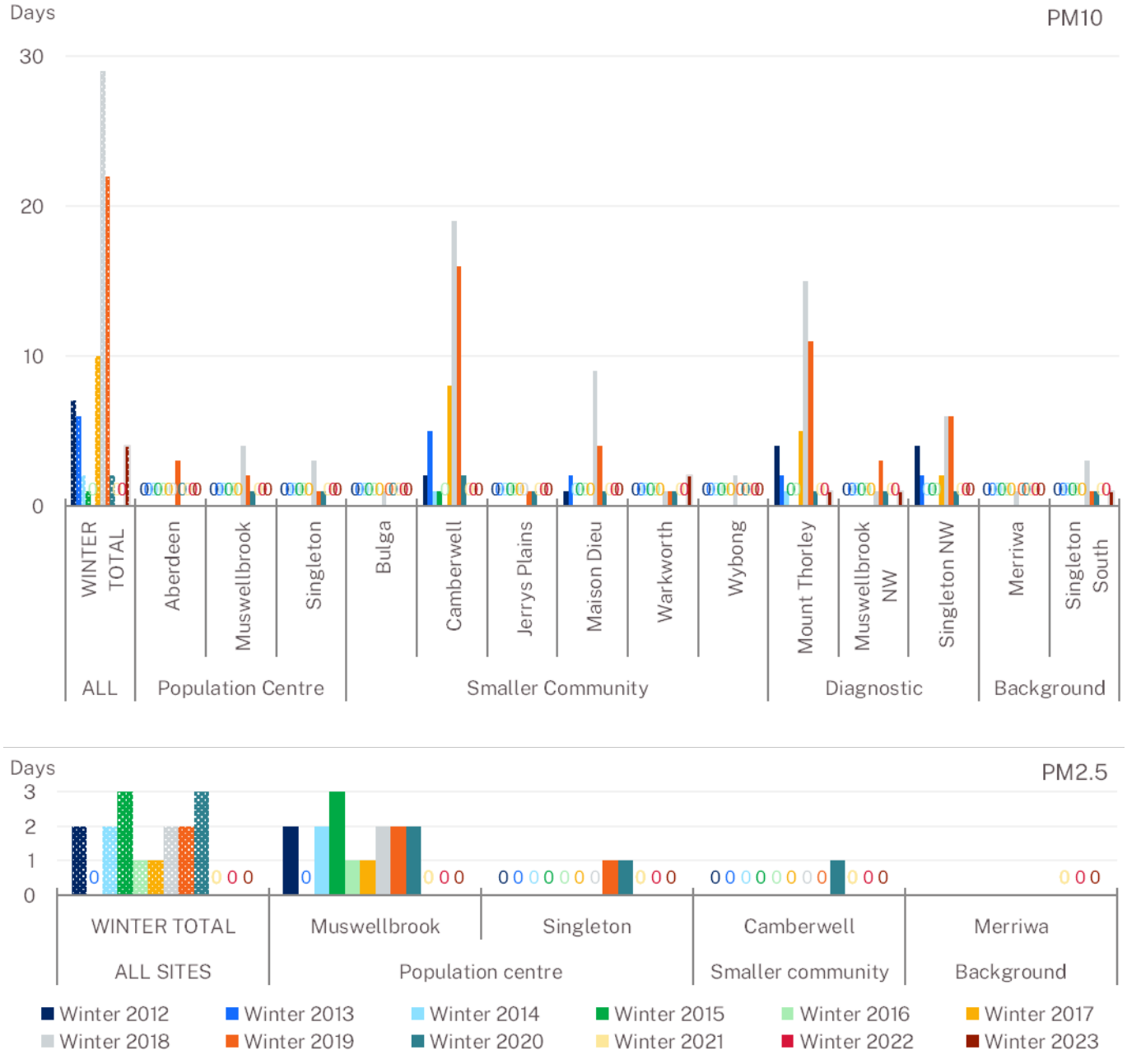

Figure 3 **Number of days above the PM10 (top) and PM2.5 (bottom) daily benchmarks: winter 2012 to winter 2023**

Note: The Merriwa background station was upgraded in July 2020 to also monitor PM2.5.

Daily time series plots

Figure 4 to Figure 7 show daily average PM10 concentrations observed during winter 2023. Levels over the daily benchmark were observed at 4 stations during the season. Raised PM10 levels are likely due to mining in the area exacerbated by the drying conditions.

PM2.5, NO_2 and SO_2 levels were below the benchmarks (Figure 8 to Figure 10).

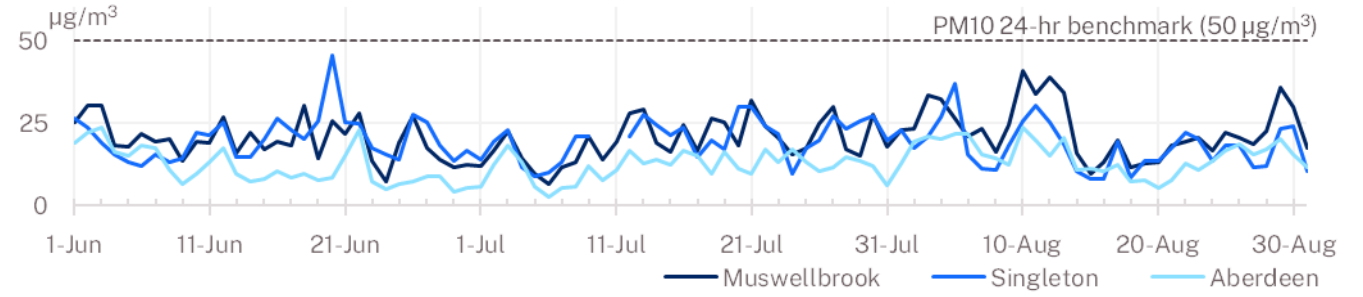

Figure 4 **Population centre stations: daily average PM10 – winter 2023**

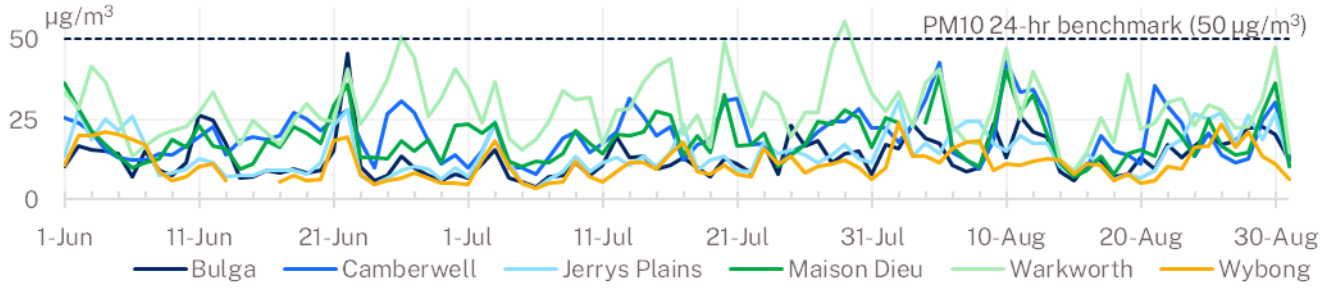

Figure 5 **Smaller community stations: daily average PM10 – winter 2023**

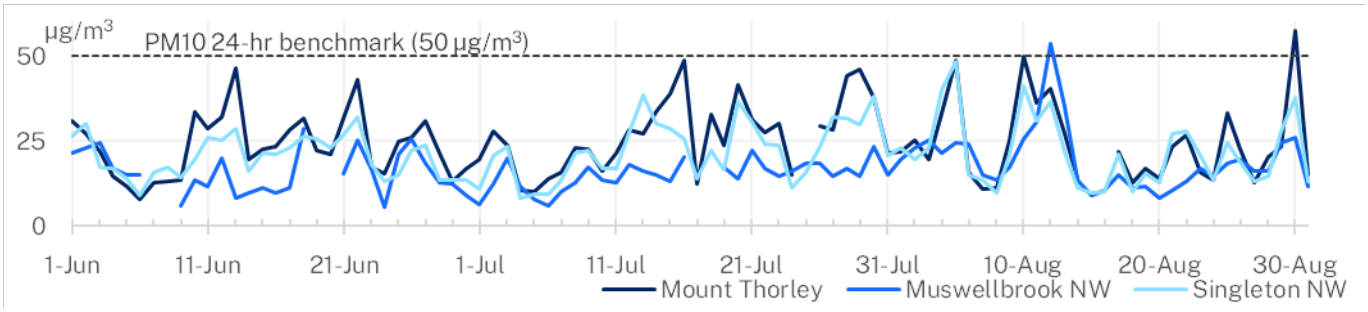

Figure 6 **Diagnostic stations: daily average PM10 – winter 2023**

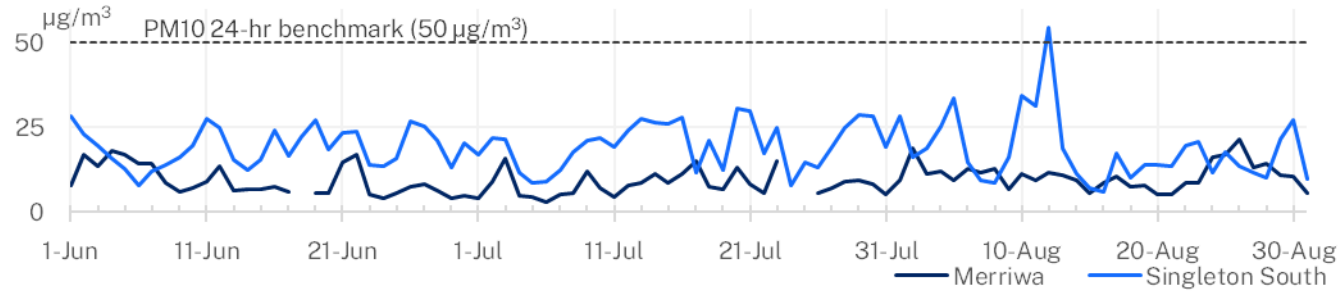

Figure 7 **Background stations: daily average PM10 – winter 2023**

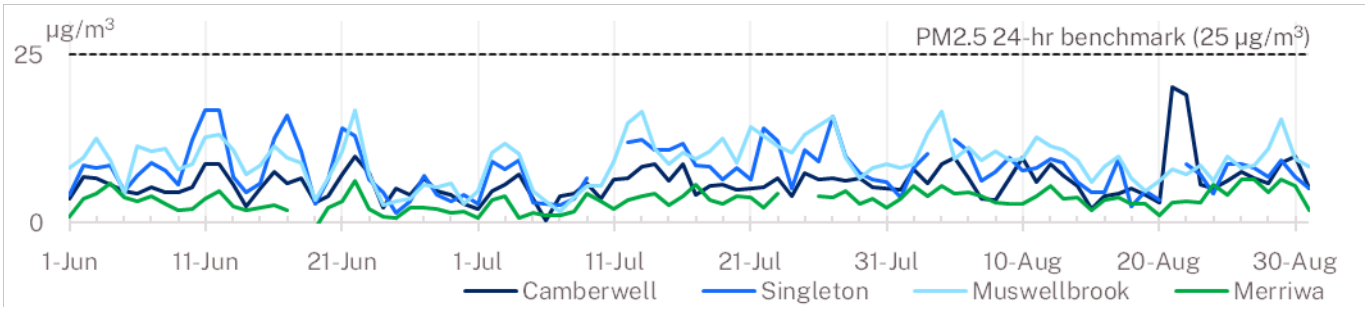

Figure 8 **Daily average PM2.5 – winter 2023**

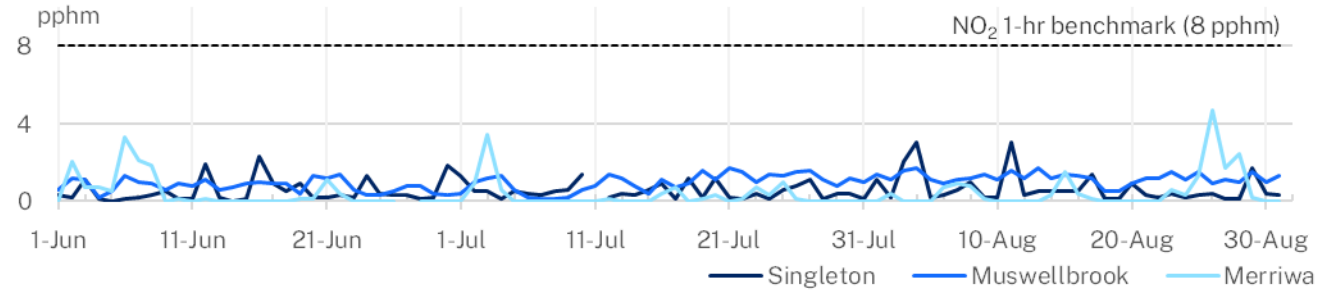

Figure 9 **Daily 1-hr maximum NO_2 – winter 2023**

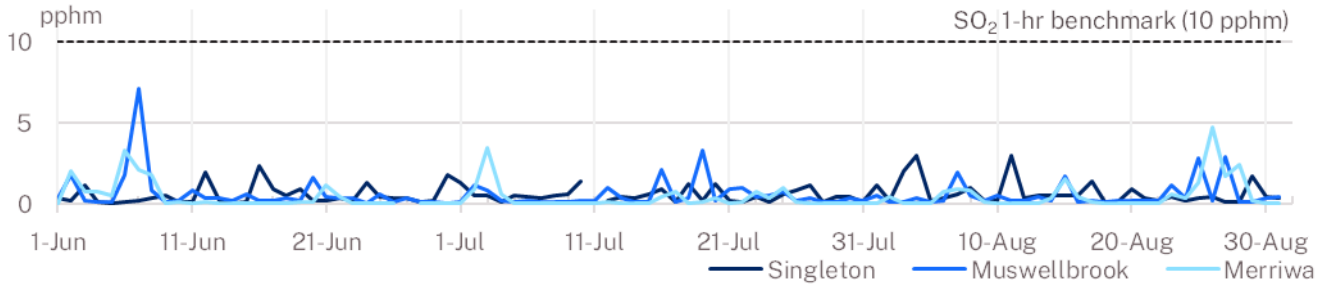

Figure 10 **Daily 1-hr maximum SO_2 – winter 2023**

Particle air quality trends at population centres

Figure 11 and Figure 12 show daily average PM10 levels during winter 2023 at large population centres, Singleton and Muswellbrook. Compared to historical observations for winter 2011 to 2022 (shaded range), PM10 levels were predominantly within historical levels during winter 2023. Elevated PM10 levels at Singleton on 20 June occurred under light northerly winds and were likely due to a local source close to the monitoring station.

Rainfall in winter 2023 was below historical levels for the season (Figure 13).

Figure 14 and Figure 15 show daily average PM2.5 levels during winter 2023 were predominantly within or below the historical levels for winter (shaded range).

Hourly particle levels at Singleton and Muswellbrook were generally low during winter 2023, with air quality categories in the good to fair ranges 99.9% of the time.

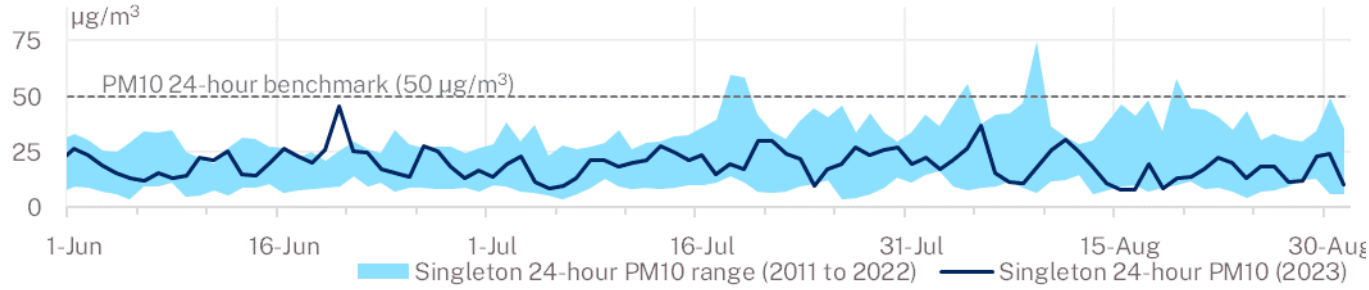

Figure 11 **Singleton daily average PM10 during winter 2023 plotted against the daily maximum and minimum PM10 levels from 2011 to 2022**

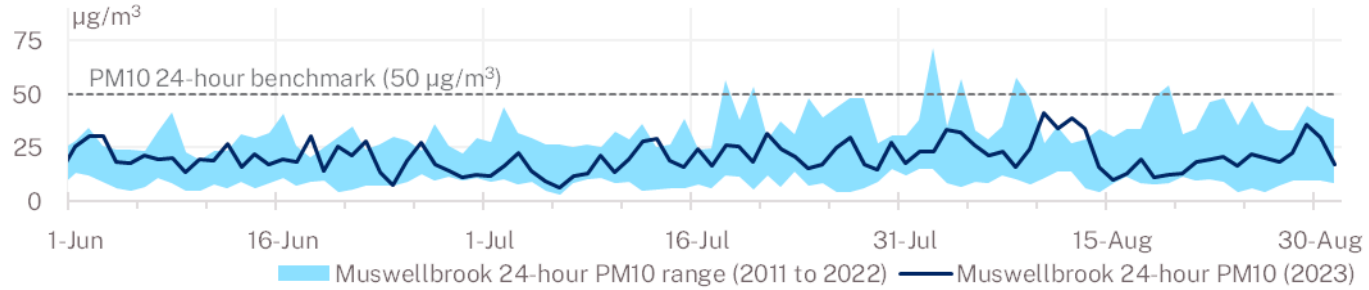

Figure 12 **Muswellbrook daily average PM10 during winter 2023 plotted against the daily maximum and minimum PM10 levels from 2011 to 2022**

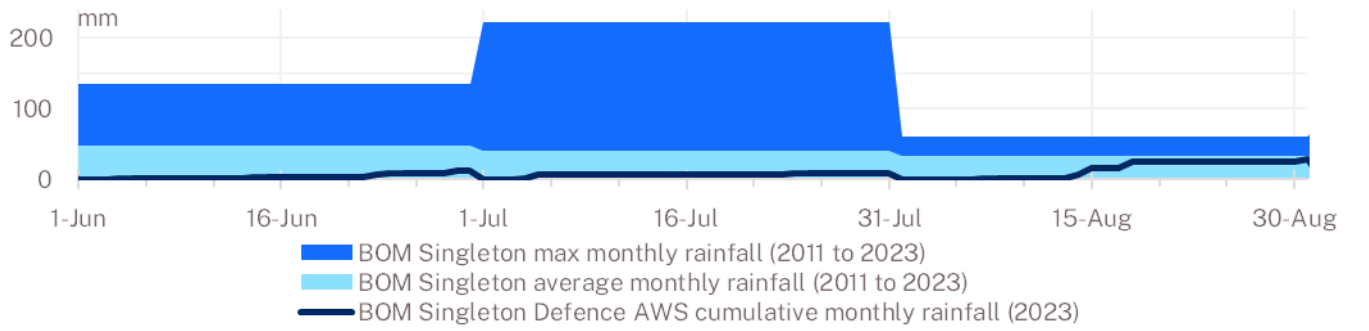

Figure 13 **Singleton cumulative monthly rainfall in winter 2023 (dark blue) against maximum monthly rainfall[vi] (medium blue) and average monthly rainfall (light blue) from 2011 to 2023[vii]**

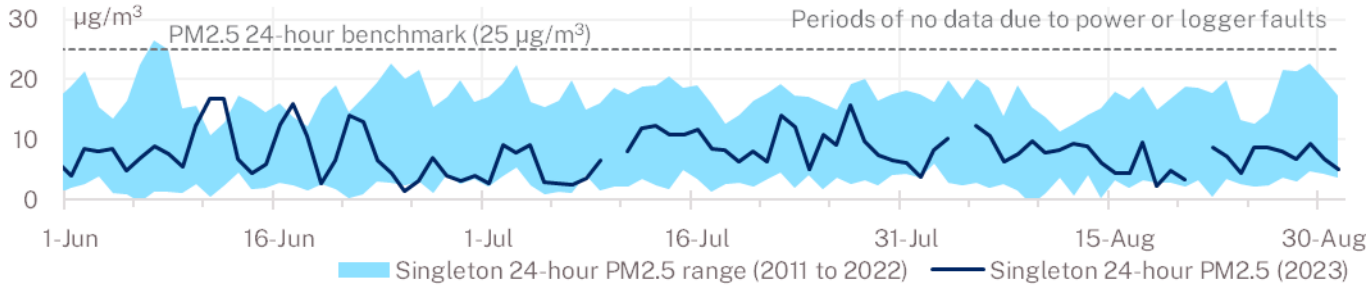

Figure 14 **Singleton daily average PM2.5 during winter 2023 plotted against the daily maximum and minimum PM2.5 levels from 2011 to 2022**

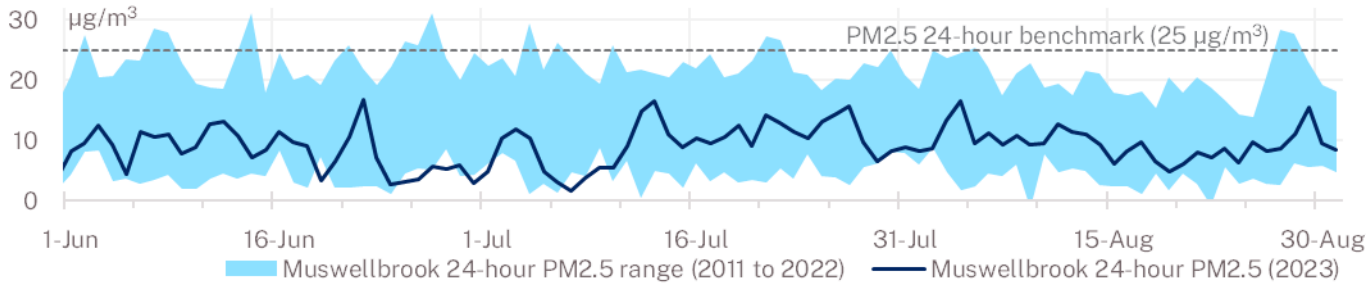

Figure 15 **Muswellbrook daily average PM2.5 during winter 2023 plotted against the daily maximum and minimum PM2.5 levels from 2011 to 2022**

Pollution roses using hourly particle data

The seasonal pollution rose maps[viii] for winter 2023 (Figure 16 and Figure 17) show that across the Upper Hunter region hourly[ix] PM10 and PM2.5 particle levels remained predominantly low. The highest hourly PM10 particle concentrations were recorded at Warkworth when winds were predominantly from the north-west of the valley.

Figure 16 **Hourly PM10 pollution rose map for the Upper Hunter region for winter 2023**

Figure 17 **Hourly PM2.5 pollution rose map for the Upper Hunter region for winter 2023**

Meteorological summary[x]

The rainfall deciles map for winter 2023 shows the Upper Hunter experienced below average rainfall (Figure 18). No substantial rainfall totals were recorded this season, leading to intensifying drought conditions in some areas of the Upper Hunter (Figure 2). In contrast, rainfall totals for the 3 previous winter seasons measured average to well above average.

The Upper Hunter region experienced highest on record maximum temperatures during winter 2023 (Figure 19). Minimum temperatures were average to above average. According to the NSW DPI[iii], extremely warm conditions were also observed globally during August 2023.

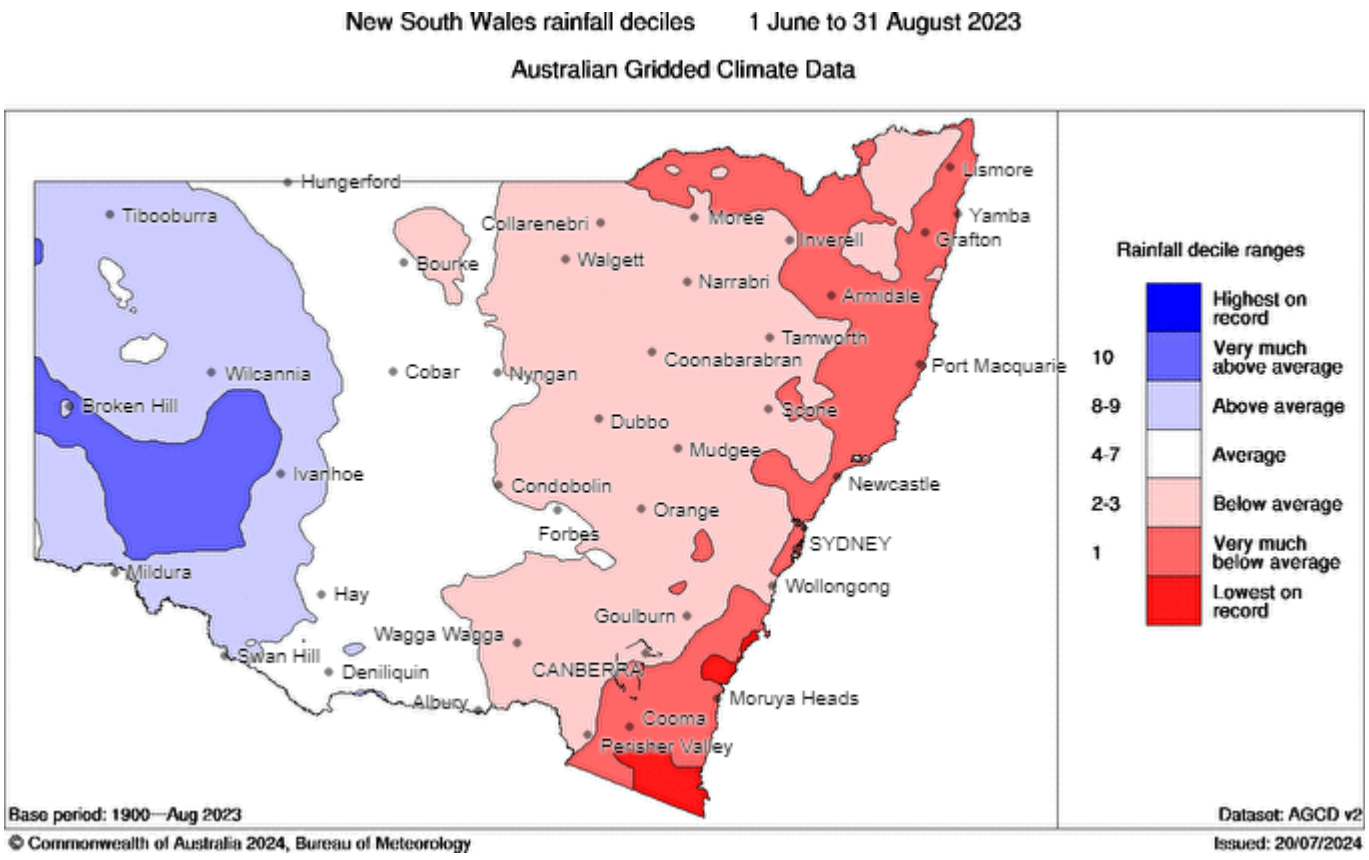

Figure 18 NSW rainfall deciles – winter 2023

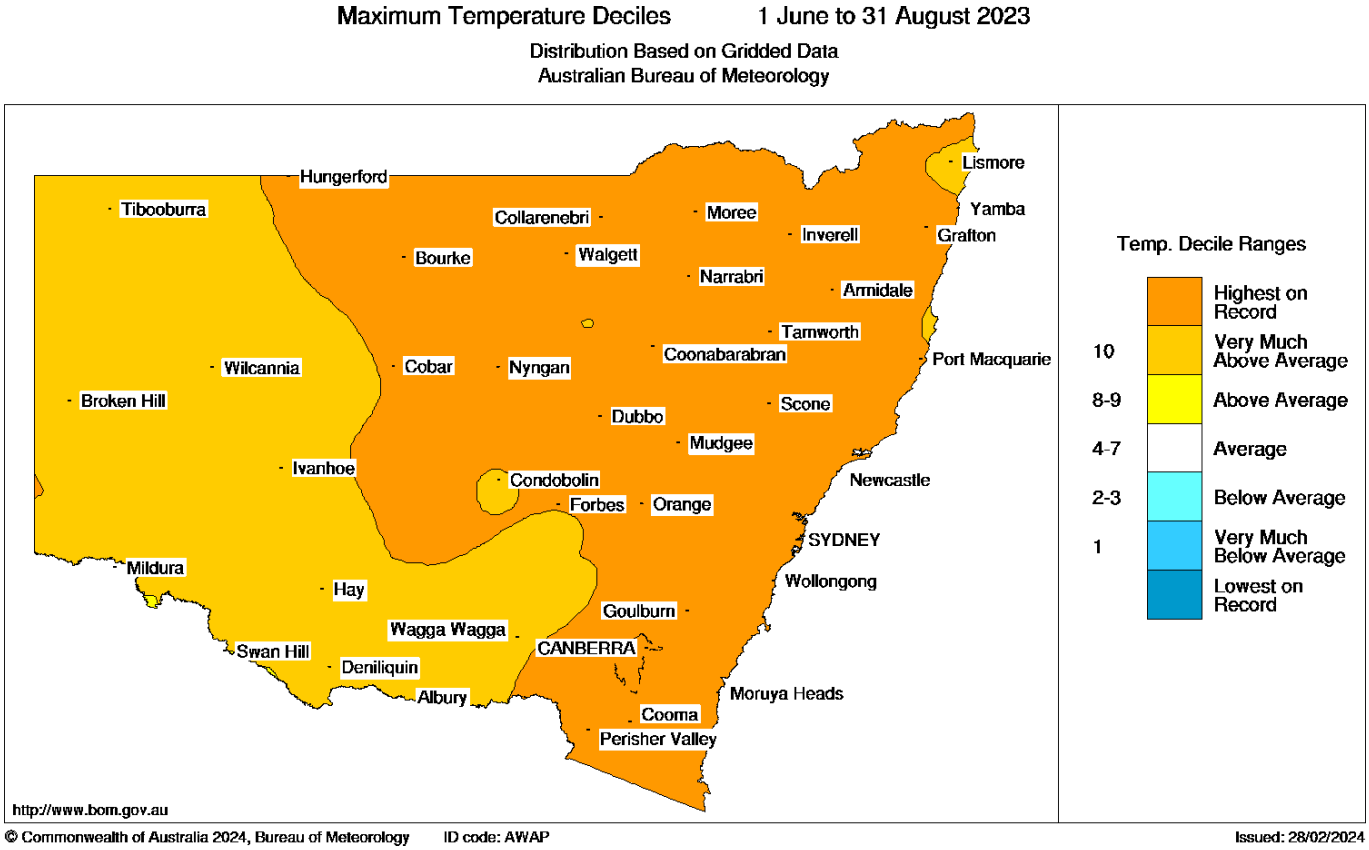

Figure 19 NSW maximum temperature deciles – winter 2023

Wind

Winds were predominantly from the north-west during winter 2023 (Figure 20), which was typical for this time of year.

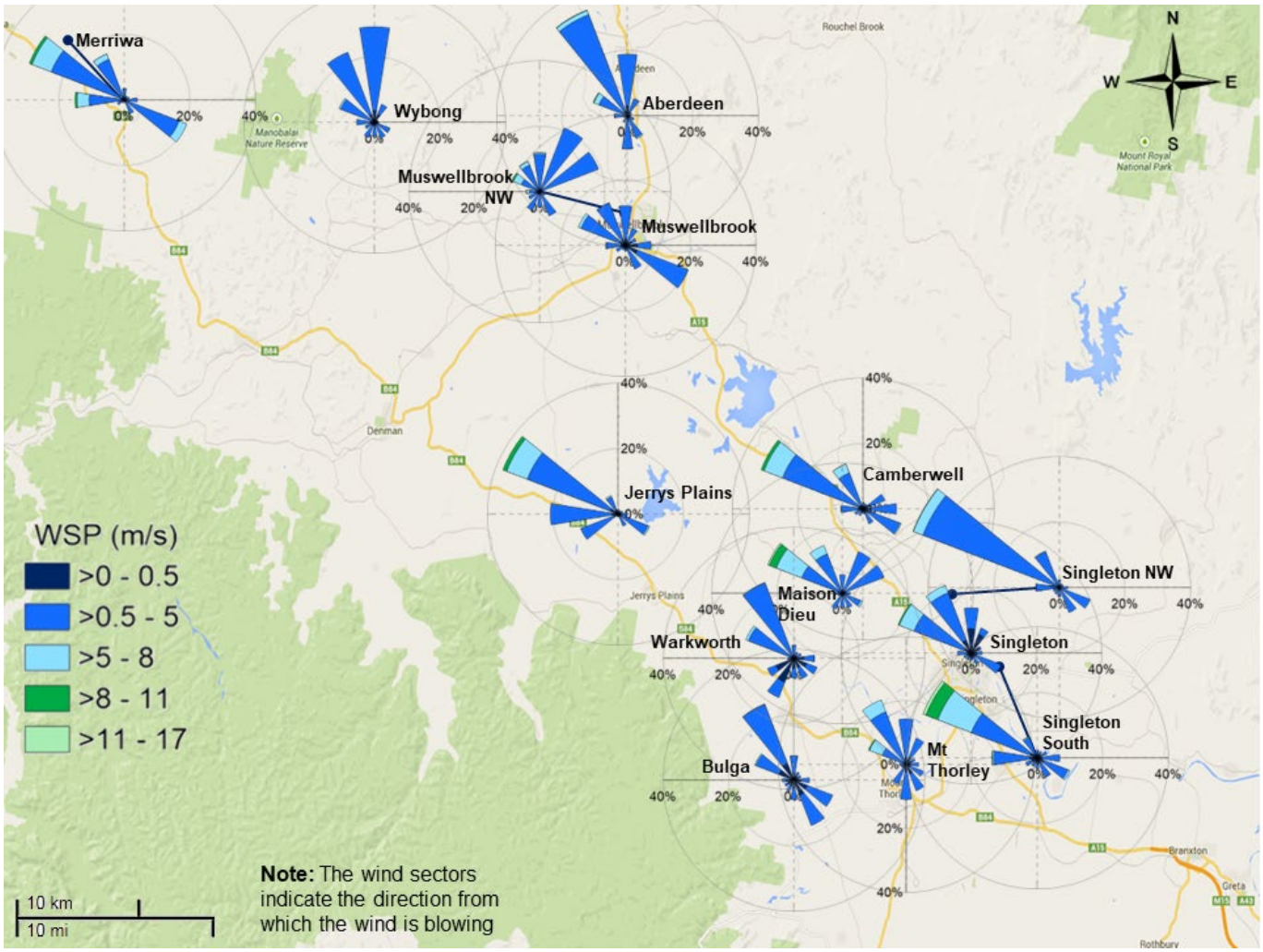

Figure 20 **Wind rose map[xi] for the Upper Hunter region for winter 2023**

Network performance

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

Table 2 Online performance (%) during winter 2023

Station	Particles PM10 daily	Particles PM2.5 daily	Gases SO_2 hourly	Gases NO_2 hourly	Meteorology Wind hourly
Aberdeen	100	-	-	-	100
Bulga	100	-	-	-	100
Camberwell	100	100	-	-	100
Jerrys Plains	100	-	-	-	100
Maison Dieu	99	-	-	-	99
Merriwa	97	97	92	93	100
Mount Thorley	97	-	-	-	100
Muswellbrook	100	100	95	95	100
Muswellbrook NW	93	-	-	-	99
Singleton	100	97	95	95	99
Singleton NW	100	-	-	-	100
Singleton South	100	-	-	-	100
Warkworth	100	-	-	-	100
Wybong	97	-	-	-	100

- = not monitored

Definitions: Upper Hunter station types

The 14 monitoring stations in the Upper Hunter serve different purposes:

Larger population: stations near the larger population centres monitor air quality in these centres.

Smaller communities: stations near smaller communities monitor air quality at those locations.

Diagnostic: provide data that can help diagnose the likely sources and movement of particles across the region; they do not provide information about air quality at population centres.

Background: the stations near Merriwa and Singleton South are at both ends of the valley and provide background data, measuring the quality of air entering and leaving the Upper Hunter Valley under predominant winds (south-easterlies and north-westerlies).

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[i] PM10 and PM2.5 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).

[ii] Rolling annual averages use 12-months of data to the end of a season. These are used indicatively to assess long-term trends using the most recent 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.

[iii] NSW Department of Primary Industries NSW State seasonal update – August 2023 (accessed October 2023)

[iv] NSW Department of Primary Industries NSW State seasonal update – August 2022 (accessed October 2023)

[v] NSW Department of Primary Industries NSW State seasonal update – August 2021 (accessed October 2023)

[vi] The maximum monthly rainfall for July is based on DCCEEW Singleton rainfall totals, as no BOM Singleton Defence AWS data available from 20 April to 12 July 2022.

[vii] The BOM Singleton STP station was decommissioned in January 2019. Historical trend data are calculated by combining monthly rainfall data from Singleton STP (January 2011 to March 2017) and Singleton Defence AWS (from April 2017).

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

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

[x] Rainfall and temperature information was sourced from the Bureau of Meteorology NSW winter 2023 climate statement and climate maps (accessed January 2024)

[xi] 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.