

Air quality in the Upper Hunter: 2022 overview

Air quality in the Upper Hunter and throughout NSW continued to improve in 2022 compared to recent years. This was primarily due to the region experiencing wetter and cooler than average daytime conditions. Particle levels at Muswellbrook and Singleton were within national benchmarks on 100% of days during 2022.

- Nitrogen dioxide (NO₂) and sulfur dioxide (SO₂) levels remained within the benchmarks.
 - Muswellbrook gases were offline for 2 months, with data not available until late February 2022, due to an instrument fault. This is important to note as, based on historical data, SO₂ levels are usually higher during summer at this station and can exceed the SO₂ benchmarks.
- Daily average levels PM_{2.5}¹ remained within the benchmark of 25 micrograms per cubic metre (µg/m³) in 2022 (Table 1). The regional maximum daily PM_{2.5} level in 2022 was 18.1 µg/m³.
- Daily average levels of PM₁₀¹ were above the benchmark of 50 µg/m³ on 2 days in 2022 (Table 2). Regional maximum daily PM₁₀ levels on these days ranged from 50.2 to 55.5 µg/m³.
 - PM₁₀ levels were within the daily benchmark across most of the network, with only Muswellbrook Northwest (NW) and Warkworth above the benchmark on one day each (Table 1).
- Annual particle levels continued to decrease compared to earlier years. PM₁₀ and PM_{2.5} remained within the annual benchmarks at all stations (Figure 1).
- Rainfall was very much above average in 2022, with NSW recording the second wettest year on record. Cooler daytime conditions occurred with maximum temperatures very much below average.

The Upper Hunter seasonal newsletters and the NSW annual air quality statement 2022 provide more detail on the region’s air quality in 2022.

Annual particle levels 2011 to 2022

Figure 1 shows the annual average PM₁₀ and PM_{2.5} particle levels from 2011 to 2022.

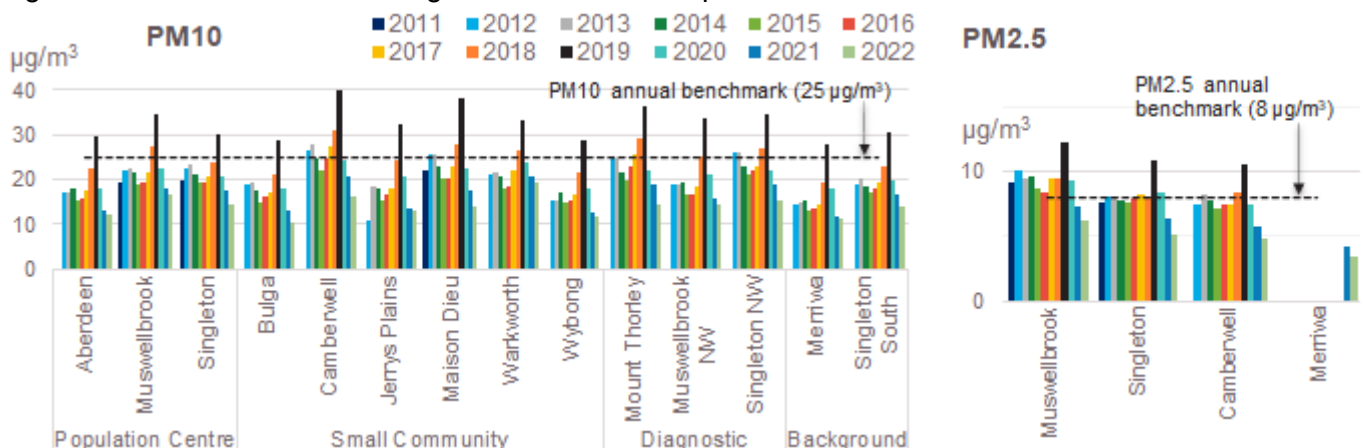


Figure 1 PM10 and PM2.5 annual averages: 2011 to 2022

Note: The Merriwa background air quality monitoring station was upgraded in July 2020 to also monitor PM_{2.5}.

¹ PM_{2.5} and PM₁₀ refer to airborne particles, less than or equal to 2.5 and 10 micrometres in diameter, respectively.

- Annual average PM10 and PM2.5 particle levels continued to decrease throughout the region in 2022 compared to earlier years. Air quality improved significantly due to continuing high rainfall totals (Figure 16) and cooler than average maximum temperatures (Figure 17). At the end of 2022, none of the state was drought affected (Figure 2), compared to 7% at the end of 2021² and 3% at the end of 2020³.
- Annual average PM10 levels were within the benchmark at all stations in 2022, ranging from 10.6 µg/m³ at Bulga to 19.3 µg/m³ at Warkworth.
From 2011 to 2021, maximum annual PM10 levels ranged from 20.8 µg/m³ in 2021 to 39.9 µg/m³ in 2019. Annual PM10 levels were over the benchmark in 2012, 2013, 2017, 2018 and 2019. In 2012 and 2013, this occurred at the Camberwell and Maison Dieu smaller community stations and Singleton NW diagnostic station. In 2017, this occurred at the Camberwell smaller community station and Mount Thorley diagnostic station. In 2018, this occurred at Muswellbrook large population centre, Camberwell, Maison Dieu and Warkworth smaller community stations and Mount Thorley and Singleton NW diagnostic stations. In 2019, this occurred at all 14 stations, during extreme drought and bushfire conditions.
- Annual average PM2.5 levels were within the benchmark at all stations in 2022, ranging from 3.4 µg/m³ at Merriwa to 6.2 µg/m³ at Muswellbrook.
From 2011 to 2021, maximum annual PM2.5 levels ranged from 7.3 µg/m³ in 2021 to 12.2 µg/m³ in 2019. Annual PM2.5 levels were over the benchmark each year prior to 2021 at Muswellbrook, 3 years at Camberwell in 2013, 2018 and 2019, and 4 years at Singleton in 2017, 2018, 2019 and 2020. Smoke from domestic wood heaters contributes significantly to particle levels at larger population centres⁴.

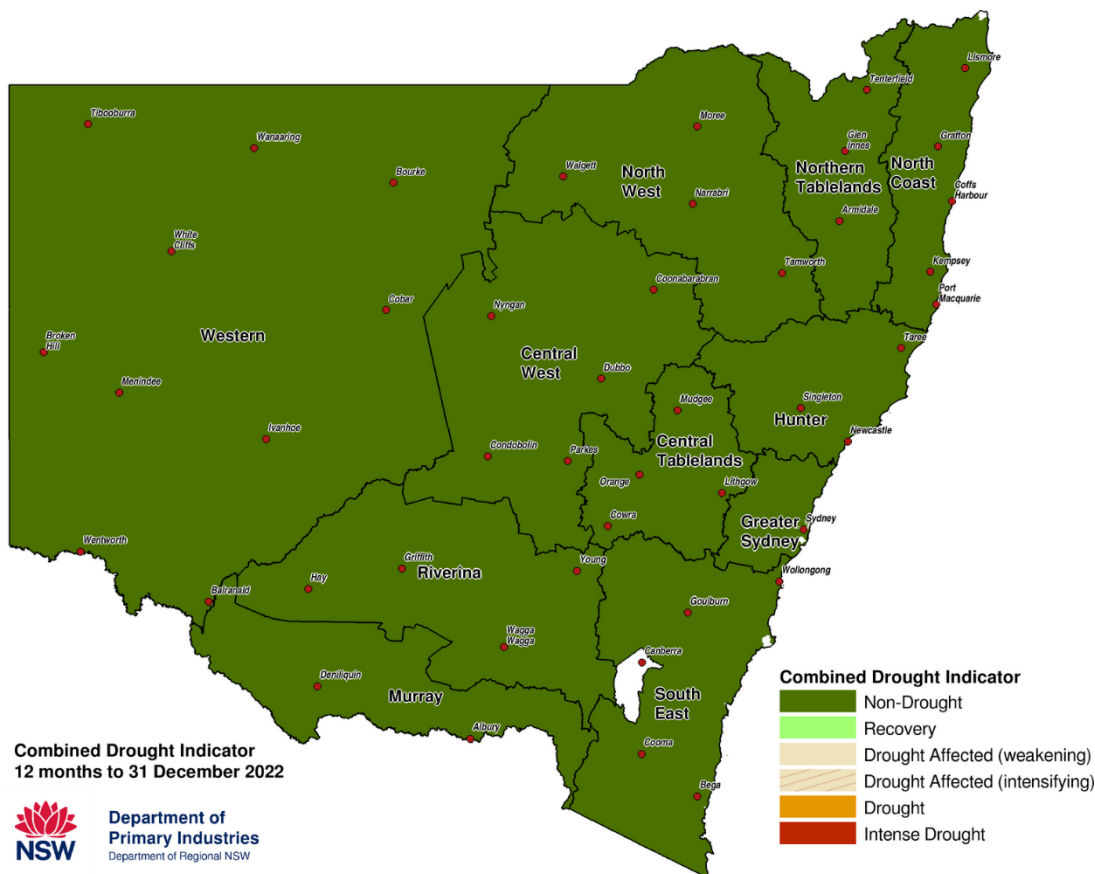


Figure 2 Department of Primary Industries NSW Combined Drought Indicator to 31 December 2022⁵

² Sourced from Department of Primary Industries [NSW State seasonal update – December 2021](#) (accessed January 2023).

³ Sourced from Department of Primary Industries [NSW State seasonal update – December 2020](#) (accessed January 2023).

⁴ The [Upper Hunter Fine Particle Characterisation Study](#) found smoke from domestic wood heaters contributed significantly to PM2.5 levels in Muswellbrook and Singleton.

⁵ Sourced from the Department of Primary Industries [NSW State seasonal update – December 2022](#) (accessed February 2023).

Days above benchmark concentrations

There were 2 days over the daily PM10 particle benchmark during 2022 across multiple stations and no days over the PM2.5 benchmark (Table 1 and Table 2). Particle levels were within national benchmarks for between 99.7% of days at Muswellbrook NW and Warkworth and 100% of days at all other stations during 2022 (Figure 3).

Gases are measured at Merriwa, Muswellbrook and Singleton in the Upper Hunter.

- All days were within the NO₂ 8 pphm hourly benchmark at all stations. The maximum hourly NO₂ level in the region was 3.0 pphm, recorded at Muswellbrook on 4 October 2022.
- All stations recorded annual NO₂ levels within the 1.5 pphm annual benchmark at all stations. The maximum annual NO₂ level in the region was 0.7 pphm, measured at Muswellbrook.
- All days were within the SO₂ 2 pphm daily benchmark at all stations. The maximum daily SO₂ level in the region was 1.6 pphm, measured at Muswellbrook on 17 March 2022.
- All days were within SO₂ 10 pphm hourly benchmark⁶ at all stations. The maximum hourly SO₂ level in the region was 10.0 pphm, recorded at Muswellbrook on 17 March 2022. On this day elevated levels occurred under light south-easterly winds, likely due to industrial power station emissions.

Note, gaseous measurements were only available at Muswellbrook from late February onwards in 2022 due to an instrument fault. This is important to note as historical data indicates SO₂ levels at Muswellbrook are usually higher during summer and can exceed the benchmarks.

Table 1 Number of days per station above the relevant national benchmarks 2022

| 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 | 1 | - | - | - | - |
| Smaller community | Wybong | 0 | - | - | - | - |
| Diagnostic | Mount Thorley | 0 | - | - | - | - |
| Diagnostic | Muswellbrook NW | 1 | - | - | - | - |
| Diagnostic | Singleton NW | 0 | - | - | - | - |
| Background | Merriwa | 0 | 0 | 0 | 0 | 0 |
| Background | Singleton South | 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)

- = not monitored.

* For explanation, refer to the end of the report [Definitions: Upper Hunter monitoring station types](#).

⁶ The measured level of SO₂ must be at least 0.1 pphm higher than the benchmark for it to be considered an exceedance.

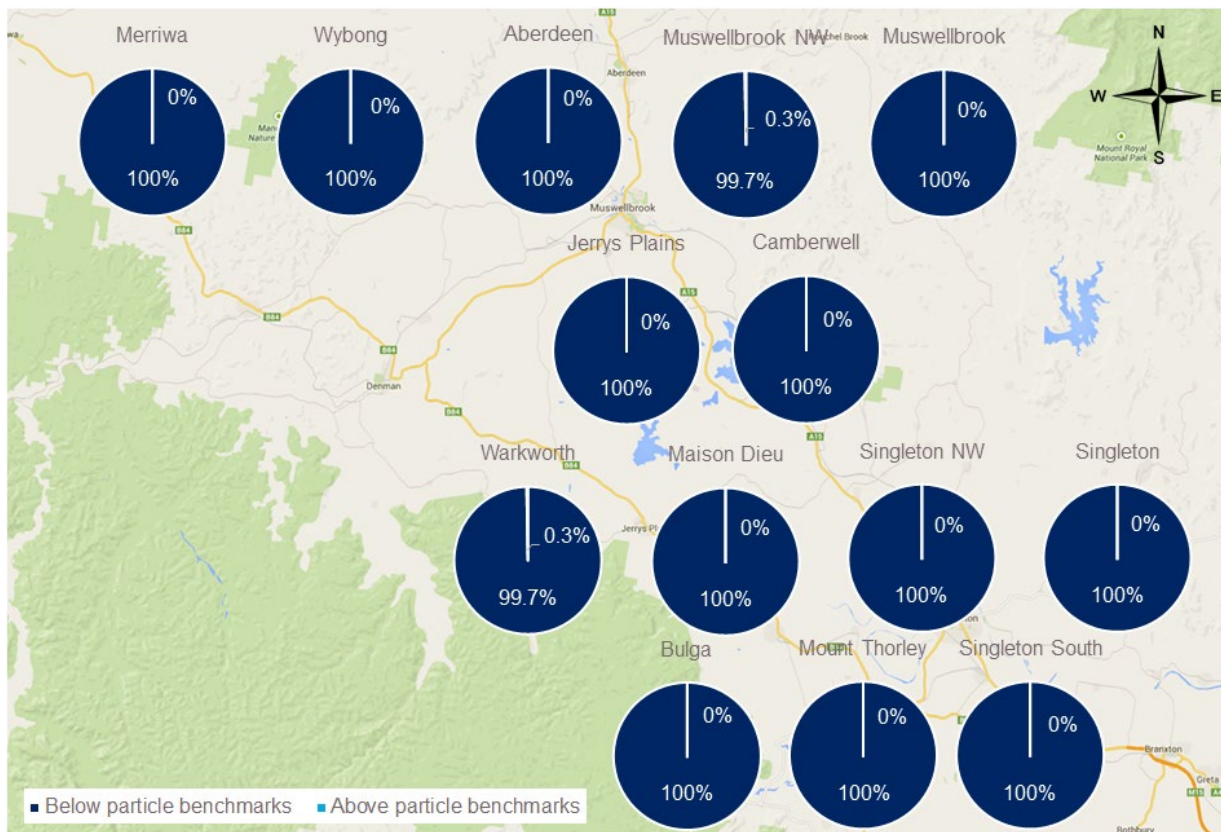


Figure 3 Percentage of days above and below particle benchmarks across the Upper Hunter – 2022

PM10 particle events

The number of days over the daily PM10 benchmark (PM10 particle events) at individual stations ranged from no days at 12 stations to 1 day at Muswellbrook NW and Warkworth (Table 1).

There were no widespread PM10 particle events during the year (Table 2).

Table 2 Days and stations above the PM10 daily benchmark – 2022

| Date | Maximum daily PM10 ($\mu\text{g}/\text{m}^3$) | Stations over benchmark | Station and daily PM10 ($\mu\text{g}/\text{m}^3$) for each station type | | | |
|----------|---|-------------------------|---|-------------------|------------------------|------------|
| | | | Larger population | Smaller community | Diagnostic | Background |
| 20/11/22 | 50.2 | 1 | - | Warkworth (50.2) | - | - |
| 12/12/22 | 55.5 | 1 | - | - | Muswellbrook NW (55.5) | - |

PM2.5 particle events

There were no days over the PM2.5 daily benchmark throughout the region (Table 1). The regional maximum daily PM2.5 level in 2022 was 18.1 $\mu\text{g}/\text{m}^3$, measured at Singleton on 31 July 2022.

Pollution roses

The PM10 and PM2.5 pollution rose maps⁷ show hourly PM10 and PM2.5 concentrations under dominant north-west and south-east prevailing winds in the Upper Hunter (Figure 4 and Figure 5). The pollution roses show that hourly PM10 and PM2.5 levels⁸ were predominantly low during 2022.

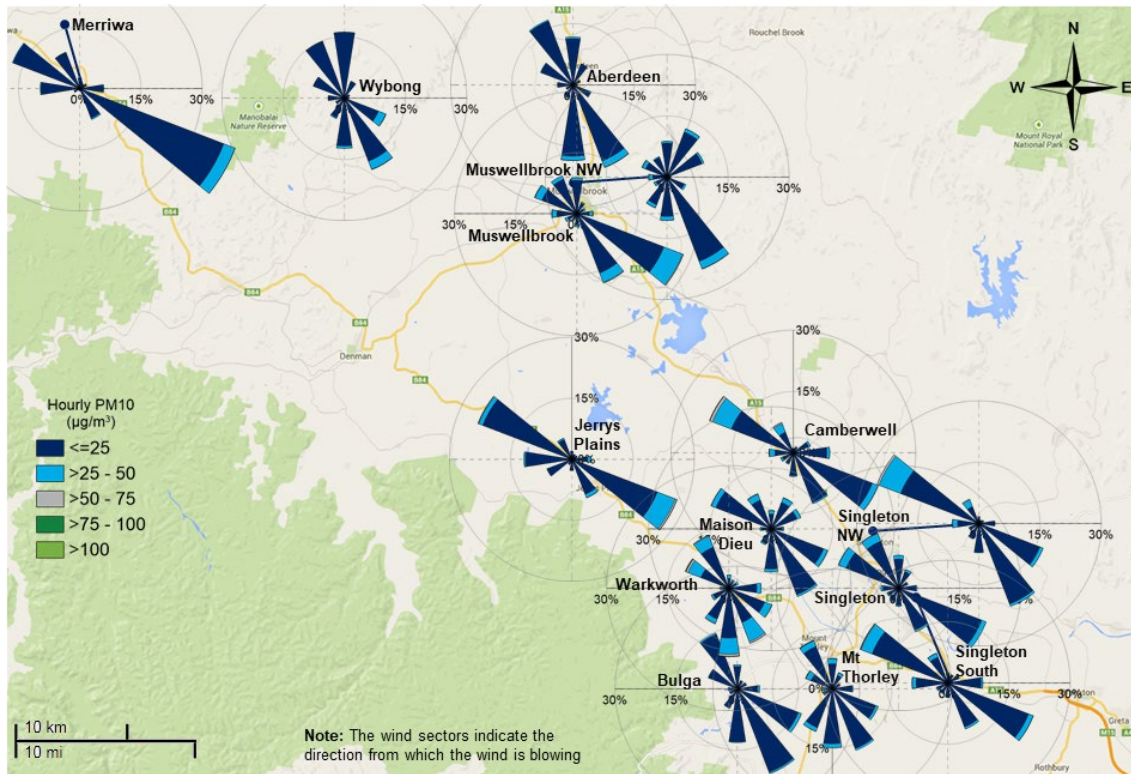


Figure 4 Hourly PM10 pollution rose map for the Upper Hunter region – 2022

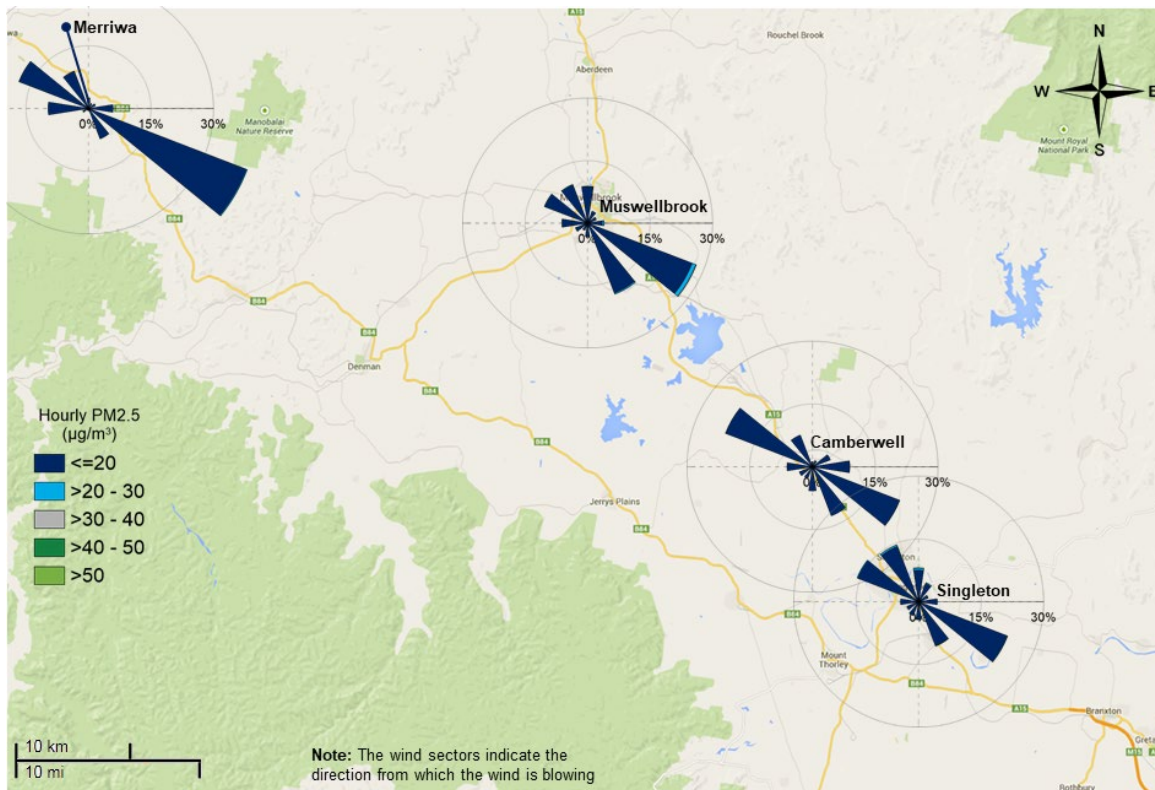


Figure 5 Hourly PM2.5 pollution rose map for the Upper Hunter region – 2022

⁷ Pollution roses show the wind direction and particle levels at a location. The length of each bar shows the percentage of time the wind blows from that compass direction. The colours along the bars indicate the particle levels, as presented in the key.

⁸ There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure.

Daily time series plots

Figure 6 to Figure 13 show daily average time series plots for PM10, PM2.5 and SO₂ and daily one-hour maximum plots for NO₂ and SO₂. The shaded areas in the figures indicate the seasons. Highest PM10 levels were observed later in the year, while highest SO₂ in the warmer months.

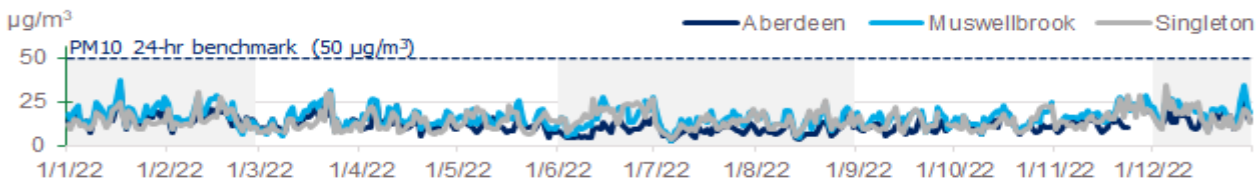


Figure 6 Population centre stations: daily average PM10 – 2022

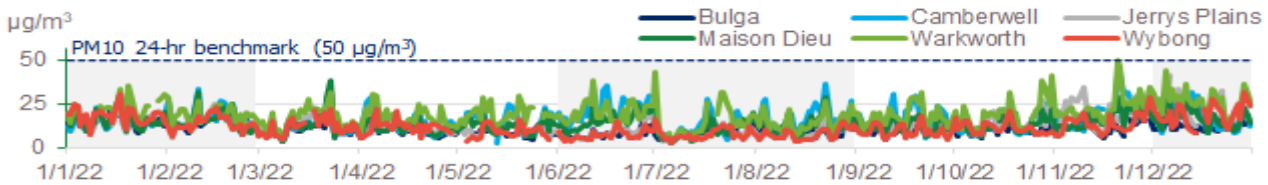


Figure 7 Smaller community stations: daily average PM10 – 2022

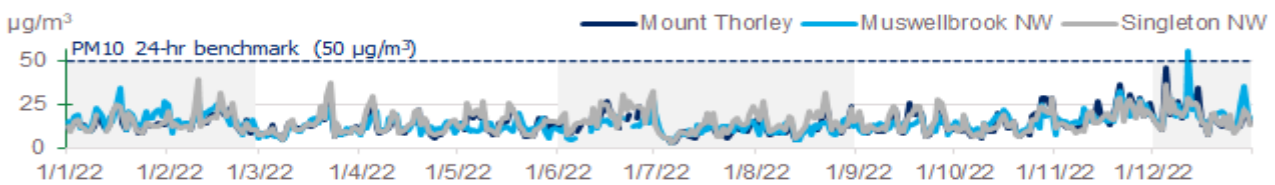


Figure 8 Diagnostic stations: daily average PM10 – 2022

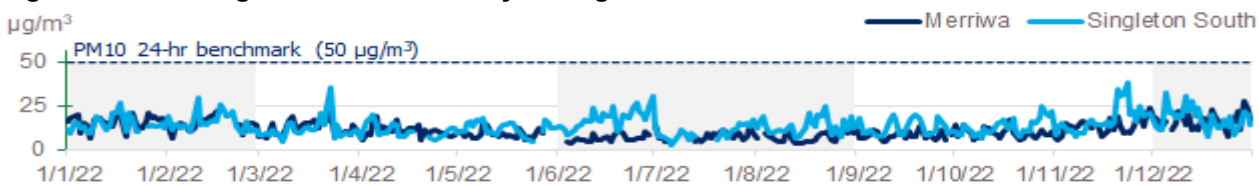


Figure 9 Background stations: daily average PM10 – 2022

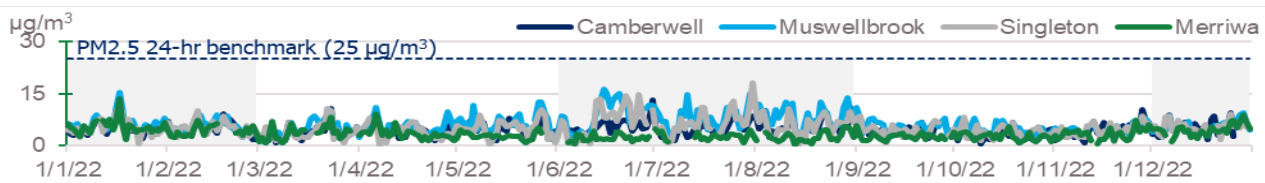


Figure 10 Daily average PM2.5 – 2022

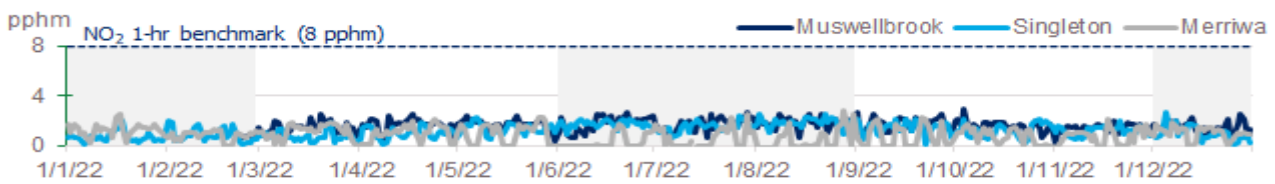


Figure 11 Daily 1-hr maximum NO₂ – 2022

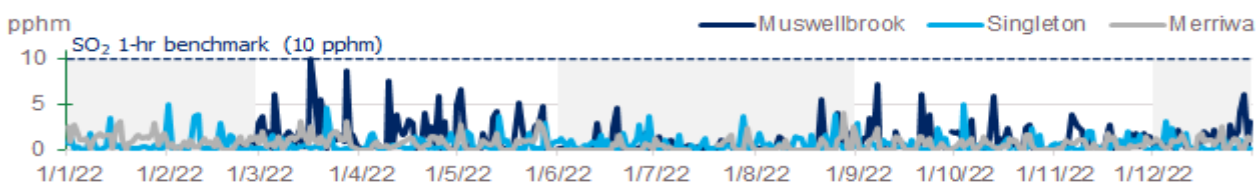


Figure 12 Daily 1-hr maximum SO₂ – 2022

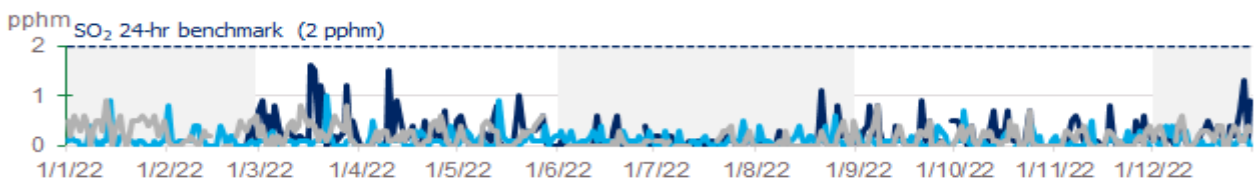


Figure 13 Daily average SO₂ – 2022

Annual comparisons 2012 to 2022

Hourly and annual NO₂ levels were within national benchmarks in 2022. This is the same as all previous years.

Hourly and daily SO₂ levels remained within the benchmarks in 2022. Previously, Muswellbrook alone would have exceeded the hourly SO₂ benchmark for between 1 day (in 2012, 2015 and 2021) and 6 days (in 2016), and the daily SO₂ benchmark for up to 2 days in 2013 (Figure 14).

In 2022, the region recorded 2 days over the PM10 benchmark. This was fewer than 2021, when there were 6 days over the benchmark. The number of days over the PM10 benchmark in earlier years ranged from 14 days in 2016 to 120 days in 2019, due to prolonged intense drought, extreme bushfires and dust storms (Figure 15).

All the larger population centres remained within the PM10 benchmark in 2022. Previously, 2019 had recorded the most days over the benchmark at these stations with 40 days at Singleton, 51 days at Aberdeen and 58 days at Muswellbrook.

For PM2.5, there were no days over the benchmark in 2022, the same as 2021. From 2012 to 2020, there were up to 32 days over the benchmark in 2019 (Figure 15). Generally, Muswellbrook recorded the most days over the benchmark prior to 2019, due to domestic woodsmoke⁹.

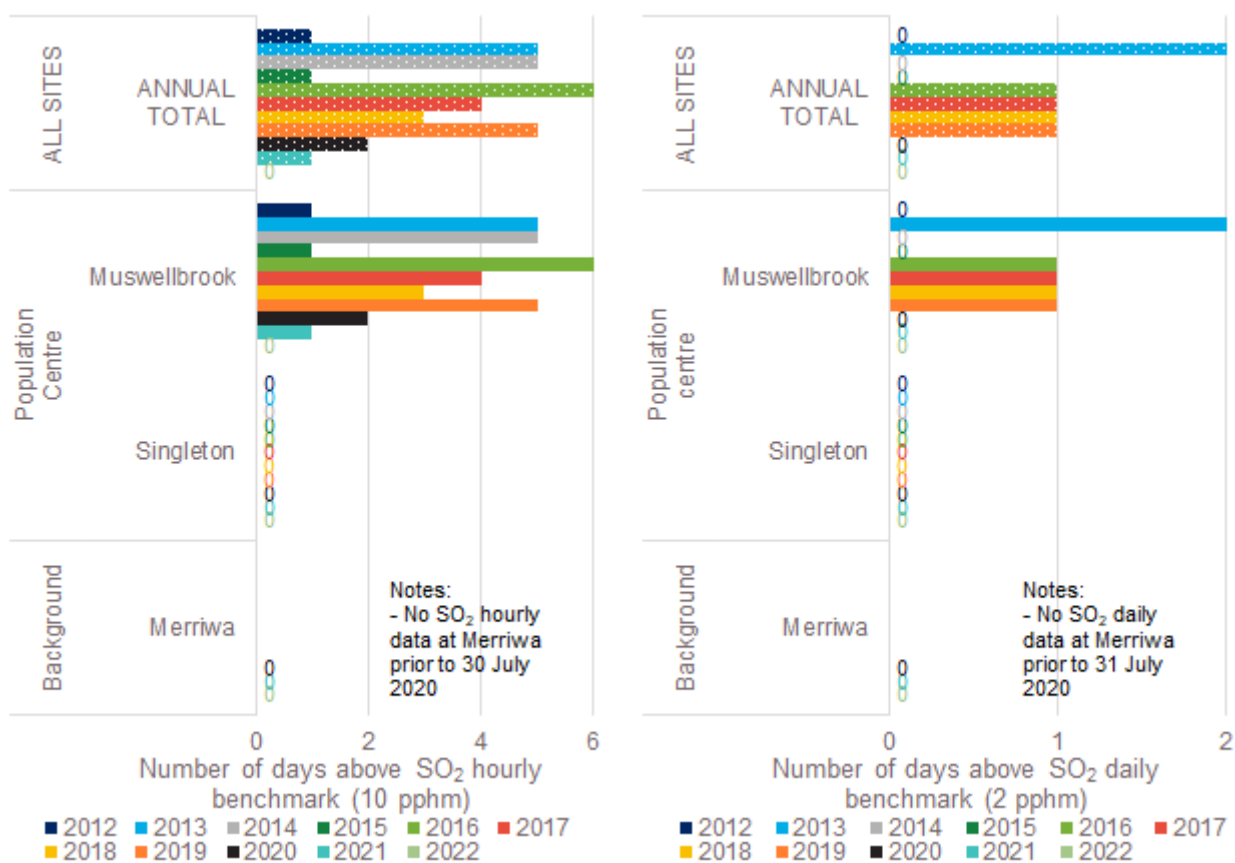


Figure 14 Number of days above the hourly SO₂ (left) and daily SO₂ (right) benchmarks from 2012 to 2022

⁹ The Upper Hunter Fine Particle Characterisation Study found smoke from domestic wood heaters contributes significantly to PM2.5 levels in Muswellbrook and Singleton during the cooler months.

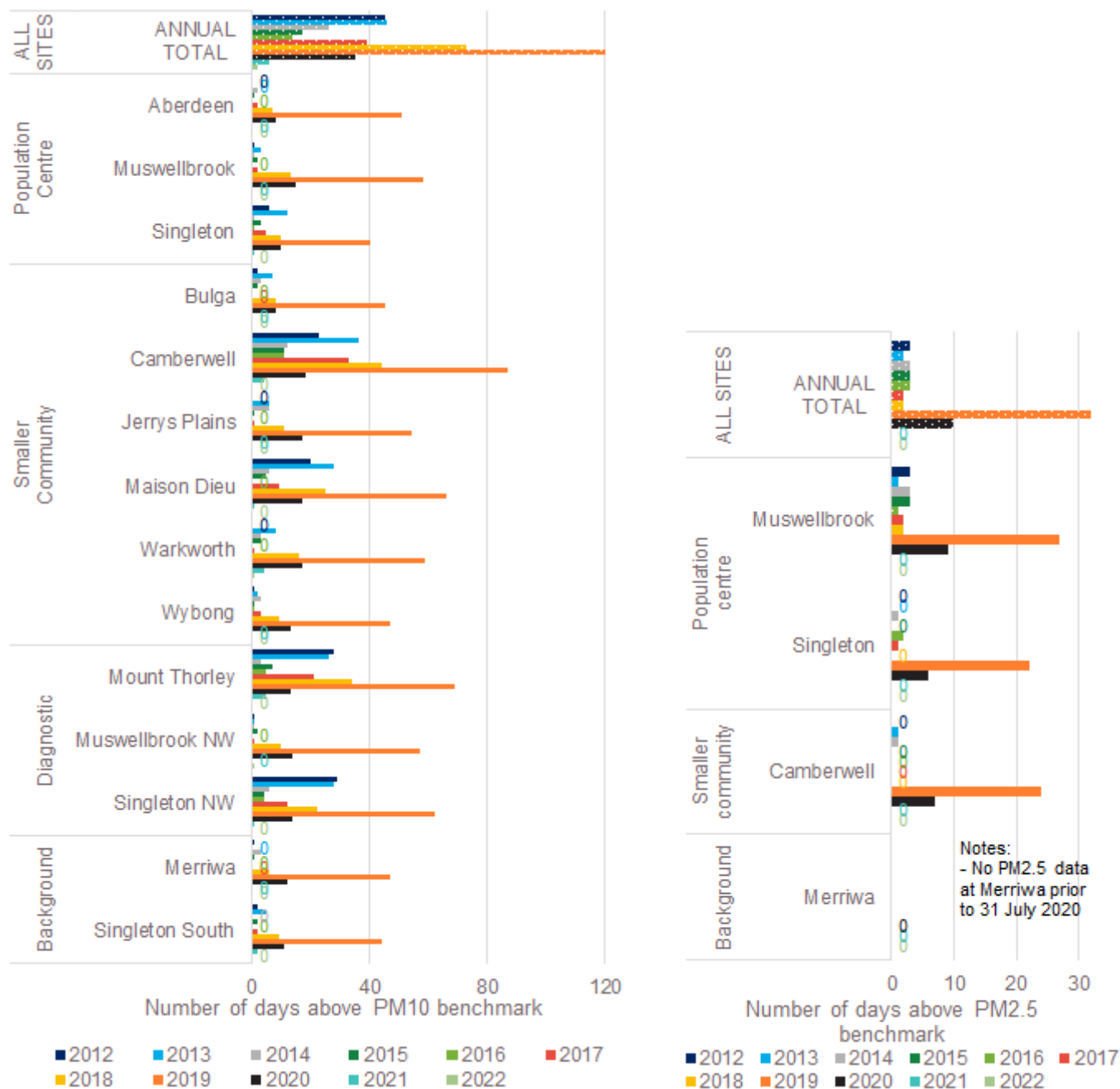


Figure 15 Number of days above the daily PM10 (left) and PM2.5 (right) benchmarks from 2012 to 2022

Meteorological summary

Rainfall and temperature¹⁰

NSW experienced exceptionally wet conditions in 2022, recording the second wettest year on record. Rainfall across the Upper Hunter was very much above average (Figure 16). The region had similar rainfall levels to 2021, up to 200 mm more rain than 2020 in some parts; and 400 to 800 millimetres more rain than 2019. Most months in 2022 recorded average or above average rainfall (Figure 18). Monthly rainfall levels were very much above average during March and from July to October.

Maximum temperatures were very much below average (Figure 17) and minimum temperatures were above average.

¹⁰ Information sourced from the BOM [NSW 2022 annual climate summary](#) and [climate maps](#) (accessed February 2023).

New South Wales rainfall deciles 1 January to 31 December 2022

Australian Gridded Climate Data

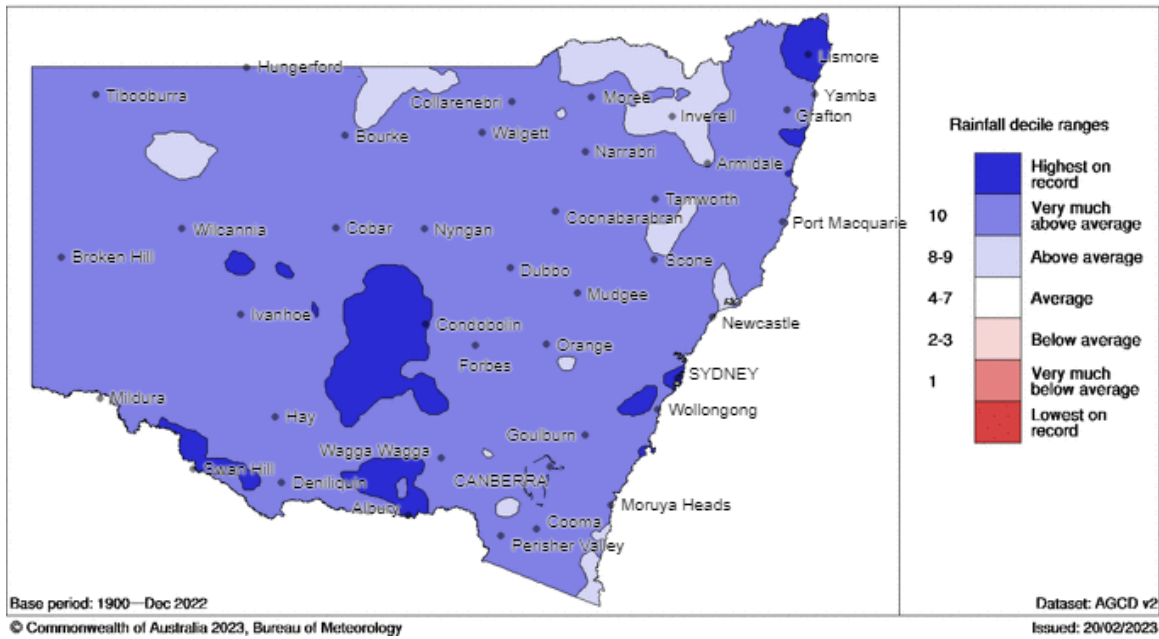


Figure 16 NSW rainfall deciles – 2022

Maximum Temperature Deciles 1 January to 31 December 2022

Distribution Based on Gridded Data
 Australian Bureau of Meteorology

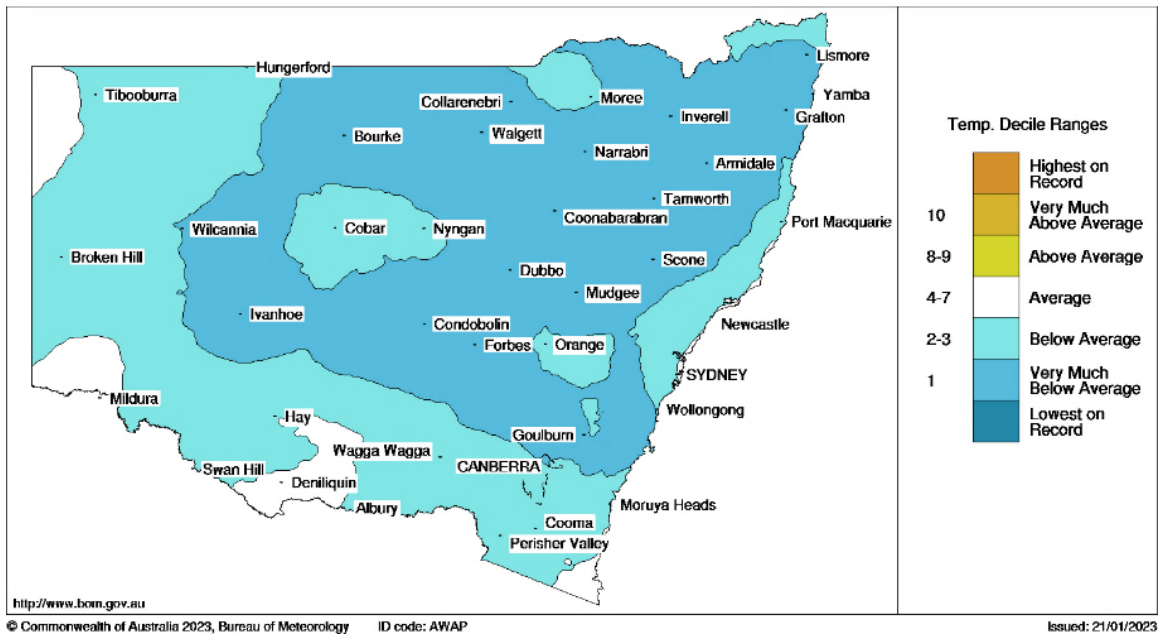


Figure 17 NSW maximum temperature deciles – 2022

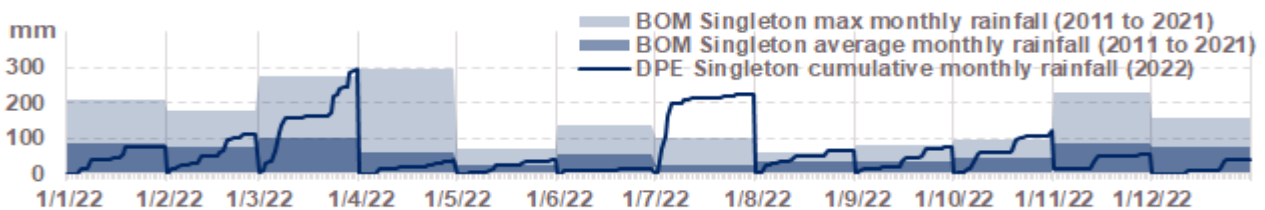


Figure 18 Singleton cumulative monthly rainfall in 2022¹¹ plotted against maximum and average monthly rainfall from 2011 to 2021¹²

¹¹ No data from BOM Singleton Defence AWS from 20 April to 12 July, so DPE Singleton data have been used for this report.

¹² The BOM STP station was decommissioned in January 2019. Statistics have been calculated from combined Singleton STP monthly rainfall data from January 2011 to March 2017 and Singleton Defence AWS monthly rainfall data from April 2017.

Winds

Upper Hunter winds were predominantly from the south-east in summer and north-west in winter in 2022 (Figure 19). During autumn and spring, winds were variable as they turned from south-easterly to north-westerly in autumn and north-westerly to south-easterly in spring. There was a lower proportion of north-westerly winds and a higher proportion of south-easterly winds in 2022, compared to 2021.

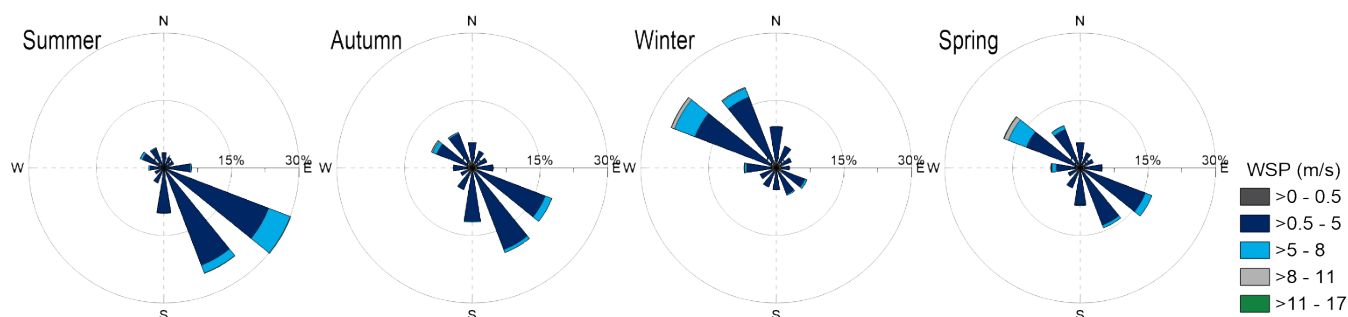


Figure 19 Seasonal wind roses using pooled wind data from all the Upper Hunter stations – 2022

Network performance

The target network performance is at least 95% available data for all parameters. The maximum online time that can be attained for NO₂ and SO₂ is 96%, due to daily calibrations.

In 2022, particle and meteorological parameters at most stations met this target (Table 3).

Table 3 Online performance (%) during 2022

| Station | Particles PM10 daily | Particles PM2.5 daily | Gases SO ₂ hourly | Gases NO ₂ hourly | Meteorology Wind hourly |
|-----------------|-------------------------|-----------------------------|---------------------------------|---------------------------------|----------------------------|
| Aberdeen | 98 | - | - | - | 98 |
| Bulga | 97 | - | - | - | 98 |
| Camberwell | 97 | 97 | - | - | 100 |
| Jerrys Plains | 97 | - | - | - | 99 |
| Maison Dieu | 99 | - | - | - | 99 |
| Merriwa | 93 | 92 | 89 | 90 | 95 |
| Mount Thorley | 95 | - | - | - | 98 |
| Muswellbrook | 99 | 99 | 81 | 81 | 99 |
| Muswellbrook NW | 98 | - | - | - | 97 |
| Singleton | 99 | 98 | 95 | 91 | 100 |
| Singleton NW | 99 | - | - | - | 99 |
| Singleton South | 96 | - | - | - | 98 |
| Warkworth | 96 | - | - | - | 99 |
| Wybong | 97 | - | - | - | 100 |

- = not monitored.

The overall reduced online times were mainly due to:

- Merriwa – power outages (6 days), intermittent datalogger faults (15 days), PM10 and PM2.5 scheduled calibrations (2 days), PM2.5 sensor replacement (3 days), PM2.5 calibration checks (2 days), SO₂ instrument fault (5 days)
- Muswellbrook SO₂ and NO₂ – instrument fault (2 months).

Definitions: Upper Hunter monitoring station types

The 14 monitoring stations in the Upper Hunter (Figure 20) serve different purposes.

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

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

Diagnostic: stations provide data to help diagnose the likely sources and movement of particles across the region. Diagnostic stations do not provide information about air quality in population centres.

Background: the stations at Merriwa and Singleton South measure air quality at the north-west and south-east extents of the region. They provide background data by measuring the quality of air entering and leaving the Upper Hunter Valley under predominant winds (south-easterlies and north-westerlies).

The Upper Hunter Air Quality Monitoring Network is operated by the NSW Government and funded by Upper Hunter coal and power industries, in accordance with the Protection of the Environment Operations (General) Regulation 2021.

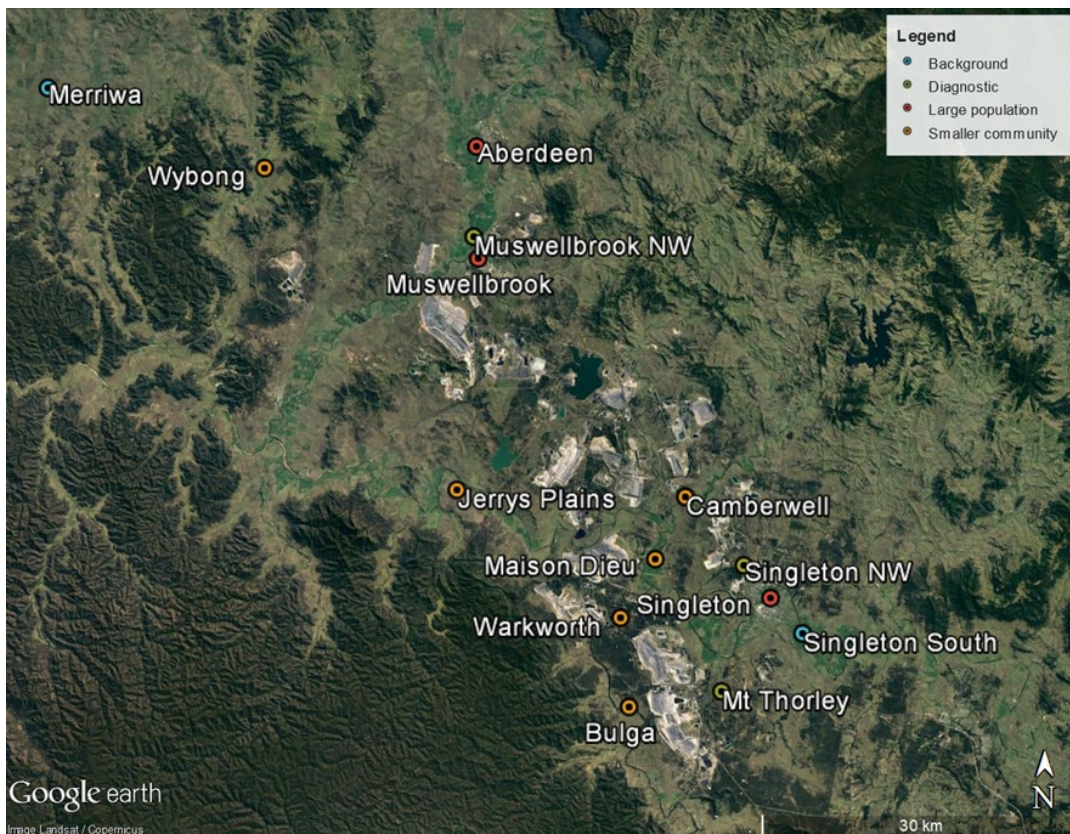


Figure 20 Upper Hunter air quality monitoring stations

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