Air quality in the Upper Hunter: Summer 2016–17

Air quality in the Upper Hunter from 1 December 2016 to 28 February 2017 was generally good.

- Levels of fine particulate matter $PM_{2.5}$ (particles less than or equal to 2.5 microns in diameter) and nitrogen dioxide (NO_2) during the summer were all below national benchmark concentrations.
- The hourly sulfur dioxide (SO_2) benchmark was exceeded at Muswellbrook for one hour on 23 December. On this day, an hourly level of 21 pphm (parts per hundred million) was recorded, briefly exceeding the national standard of 20 pphm. The event is discussed in more detail in a separate section. This was the first time since 1994 that any site in the NSW air quality monitoring network has recorded SO_2 levels above the national benchmark.
- Daily average levels of particulate matter PM_{10} (particles less than or equal to 10 microns in diameter) were above the 50 µg/m^3 benchmark on 12 days during the summer (14 and 30–31 December, 11, 14, 18, 24 and 30–31 January, 6 and 11–12 February). Maximum daily PM_{10} levels on these days ranged from 52.1 to 82.1 µg/m^3.
    - Aberdeen, Muswellbrook, Muswellbrook NW, Singleton, Warkworth and Wybong each recorded one day over the PM_{10} benchmark, Maison Dieu recorded two days, Singleton NW recorded three days, Mt Thorley recorded six days, and Camberwell recorded 11 days.
    - The larger population sites recorded PM_{10} levels over the benchmark on 18 January (Singleton) and 12 February (Aberdeen and Muswellbrook). These were exceptional events as they were due to effects of bushfire smoke.
    - The most extensive PM_{10} event occurred on 11 and 12 February when Aberdeen, Camberwell, Maison Dieu, Mt Thorley, Muswellbrook, Muswellbrook NW, Warkworth and Wybong all recorded levels over the benchmark on at least one of these days. There were several fires burning and smoke reported in or near the region during this period[1].
    - On 18 January, Camberwell, Singleton and Singleton NW recorded PM_{10} levels above the benchmark. Elevated particle levels occurred in the early evening coinciding with a south-easterly change. $PM_{2.5}$ concentrations also spiked at this time. A large fire[2] was burning at Kurri Kurri, approximately 35 km south-east of Singleton.
    - There were fires[3] burning on most PM_{10} event days, which may have contributed to elevated particle levels in the region, along with local dust sources.
    - The number of days over the PM_{10} benchmark in summer 2016–17 (12 days) was higher compared to those in the previous four years. The next highest number of days occurred in summer 2013–14 (nine days) and summer 2012–13 (six days).
- The Upper Hunter experienced below average rainfall during summer 2016–17. Conditions were drier and wind speeds higher than the previous two summers. Maximum temperatures were very much above average. Summer 2016–17 was the warmest on record for NSW, with Scone and Cessnock amongst the sites recording a record number of days 40 ºC or warmer.

Recent analysis by the NSW Office of Environment Heritage (OEH) examined seasonal trends in Upper Hunter air quality and meteorology. Periods with below average rainfall, above average temperatures and higher wind speeds, as in summer 2016–17, tended to be associated with elevated PM_{10} levels, especially during bush fires and hazard reduction burning.

[1] Rural Fire Service (RFS) ICON database: For example: fires of 250ha “New England Hwy, Whittingham”, 6ha “Old New England Hwy, Ravensworth”, 5ha “Giants Creek Rd, Giants Creek”, 0.1ha “Muscle Creek Rd, Muscle Creek” and 0.5ha Glendon Rd, Clydesdale”.
[2] RFS ICON database: 686 ha ‘Kurri Kurri’ fire from 18-25 January
[3] RFS ICON database: For example, 1159ha “Forbes St, Abermain” fire from 13–20 December, 238ha “Dog Leg” fire from 29 December – 13 January, 19ha “Loxford fire” from 11–12 January, 14ha “Mcinerney Rd, Camberwell” fire from 24–26 January, 10ha “New England Hwy, Aberdeen” fire from 30–31 January and 20ha “Cessnock Rd, Neath” fire from 31 January – 1 February.

Annual air quality trends in the Upper Hunter

A comparison of the annual average levels of PM_{10} and $PM_{2.5}$, since the Upper Hunter Air Quality Monitoring stations were established, shows the long term trends in particle levels. The benchmarks for annual average particle levels are 25 µg/m^3 for PM_{10} and 8 µg/m^3 for $PM_{2.5}$, based on a calendar year.

Figure 1 shows the PM_{10} and $PM_{2.5}$ *rolling* annual averages, based on the 12-month periods, from summer to summer for 2012–13 to 2016–17. The comparison shows that particle levels generally were lower to the end of summer in 2015–16 and 2016–17 than in the earlier years 2012–13 and 2013–14.

At the larger population sites, the PM_{10} and $PM_{2.5}$ *rolling* averages to the end of summer 2016–17 remained similar to the previous two year periods, despite a very hot and dry summer. At some sites closer to the mines, particularly Camberwell and Mt Thorley, the PM_{10} annual *rolling* averages increased compared to the two previous years, but still remained below the earlier years 2012–13 and 2013–14.

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

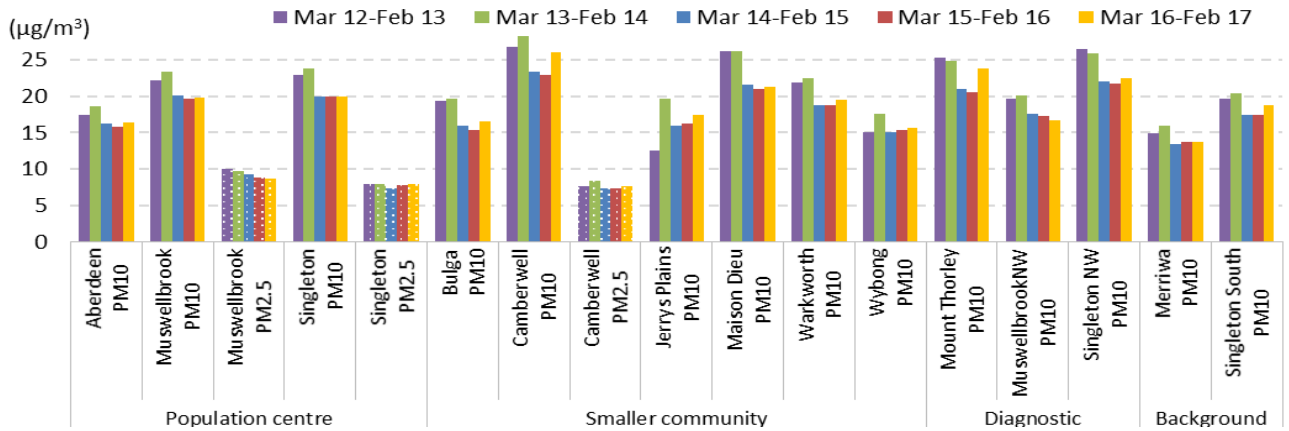

Figure 1: PM_{10} and $PM_{2.5}$ rolling annual averages to the end of summer: 2012–13 to 2016–17

Days above benchmark concentrations

There were 12 days over the PM_{10} benchmark during summer 2016–17 and one day over the SO_2 hourly benchmark.

Table 1: Number of days above the relevant benchmarks – summer 2016–17

Station type*	Station	**PM_{10} daily** [50 µg/m^3 benchmark]	**$PM_{2.5}$ daily** [25 µg/m^3 benchmark]	**SO_2 hourly** [20 pphm benchmark]	**SO_2 daily** [8 pphm benchmark]	**NO_2 hourly** [12 pphm benchmark]
Population centre	**Aberdeen**	1	-	-	-	-
Population centre	**Muswellbrook**	1	0	1	0	0
Population centre	**Singleton**	1	0	0	0	0
Smaller community	**Bulga**	0	-	-	-	-
Smaller community	**Camberwell**	11	0	-	-	-
Smaller community	**Jerrys Plains**	0	-	-	-	-
Smaller community	**Maison Dieu**	2	-	-	-	-
Smaller community	**Warkworth**	1	-	-	-	-
Smaller community	**Wybong**	1	-	-	-	-
Diagnostic	**Mount Thorley**	6	-	-	-	-
Diagnostic	**Muswellbrook NW**	1	-	-	-	-
Diagnostic	**Singleton NW**	3	-	-	-	-
Background	**Merriwa**	0	-	-	-	-
Background	**Singleton South**	0	-	-	-	-

µg/m^3 = microgram per cubic metre and 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

Daily time series plots

Daily average time series plots for PM_{10} and $PM_{2.5}$ and daily one hour maximum plots for NO_2 and SO_2 show the daily concentrations throughout the summer season.

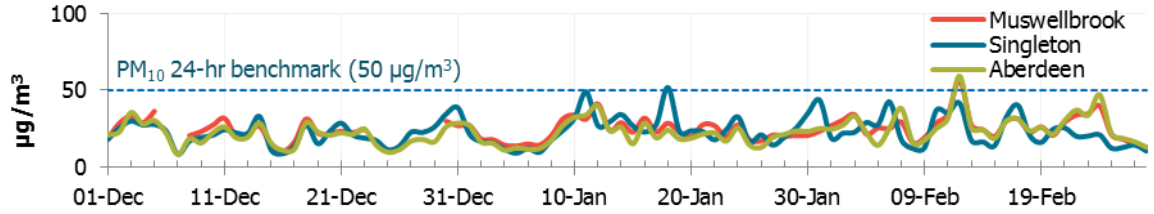

Figure 2: Population centre sites: daily average PM_{10} – summer 2016–17

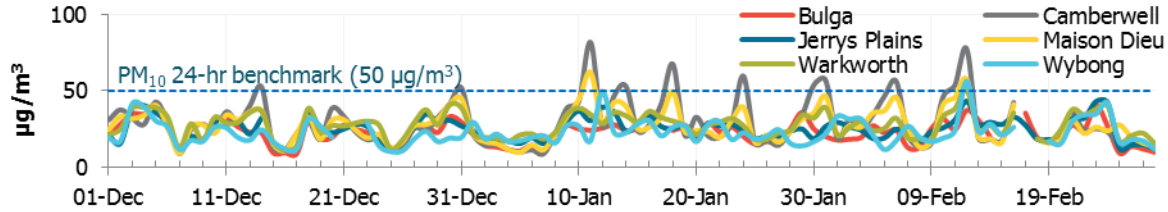

Figure 3: Smaller community sites: daily average PM_{10} – summer 2016–17

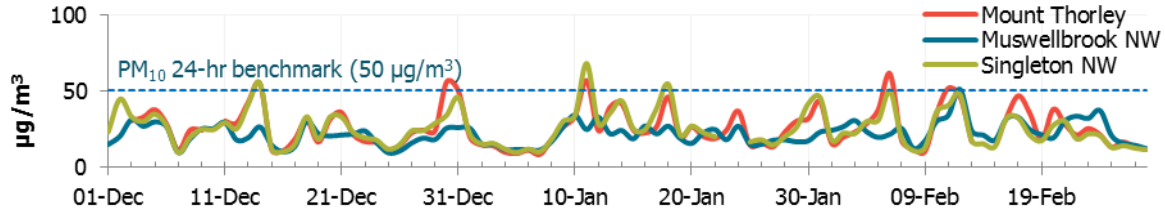

Figure 4: Diagnostic sites: daily average PM_{10} – summer 2016–17

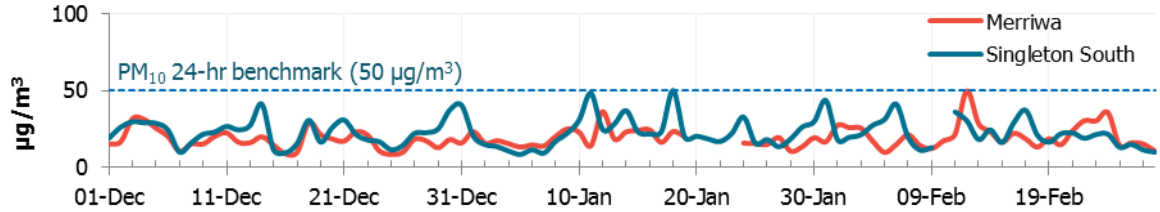

Figure 5: Background sites: daily average PM_{10} – summer 2016–17

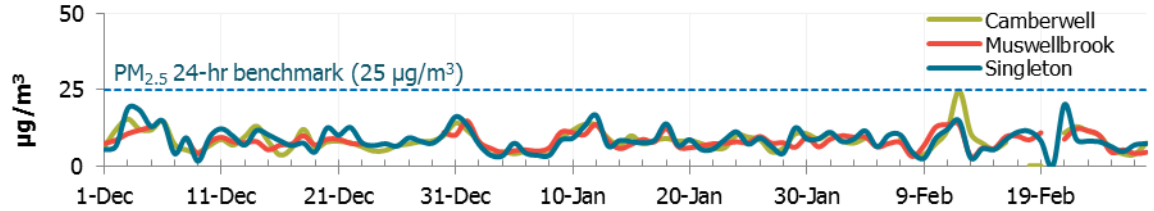

Figure 6: Daily average $PM_{2.5}$ – summer 2016–17

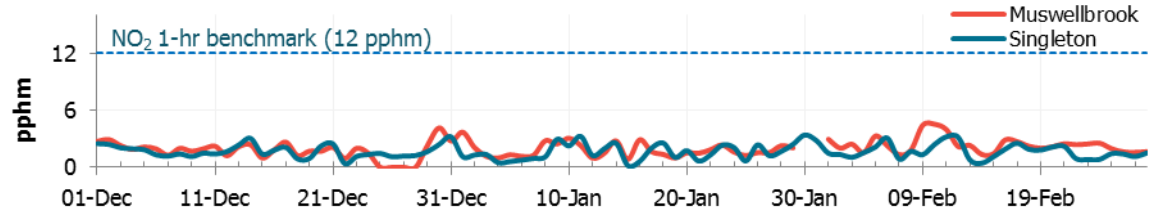

Figure 7: Daily 1-hr maximum NO_2 – summer 2016–17

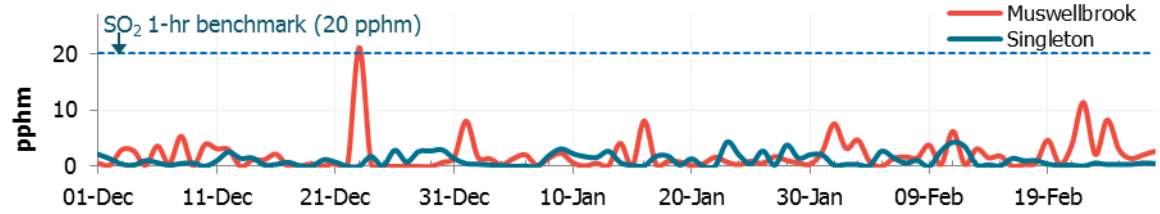

Figure 8: Daily 1-hr maximum SO_2 – summer 2016–17

Pollution roses

The seasonal PM_{10} pollution rose map shows that hourly PM_{10} levels were generally low during summer 2016–17, with only a small percentage of elevated hourly levels at some sites.

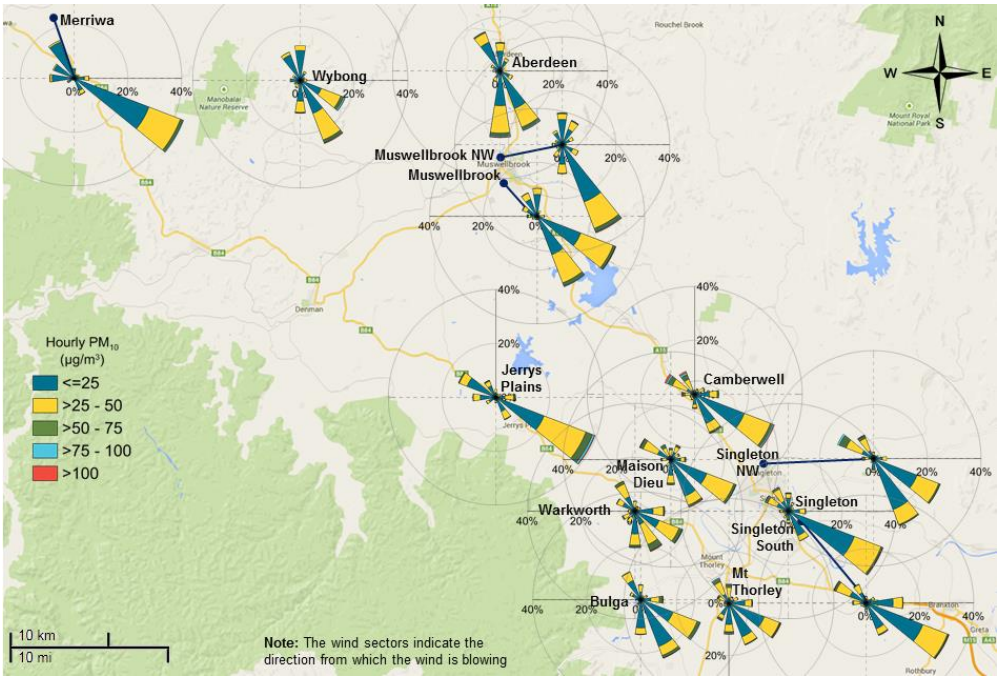

Figure 9: Hourly PM_{10} pollution rose map for the Upper Hunter region for summer 2016–17

Seasonal comparisons

This section compares air quality levels in summer 2016–17 with previous summer seasons.

All days were below the benchmark concentrations for $PM_{2.5}$ and NO_2 in summer in the past five years.

There was one day over the SO_2 benchmark at Muswellbrook during summer 2016–17. All days were below the SO_2 benchmarks in previous years.

The daily average PM_{10} concentrations were above the benchmark on 12 days during summer 2016–17. This can be attributed overall to an increase in the number of days over the PM_{10} benchmark at Camberwell and Mt Thorley. These diagnostic monitoring stations provide data to diagnose the impact of mining activity on the movement of particles across the region. The number of days over the PM_{10} benchmark was higher in summer 2016–17 compared to the same season in the previous four years. The next highest number of days occurred in summer 2013–14 (nine days) and summer 2012–13 (six days).

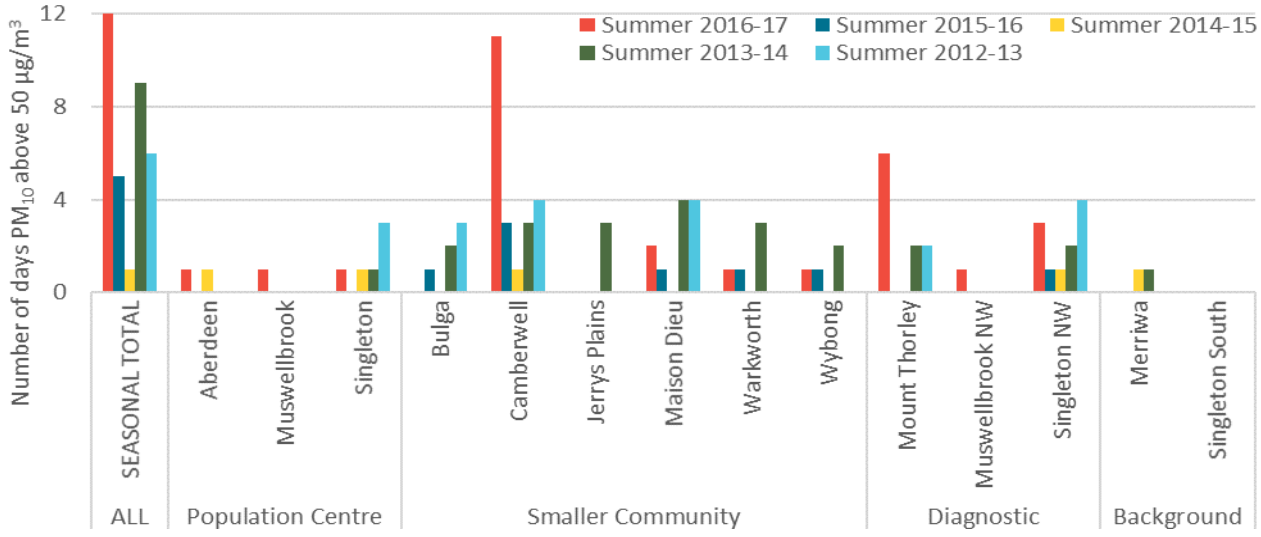

Figure 10: Number of days above the PM_{10} benchmark during the 2012–13 to 2016–17 summer seasons

Summer particle air quality trends in the Upper Hunter

Figure 11 and Figure 12 show daily average levels of PM_{10} during summer 2016–17, compared to the daily maximum and minimum (i.e. range) of PM_{10} levels for the summers from 2011–12 to 2015–16, at Singleton and Muswellbrook. These show that daily PM_{10} levels were generally higher in the latter part of summer 2016–17 compared to earlier years. Some days recorded the maximum level since the establishment of the network. These elevated levels coincide with periods of little or no rainfall, with well below average rainfall in January and February.

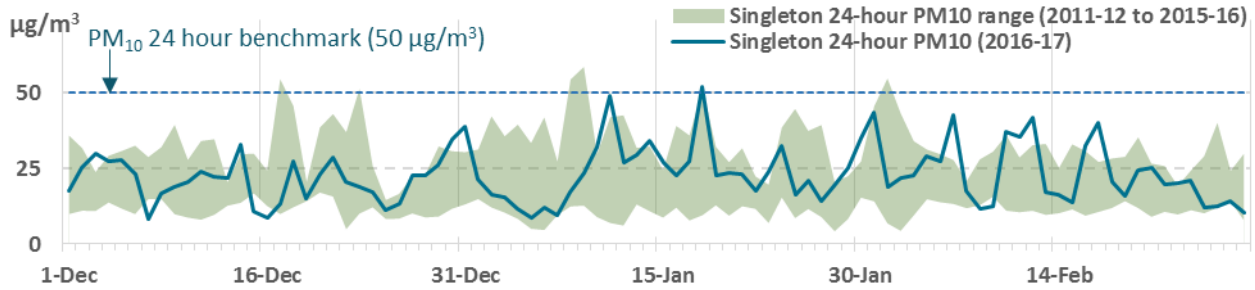

Figure 11: Singleton daily average PM_{10} during summer 2016–17 plotted against the daily maximum and minimum PM_{10} levels recorded from summer 2011–12 to 2015–16

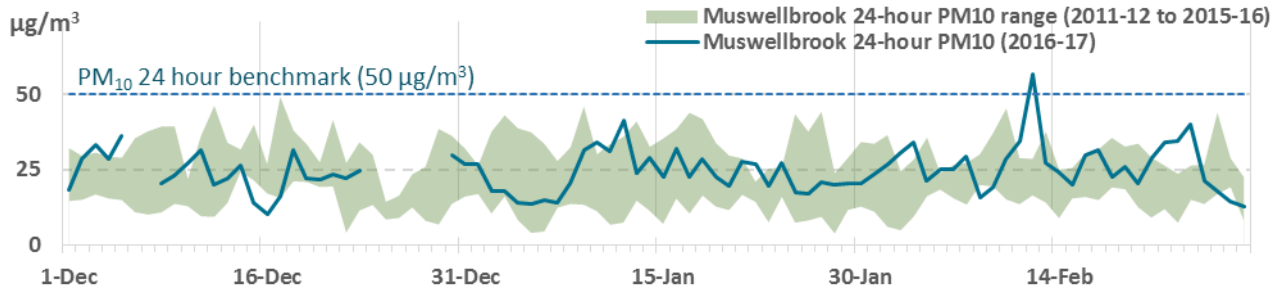

Figure 12: Muswellbrook daily average PM_{10} during summer 2016–17 plotted against the daily maximum and minimum PM_{10} levels recorded from summer 2011–12 to 2015–16

Figure 13 and Figure 14 show daily average levels of $PM_{2.5}$ during summer 2016–17, compared to the daily maximum and minimum levels from summer 2011–12 to 2015–16, at Singleton and Muswellbrook. These show that daily $PM_{2.5}$ levels were generally higher in summer 2016–17 compared to earlier years.

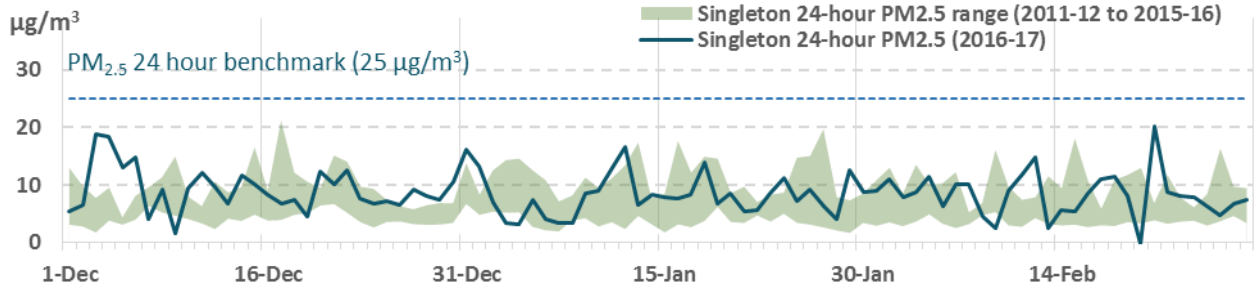

Figure 13: Singleton daily average $PM_{2.5}$ during summer 2016–17 plotted against the daily maximum and minimum $PM_{2.5}$ levels recorded from summer 2011–12 to 2015–16

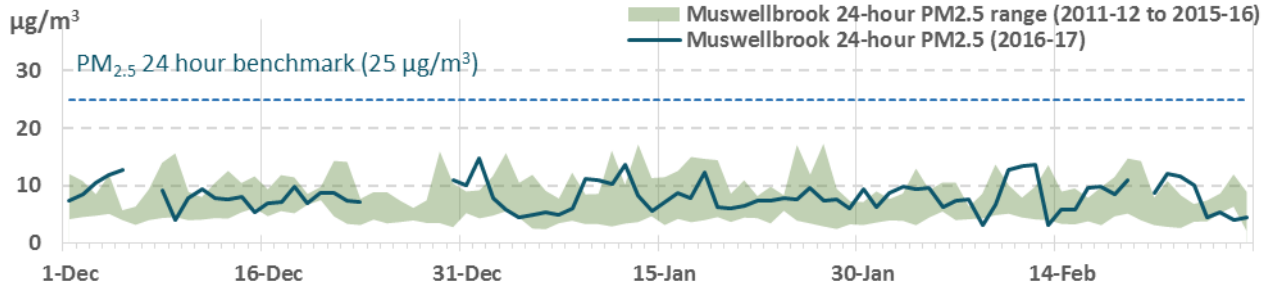

Figure 14: Muswellbrook daily average $PM_{2.5}$ during summer 2016–17 plotted against the daily maximum and minimum $PM_{2.5}$ levels recorded from summer 2011–12 to 2015–16

Muswellbrook SO_2 event

Muswellbrook typically records higher maximum SO_2 concentrations compared to other sites within the OEH NSW monitoring network. However, previous SO_2 levels have remained below the national benchmarks. On 23 December 2016, at 8am, the hourly SO_2 concentration peaked at 21 pphm, exceeding the benchmark of 20 pphm.

The synoptic conditions on this day showed a high pressure system centred in the Tasman Sea, extending across the eastern part the continent (Figure 15). Typically, under this synoptic pattern, surface winds are light and atmospheric conditions are stable. These conditions potentially limit atmospheric dispersion over the Hunter region.

At Muswellbrook, on this day, winds were light south-easterly, shown by the pollution rose (Figure 16).

The main source of SO_2 and NOx emissions within the region is electricity generation at the power stations. The Air Emissions in My Community web tool reports that power stations contribute 99.9% of the SO_2 in the Muswellbrook local government area (126 kilotonnes per year). Bayswater and Liddell power stations are located approximately 15 kilometres southeast of Muswellbrook. The SO_2 peak coincided with a peak in oxides of nitrogen (NOx) at the site (Figure 17). Hence, it appears that the SO_2 exceedance at Muswellbrook was due to transport of SO_2 emissions from the power stations.

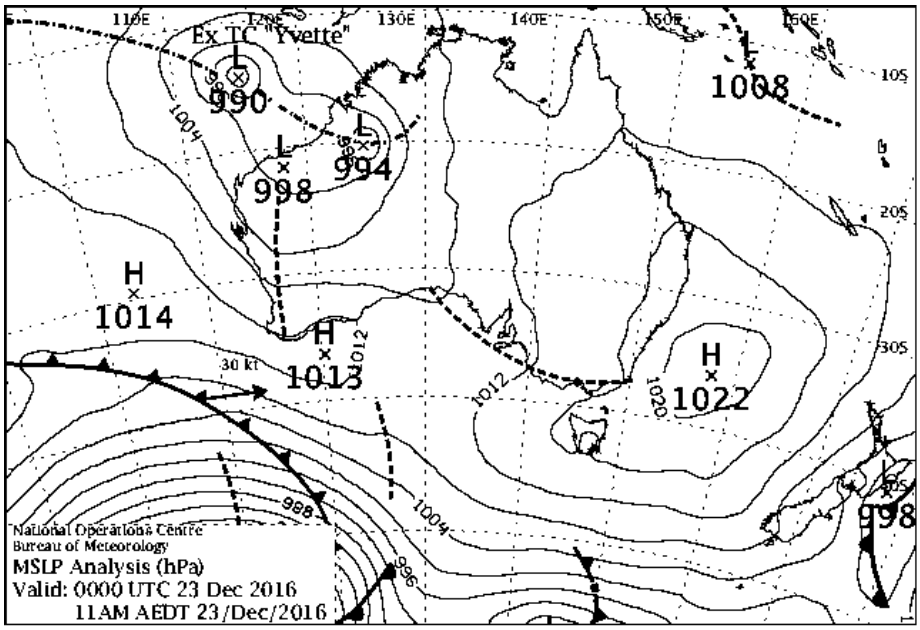

Figure 15: Bureau of Meteorology synoptic chart[4] for 23 December 2016 11am

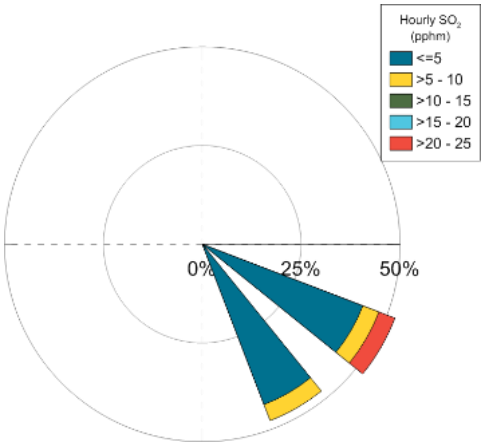

Figure 16: Muswellbrook SO_2 pollution rose - 23 December 2016

[4] Sourced from http://www.bom.gov.au/australia/charts/archive/index.shtml

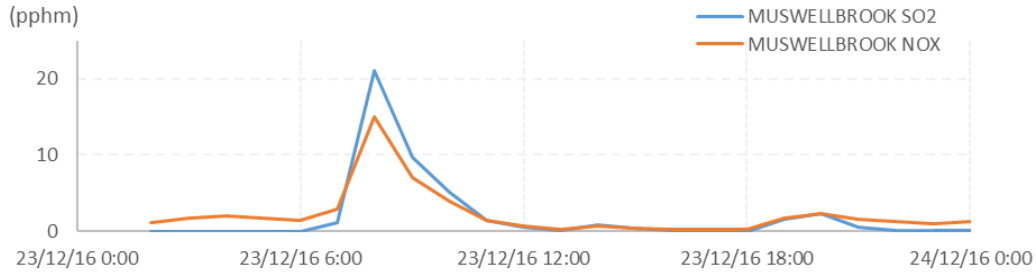

Figure 17: Muswellbrook SO_2 and NO_X time series - 23 December 2016

OEH has undertaken numerical air quality modelling to better understand the meteorological conditions and their effects on SO_2 levels on 23 December 2016. The modelling was able to predict the meteorology on this day with sufficient accuracy to re-produce the measured conditions. The timing of the SO_2 peak was also accurately predicted. However, the magnitude of the peak was significantly under-predicted.

OEH are awaiting additional atmospheric data to further improve the model performance, with work planned to better understand the complex meteorological conditions that occurred on this day.

Meteorological summary

Rainfall and temperature[5]

The Upper Hunter experienced below-average rainfall overall during summer 2016–17, with average rainfall recorded during December. Summer 2016–17 was drier than the previous two summers. Summer 2016–17 rainfall was around 100 to 400 millimetres less compared to summers 2015–16 and 2014–15, while up to 50 millimetres more compared to summer 2013–14.

Summer 2016–17 was reported as the warmest on record for NSW, with Scone and Cessnock amongst the sites recording a record number of summer days 40 ºC or warmer. Maximum temperatures were 'very much above average' and minimum temperatures reached 'highest on record' during the season.

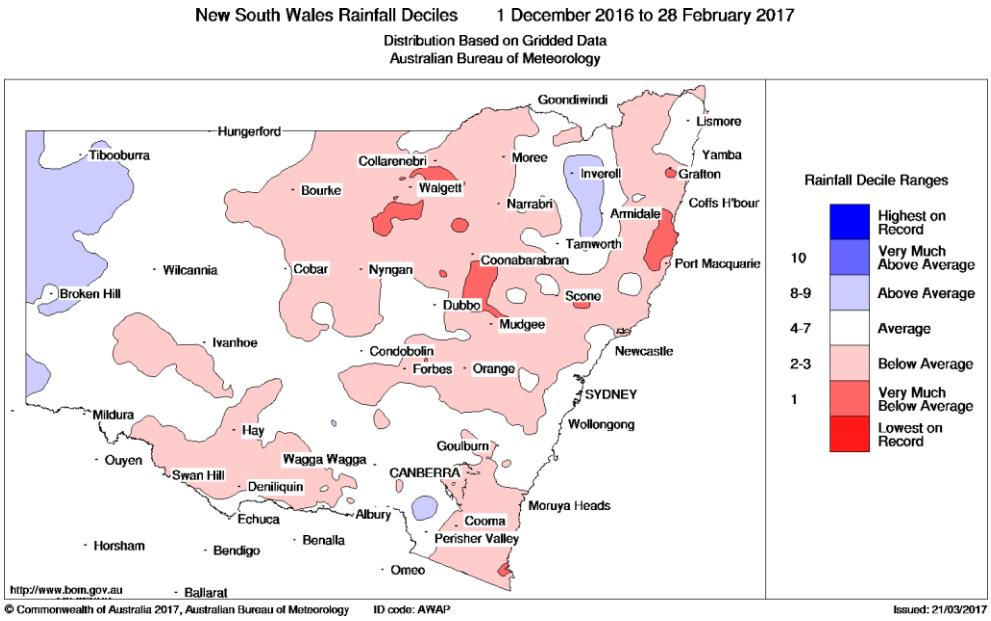

Figure 18: NSW rainfall deciles – summer 2016–17

Wind

The winds were predominantly from the southeast throughout the region during summer 2016–17, which is typical for this time of the year. Wind speeds in summer 2016–17 were generally higher than the previous two summer seasons 2014–15 and 2015–16, while similar to summer 2012–13 and 2013–14.

[5] Rainfall and temperature information are from the Bureau of Meteorology New South Wales summer 2016–17 climate statement, Special Climate Statement 61—exceptional heat in southeast Australia in early 2017 and climate maps (accessed May 2017)

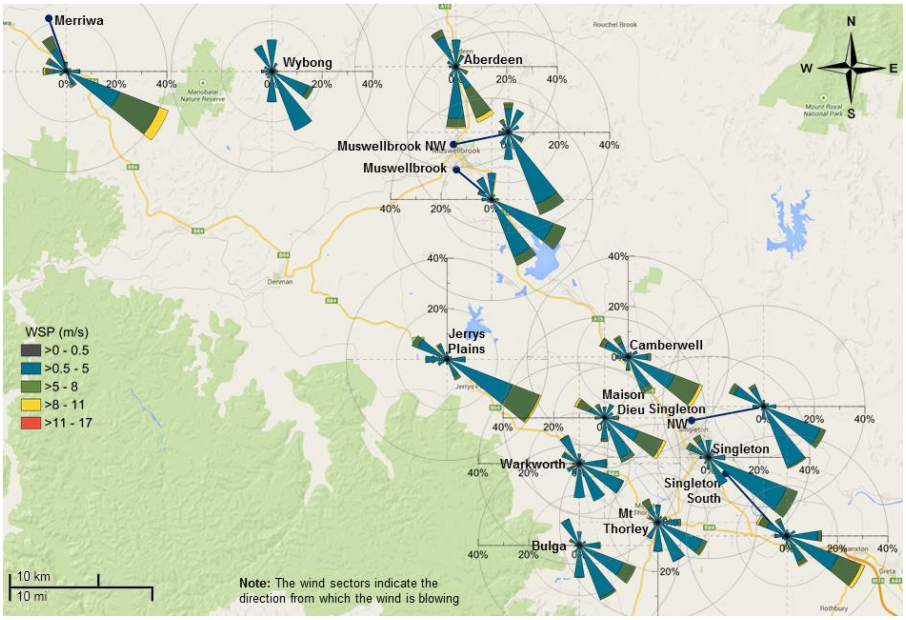

Figure 19: Wind rose map[6] for the Upper Hunter region for summer 2016–17

Network performance

The target network performance is at least 95% available data for all parameters. 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 summer 2016–17

Station	Particles PM_{10} daily	Particles $PM_{2.5}$ daily	Gases SO_2 hourly	Gases NO_2 hourly	Meteorology Wind hourly
Aberdeen	100	-	-	-	92
Bulga	96	-	-	-	100
Camberwell	96	93	-	-	97
Jerrys Plains	98	-	-	-	100
Maison Dieu	98	-	-	-	99
Merriwa	96	-	-	-	90
Mount Thorley	96	-	-	-	100
Muswellbrook	91	90	89	87	90
Muswellbrook NW	100	-	-	-	100
Singleton	100	100	92	95	99
Singleton NW	98	-	-	-	100
Singleton South	99	-	-	-	99
Warkworth	99	-	-	-	100
Wybong	96	-	-	-	100

- = not monitored

The overall reduced online times were mainly due to:

- Muswellbrook – all parameters – data logger issues (one day) and power outage (five days)
- Camberwell $PM_{2.5}$ – instrument problem (one day) and power outage (three days)
- Aberdeen wind – communication problems (seven days)
- Merriwa wind – power outage (two days) and communications problems (five days)

[6] Wind roses show the wind direction and speed at a location. The length of each bar around the circle in these wind roses show the percentage of time that the wind blows from a particular direction. The colours along the bars indicate the wind speed categories.

Definitions: Upper Hunter monitoring station types

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

Larger population: stations near 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: provide data that can help to diagnose the likely sources and movement of particles across the region as a whole; 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).

Published by: Office of Environment and Heritage, 59–61 Goulburn Street, Sydney South 1232. Ph: 131 555 (environment information and publications requests). TTY: (02) 9211 4723.
Email: info@environment.nsw.gov.au;
Web: www.environment.nsw.gov.au.

ISSN 2206-0391 OEH 2017/0234 May 2017