Air quality in the Upper Hunter – 2016 overview

Upper Hunter air quality from 1 January to 31 December 2016 was generally good.

- Levels of nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) measured at Muswellbrook and Singleton have remained below the relevant national benchmarks, except for one-hour SO_2 briefly over the 20 parts per hundred million (pphm) benchmark at Muswellbrook on 23 December (21 pphm).
- Daily average levels of fine particulate matter $PM_{2.5}$ (particles less than or equal to 2.5 microns in diameter) were above the 25 micrograms per cubic metre (µg/m^3) benchmark on three days (7–8 May and 4 July). Regional maximum daily $PM_{2.5}$ on these days ranged from 25.5 to 29.4 µg/m^3.
    - Singleton recorded two consecutive days over the $PM_{2.5}$ benchmark (7–8 May). These were exceptional events due to hazard reduction burns.
    - Muswellbrook recorded one day over the benchmark, due to a nearby factory fire.
    - The number of days over the $PM_{2.5}$ benchmark was similar to the previous four years.
- Daily average levels of PM_{10} (particles less than or equal to 10 microns in diameter) were above the 50 µg/m^3 benchmark on 14 days (12 January, 26 February, 2 and 6 April, 23 May, 10 and 16 October, 5, 7–8 and 19 November and 14, 30–31 December). Regional maximum daily PM_{10} levels on these days ranged from 51.2 to 84.1 µg/m^3.
    - There were no days over the benchmark at Muswellbrook and Aberdeen larger population sites. There was one day at Singleton (6 April), an exceptional event due to hazard reduction burns.
    - Elevated PM_{10} levels were mainly measured in the southeast and at sites closer to mines. Days over the benchmark were recorded at Singleton and Wybong (one day each), Singleton North West (NW) (four days), Mount Thorley (five days) and Camberwell (11 days).
    - The number of days over the PM_{10} benchmark was fewer in 2016, compared to the previous four years. In 2016, 4% of days were over the benchmark, compared with 12% in 2012 and 2013.
- Annual average PM_{10} levels at all 14 sites were below the 25 µg/m^3 benchmark. $PM_{2.5}$ levels were below the annual benchmark of 8 µg/m^3 at two of the three sites (exceeding at Muswellbrook).
- The Upper Hunter had average rainfall in 2016, similar to the previous three years. Conditions were dry to very dry from the end of summer and autumn, while particularly wet in January, June and September. Temperatures were above to very much above average.

Further detail on the region's air quality during 2016 can be found in the Upper Hunter seasonal newsletters. This includes information on pollution events, such as bushfires and dust storms.

Air Quality Index

Air quality in the Upper Hunter was generally good in 2016. The Air Quality Index categories of very good to fair show that air quality was within national benchmarks on at least 97% of days (Figure 1).

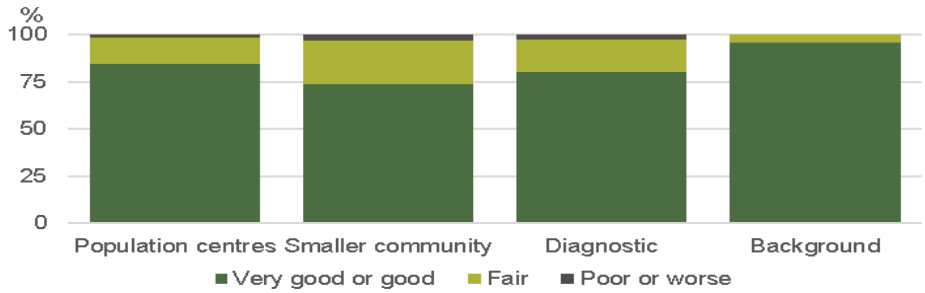

Figure 1 2016 Air Quality Index categories as a percentage of time for each Upper Hunter station type

Note: See Figure 17 for more information about Upper Hunter station types and locations.

Annual particle air quality and trends 2011 to 2016

In 2016, PM_{10} levels at all 14 sites were below the annual benchmark. $PM_{2.5}$ levels were below the annual benchmark at two of the three sites (Figure 2).

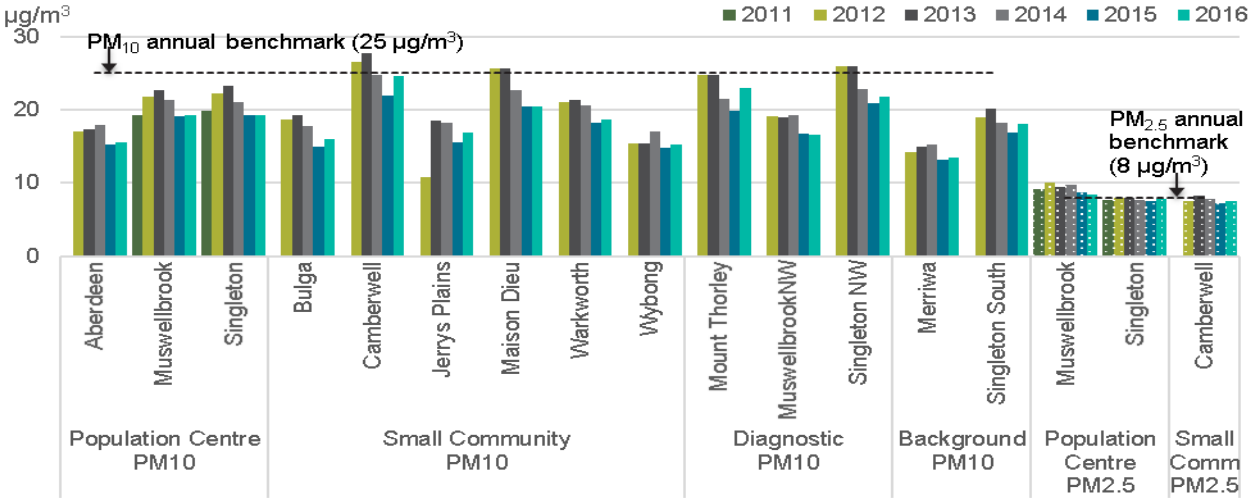

Figure 2 PM_{10} and $PM_{2.5}$ annual averages: 2011 to 2016

In larger population centres, PM_{10} annual average levels in 2016 were similar compared to 2015 and lower than in 2012 to 2014. In smaller communities and diagnostic sites closer to the mines (in particular at Camberwell and Mt Thorley), the PM_{10} annual averages increased in 2016 compared to 2015. However, PM_{10} levels at these sites generally remained lower than in the earlier years 2012 to 2014. Since the establishment of the network, annual PM_{10} concentrations were over the benchmark in 2012 and 2013 at two smaller community sites (Camberwell and Maison Dieu) and one diagnostic site (Singleton NW).

Annual average $PM_{2.5}$ levels remained below the benchmark at Singleton and Camberwell in 2016 but were above the benchmark at Muswellbrook. Smoke from domestic wood heaters contributes significantly to particle levels at larger population centres[1]. Since the establishment of the network, the $PM_{2.5}$ annual benchmark has been exceeded each year at Muswellbrook and in 2013 at Camberwell.

Larger population centres and national air quality goals in 2016

Singleton achieved the National Environment Protection (Ambient Air Quality) Measure (Air NEPM) goals[2] for NO_2, SO_2 and PM_{10} and $PM_{2.5}$:

- The Air NEPM daily goals for PM_{10} and $PM_{2.5}$ allowed for the exceptional events that occurred on three days at Singleton in autumn 2016. Particle levels exceeded the daily PM_{10} benchmark on 6 April and the daily $PM_{2.5}$ benchmark on 7–8 May, all due to hazard reduction burns.

Muswellbrook achieved the Air NEPM goals for NO_2, SO_2 and PM_{10} but not for $PM_{2.5}$:

- The Air NEPM hourly goal for SO_2 allowed for the one exceedance that occurred in summer 2016. At Muswellbrook, at 8:00 am on 23 December 2016, the hourly average SO_2 concentration peaked at 21 pphm, exceeding the benchmark of 20 pphm. This was the first time since 1994 that an SO_2 level above the hourly benchmark was recorded in the NSW air quality monitoring network. The event is described in the Upper Hunter Summer 2016-17 seasonal newsletter.
- Muswellbrook exceeded Air NEPM goals for the daily and annual $PM_{2.5}$ benchmarks. On 4 July, the daily $PM_{2.5}$ concentration peaked at 29.4 µg/m^3, exceeding the daily benchmark of 25 µg/m^3, due to a local factory fire. Muswellbrook recorded an annual average $PM_{2.5}$ concentration of 8.4 µg/m^3, exceeding the annual benchmark of 8 µg/m^3.

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[1] Upper Hunter Fine Particle Characterisation Study

[2] The Air NEPM was updated in 2016. PM_{10} and $PM_{2.5}$ goals are for no exceedances of the standards in a calendar year, other than during exceptional events. The exceptional event rule was introduced to allow for exceedances of daily average standards due to bushfires, hazard reduction burns or continental dust. The SO_2 goals allow one day with an exceedance of the standards per year.

Days above benchmark concentrations

There were 14 days over the PM_{10} benchmark and three days over the $PM_{2.5}$ benchmark during 2016 (Table 1). The particle events during 2016 were not widespread events, with the majority of events occurring at only one site (Table 2 and Table 3) and no more than three sites on any one day.

There was one day over the SO_2 hourly benchmark at Muswellbrook (Table 4).

Table 1 Number of days above the relevant benchmarks – 2016

Station type*	Station	PM_{10} daily [50 µg/m³ benchmark]	$PM_{2.5}$ daily [25 µg/m³ benchmark]	SO_2 hourly [20 pphm benchmark]	SO_2 daily [8 pphm benchmark]	NO_2 hourly [12 pphm benchmark]
Population centre	Aberdeen	0	-	-	-	-
Population centre	Muswellbrook	0	1	1	0	0
Population centre	Singleton	1	2	0	0	0
Smaller community	Bulga	0	-	-	-	-
Smaller community	Camberwell	11	0	-	-	-
Smaller community	Jerrys Plains	0	-	-	-	-
Smaller community	Maison Dieu	0	-	-	-	-
Smaller community	Warkworth	0	-	-	-	-
Smaller community	Wybong	1	-	-	-	-
Diagnostic	Mount Thorley	5	-	-	-	-
Diagnostic	Muswellbrook NW	0	-	-	-	-
Diagnostic	Singleton NW	4	-	-	-	-
Background	Merriwa	0	-	-	-	-
Background	Singleton South	0	-	-	-	-

µg/m³ = microgram 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

Table 2 Days above the PM_{10} daily benchmark – 2016

Date	Maximum daily PM_{10} (µg/m³)	Number of sites above benchmark	Station and daily PM_{10} (µg/m³)
12/01/2016	51.2	1	Camberwell (51.2)[β]
26/02/2016	52.1	2	Singleton NW (51.1)[π], Wybong (52.1)[β]
02/04/2016	51.2	1	Camberwell (51.2)[β]
06/04/2016	60.8	2	Camberwell (58.6)[β], Singleton (60.8)[α]
23/05/2016	65.7	2	Camberwell (65.7)[β], Mount Thorley (51.9)[π]
10/10/2016	60.0	1	Camberwell (60.0)[β]
16/10/2016	53.1	1	Camberwell (53.1)[β]
05/11/2016	56.1	1	Camberwell (56.1)[β]
07/11/2016	60.5	2	Camberwell (54.4)[β], Singleton NW (60.5)[π]
08/11/2016	84.1	3	Camberwell (64.3)[β], Mount Thorley (84.1)[π], Singleton NW (51.2)[π]
19/11/2016	66.5	1	Mount Thorley (66.5)[π]
14/12/2016	54.9	3	Camberwell (52.6)[β], Mount Thorley (54.6)[π], Singleton NW (54.9)[π]
30/12/2016	55.8	1	Mount Thorley (55.8)[π]
31/12/2016	52.1	1	Camberwell (52.1)[β]

[α] larger population centre, [β] smaller community site, [π] diagnostic site

Table 3 Days above the $PM_{2.5}$ daily benchmark – 2016

Date	Maximum daily $PM_{2.5}$ (µg/m³)	Number of sites above benchmark	Station
07/05/2016	25.5	1	Singleton
08/05/2016	27.7	1	Singleton
04/07/2016	29.4	1	Muswellbrook

Table 4 Days above the SO_2 hourly benchmark - 2016

Date	Maximum hourly SO_2 (pphm)	Number of sites above benchmark	Station (and number of hours exceeded)
23/12/2016	21.0	1	Muswellbrook (1)

Pollution rose

The PM_{10} pollution rose map[3] shows hourly PM_{10} concentrations, under dominant northwest and southeast prevailing winds in the Upper Hunter Valley (Figure 3).

For example, Figure 3 shows that in 2016, Muswellbrook received its highest hourly PM_{10} concentrations, mostly during south-easterly winds and secondly during north-westerly winds.

The pollution roses show that hourly PM_{10} levels generally remained low across the region during 2016. A small percentage of elevated hourly levels (above 75 µg/m³)[4] were recorded at sites closer to mines, such as Camberwell and Mount Thorley.

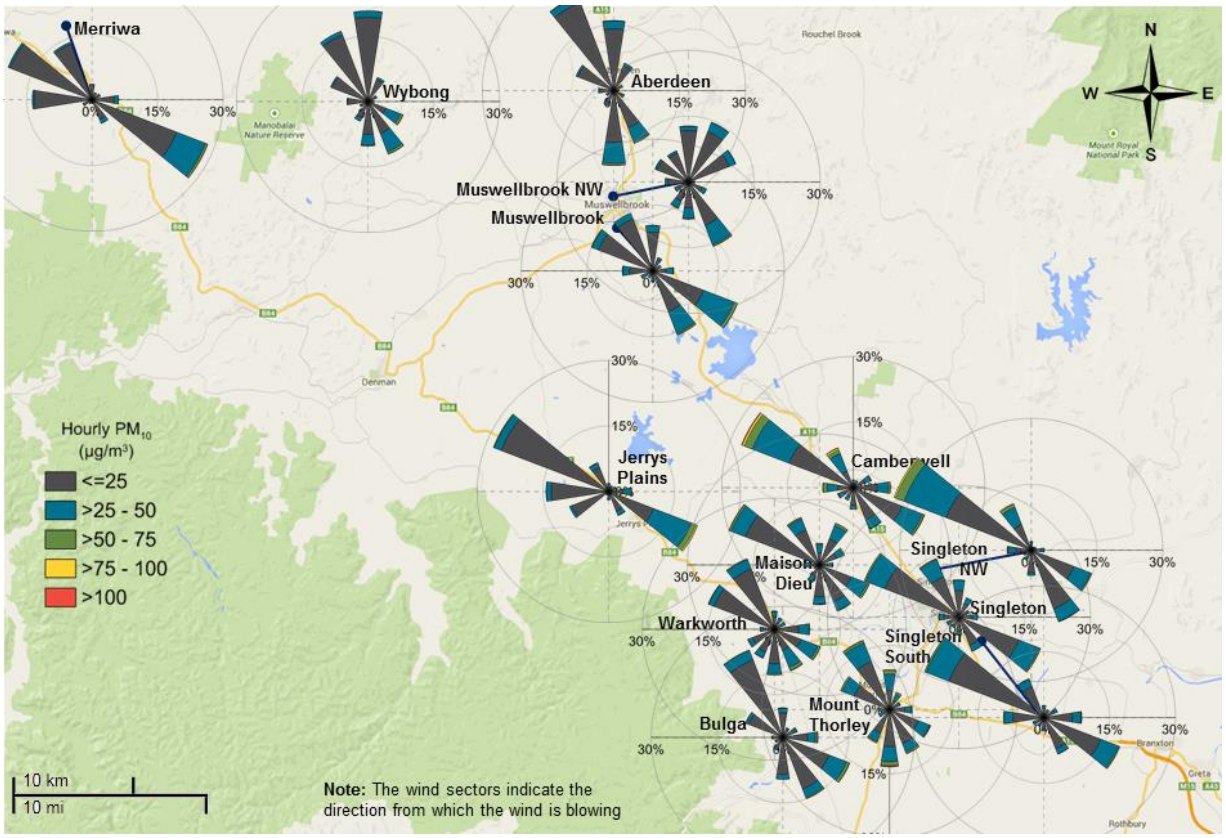

Figure 3 Hourly PM_{10} pollution rose map for the Upper Hunter region – 2016

[3] 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 that the wind blows from a particular compass direction. The colours along the bars indicate the levels of particle concentrations, as presented in the key.

[4] The Air NEPM sets no standard for the hourly PM_{10} concentrations. An hourly PM_{10} concentration of 75 µg/m³ generally indicates relatively elevated PM_{10} levels and a higher likelihood that the daily PM_{10} benchmark of 50 µg/m³ may be exceeded.

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 levels generally below benchmarks in 2016 (Figure 4 to Figure 10). Shaded areas show seasons.

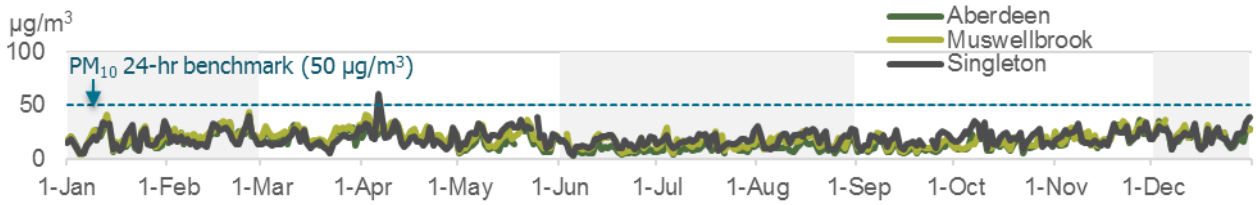

Figure 4 Population centre sites: daily average PM_{10} – 2016

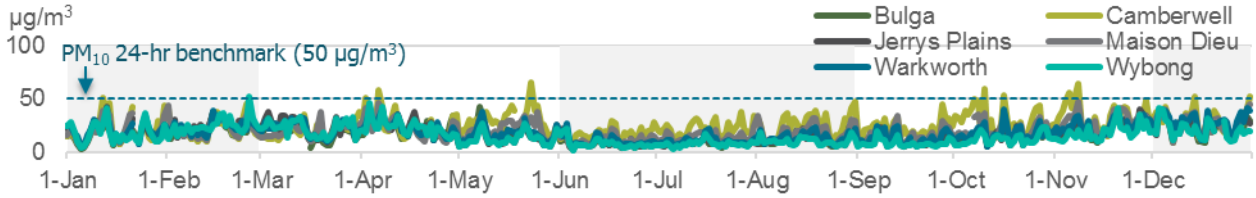

Figure 5 Smaller community sites: daily average PM_{10} – 2016

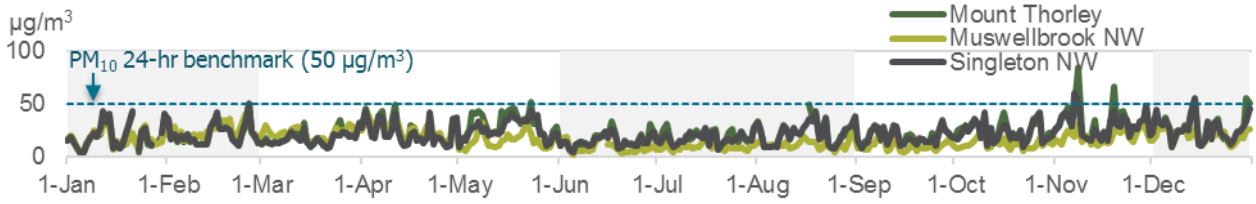

Figure 6 Diagnostic sites: daily average PM_{10} – 2016

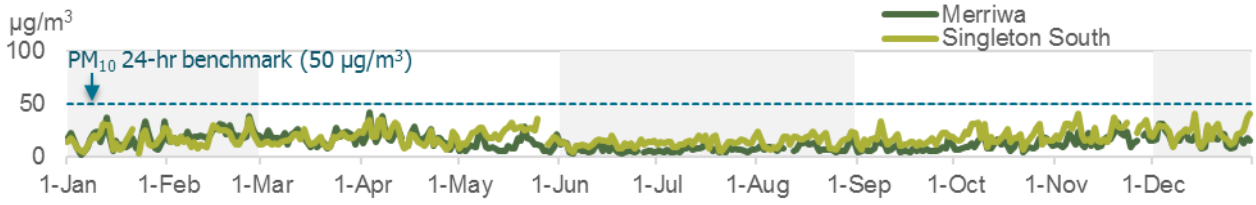

Figure 7 Background sites: daily average PM_{10} – 2016

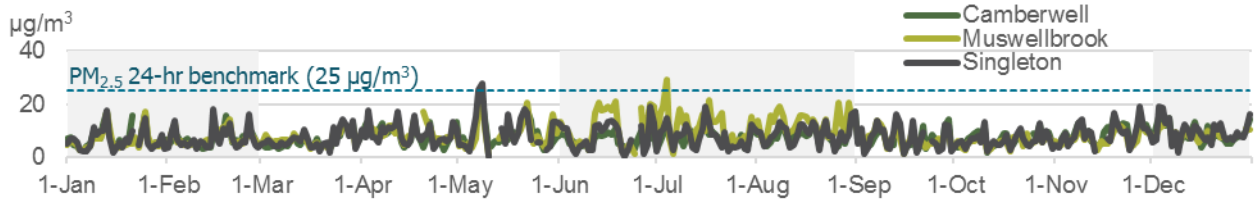

Figure 8 Daily average $PM_{2.5}$ – 2016

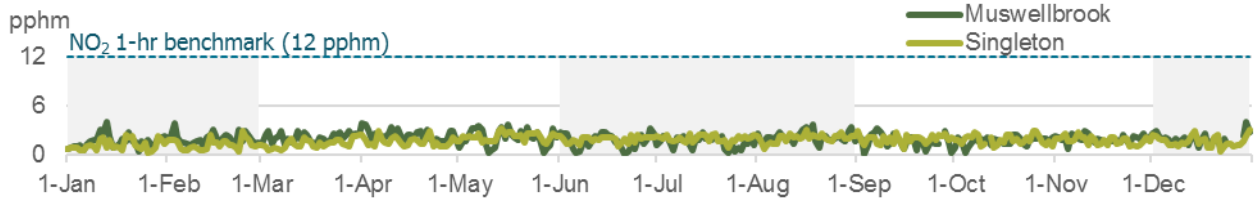

Figure 9 Daily 1-hr maximum NO_2 – 2016

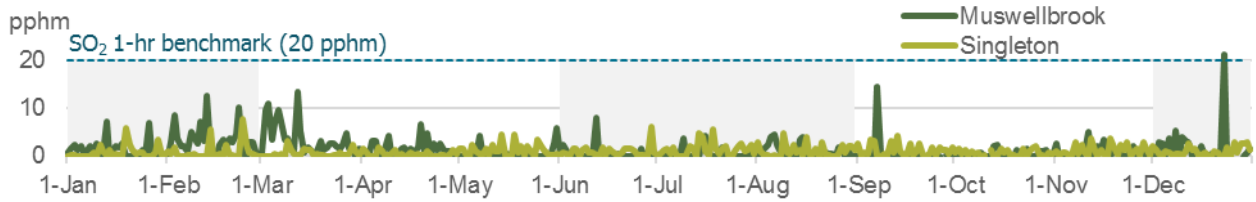

Figure 10 Daily 1-hr maximum SO_2 – 2016

Annual comparisons 2012 to 2016

Concentrations of NO_2 and SO_2 measured at Muswellbrook and Singleton remained below the relevant national benchmarks in 2016, except for one hour. As noted above, SO_2 briefly exceeded the hourly benchmark at Muswellbrook on 23 December. This is the first exceedance of an SO_2 benchmark by the NSW air quality monitoring network since 1994.

The number of days over the daily PM_{10} benchmark varies between sites and over time (Figure 11). The total number of days over the daily PM_{10} benchmark has decreased over time, with fewest days recorded in 2016 (Figure 11). There were 14 distinct days over the PM_{10} benchmark in 2016, compared with 45 and 46 days in 2012 and 2013, respectively.

At the larger population centres, the highest number of days over the PM_{10} benchmark occurred in 2013, with 12 days at Singleton and three days at Muswellbrook. During 2013, there was an increase in bushfires in the region, including the NSW bushfire emergency in spring 2013. In contrast, 2016 recorded one exceedance day during an exceptional event at Singleton and no days at Muswellbrook.

Overall, the larger population centres recorded fewer days over the PM_{10} daily benchmark than monitoring sites closer to mining operations. At these smaller communities and diagnostic sites, the highest annual number of days over the PM_{10} benchmark was 36 days at Camberwell in 2013.

For $PM_{2.5}$, the larger population sites recorded up to three days a year over the benchmark (Figure 11). More $PM_{2.5}$ exceedances generally occurred at Muswellbrook, most likely due to domestic wood smoke[5].

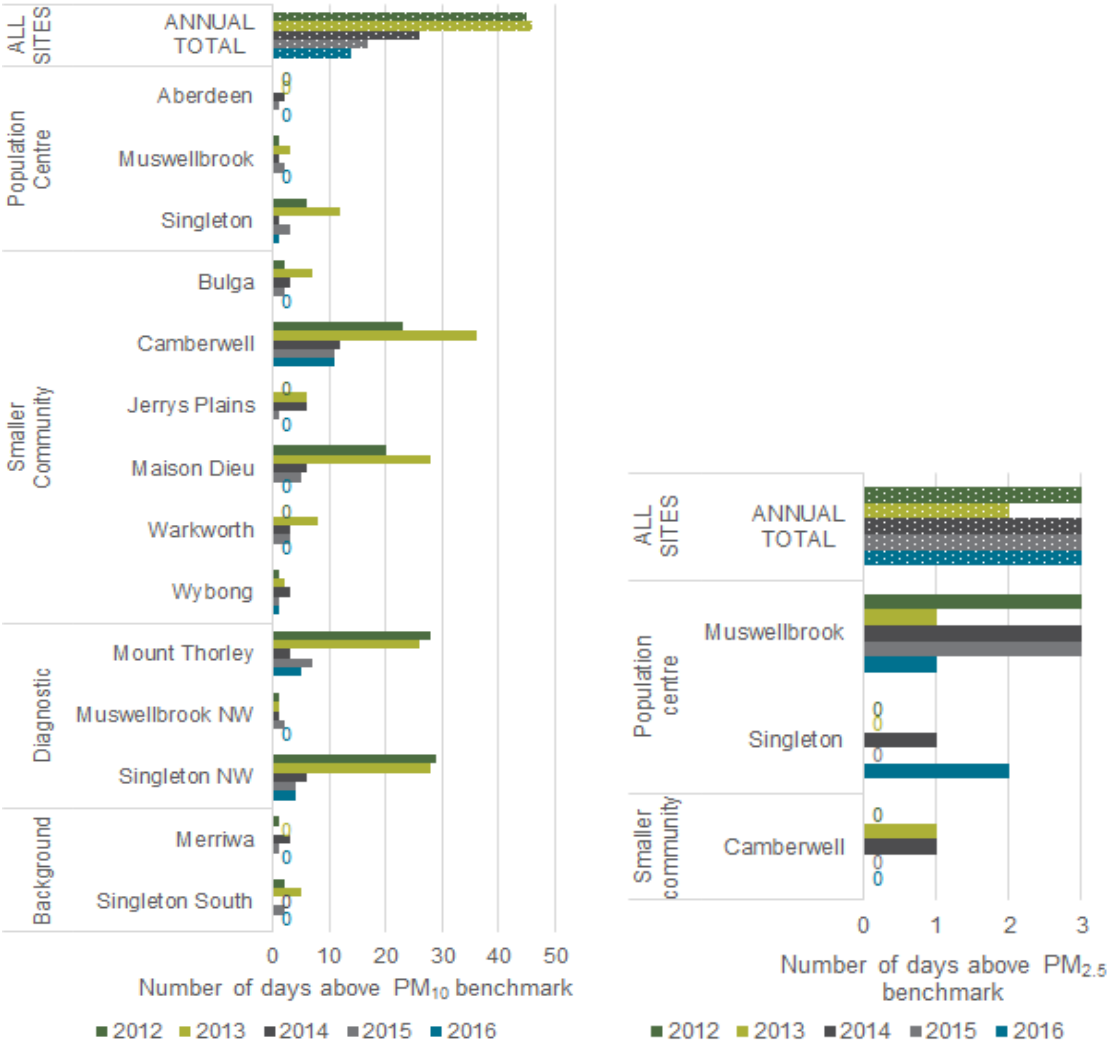

Figure 11 Number of days (including exceptional events) above the daily PM_{10} and $PM_{2.5}$ benchmarks from 2012 to 2016

[5] The Upper Hunter Fine Particle Characterisation Study found smoke from domestic wood heaters contributed significantly to $PM_{2.5}$ levels in Muswellbrook and Singleton.

Meteorological summary

Rainfall and temperature[6]

The Upper Hunter experienced average rainfall in 2016 (Figure 12), similar compared to the three previous years. January 2016 experienced wet conditions followed by dry to very dry conditions for the remainder of summer and autumn. Average to above average rainfall was recorded from winter to the end of 2016, with particularly wet conditions in June and September (Figure 13).

Maximum temperatures were above to very much above average and minimum temperatures were very much above average in 2016 (Figure 12).

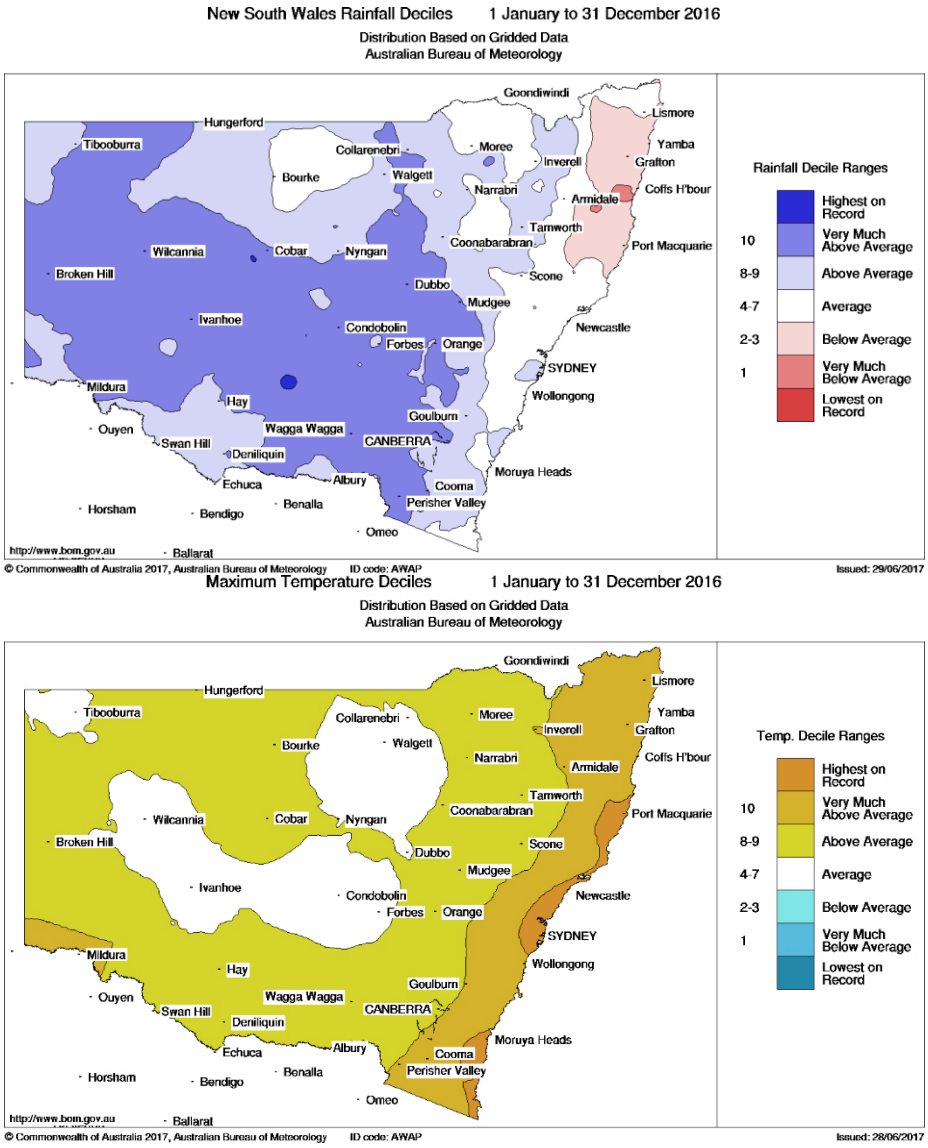

Figure 12 NSW rainfall and maximum temperature deciles – 2016

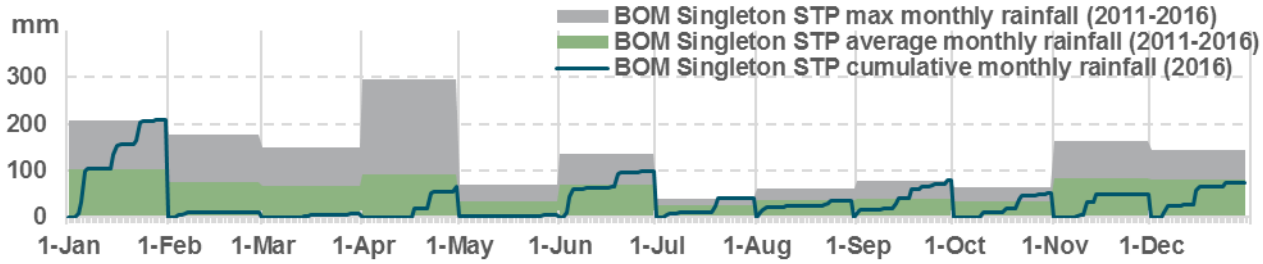

Figure 13 Bureau of Meteorology Singleton STP[7] monthly rainfall – 2016

[6] Rainfall and temperature information are from the Bureau of Meteorology New South Wales 2016 annual climate statement and climate maps (accessed February 2018)

[7] Sourced from the Bureau of Meteorology Climate Data Online website (accessed February 2018)

Wind

Upper Hunter winds were predominantly from the southeast in summer and northwest in winter in 2016 (Figure 14). During autumn, winds were variable as they turned from south-easterly to north-westerly. The overall wind patterns observed in the Upper Hunter during the summer, autumn and winter seasons in 2016 are typical for the region. However, during spring winds were predominantly from the northwest in 2016, with less variability than is typical for this transitional season. The strongest winds were generally from the northwest in winter and spring.

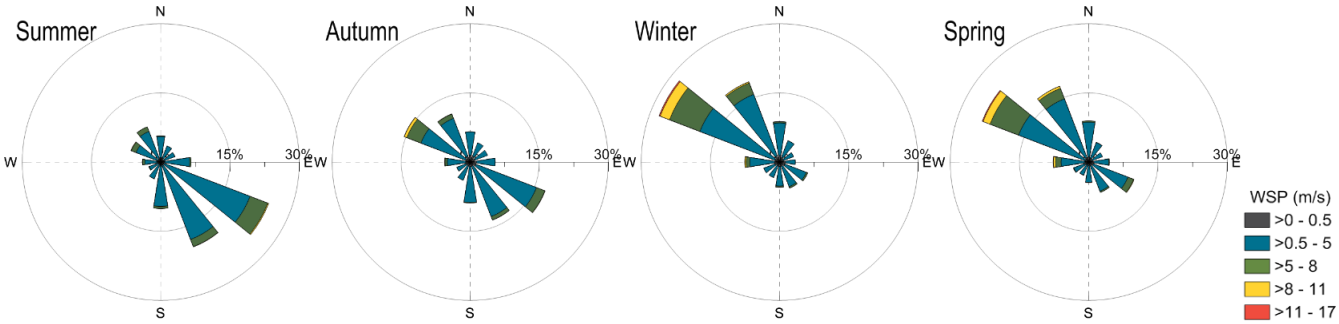

Figure 14 Seasonal wind roses using pooled wind data from all the Upper Hunter sites – 2016

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.

In 2016, particle and meteorological parameters met this target, with the exception of PM_{10} at Mount Thorley (94%) due to power failure and instrument problems (Table 5).

Table 5 Online performance (%) during 2016

Station	Particles PM_{10} daily	Particles $PM_{2.5}$ daily	Gases SO_2 hourly	Gases NO_2 daily	Meteorology Wind hourly
Aberdeen	98	-	-	-	97
Bulga	99	-	-	-	99
Camberwell	99	98	-	-	99
Jerrys Plains	98	-	-	-	99
Maison Dieu	97	-	-	-	99
Merriwa	99	-	-	-	98
Mount Thorley	94	-	-	-	97
Muswellbrook	97	96	93	93	97
Muswellbrook NW	99	-	-	-	98
Singleton	99	96	94	95	99
Singleton NW	99	-	-	-	100
Singleton South	99	-	-	-	99
Warkworth	98	-	-	-	96
Wybong	99	-	-	-	100

- = not monitored

Online statistics

The OEH Upper Hunter Air Quality Monitoring Network (UHAQMN) map website is updated hourly and provides facilities for viewing near real-time Upper Hunter air quality data. Anyone visiting the website can view the hourly PM_{10}, $PM_{2.5}$, NO_2, SO_2, wind direction and wind speed data; create their own graphs of the hourly data; download historical data; and compare Upper Hunter values with other NSW sites.

During 2016, the number of unique page views[8] each day cycled between 1 and 111 (Figure 15), with a total of 5225 in the year. On 8 November, page views peaked at 111 during large bushfires.

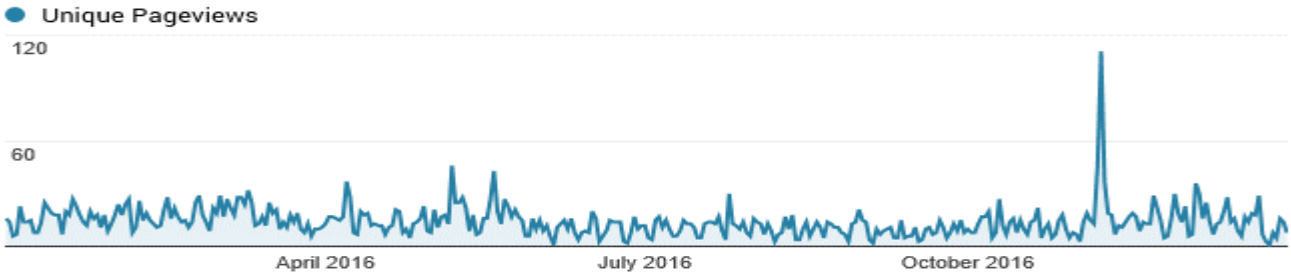

Figure 15 Unique page views for the UHAQMN map webpage – 2016

Air quality alerts

The UHAQMN triggers automatic alerts as Short Message Service (SMS) text messages and emails, to inform subscribers in the community when air quality is 'poor'[9]. Alerts allow community members, whose health may be affected by air pollution (e.g. people with asthma, other respiratory diseases and heart disease) to be aware of local air quality and manage their exposure when pollution levels are high.

The number of subscribers to the UHAQMN alerts has varied over the years and between sites (Figure 16). Most subscribers joined in 2012 and 2013, the first years of operations. Annual subscriptions have increased each year, with some sites receiving more new subscriptions in 2016 compared to 2014 and 2015.

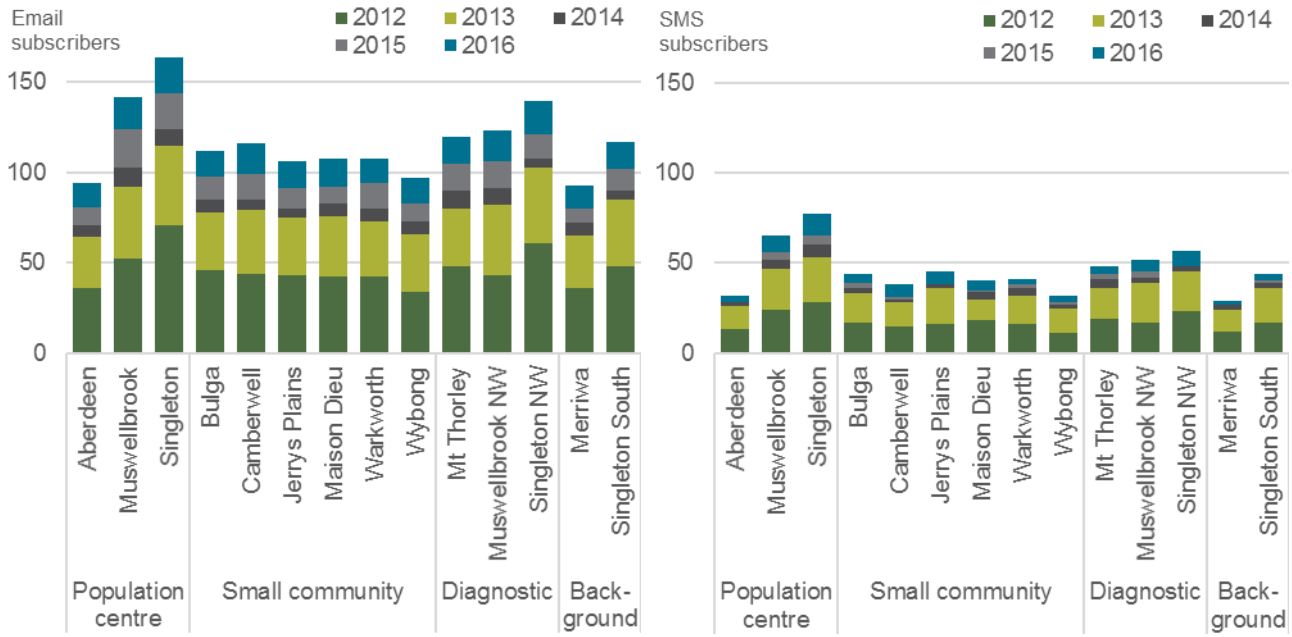

Figure 16 Number of public subscribers to email (left) and SMS (right) alerts for each air quality monitoring station (as of 31 December 2016)

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[8] Unique page views are based on the number of unique visits in each 30-minute session

[9] For particles, an alert is triggered when the *rolling* 24-hour average exceeds the daily benchmark. Since the national daily benchmark is based on the 24-hour average from midnight to midnight, an alert may not result in an exceedance of the national benchmark. One event-day may trigger multiple alerts over more than one day and at more than one site.

Definitions: Upper Hunter monitoring station types

The 14 monitoring stations in the Upper Hunter (Figure 17) 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 sites do not provide information about air quality in population centres.

Background: the stations at Merriwa and Singleton South measure air quality at the northwest and southeast 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 UHAQMN 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 2009.

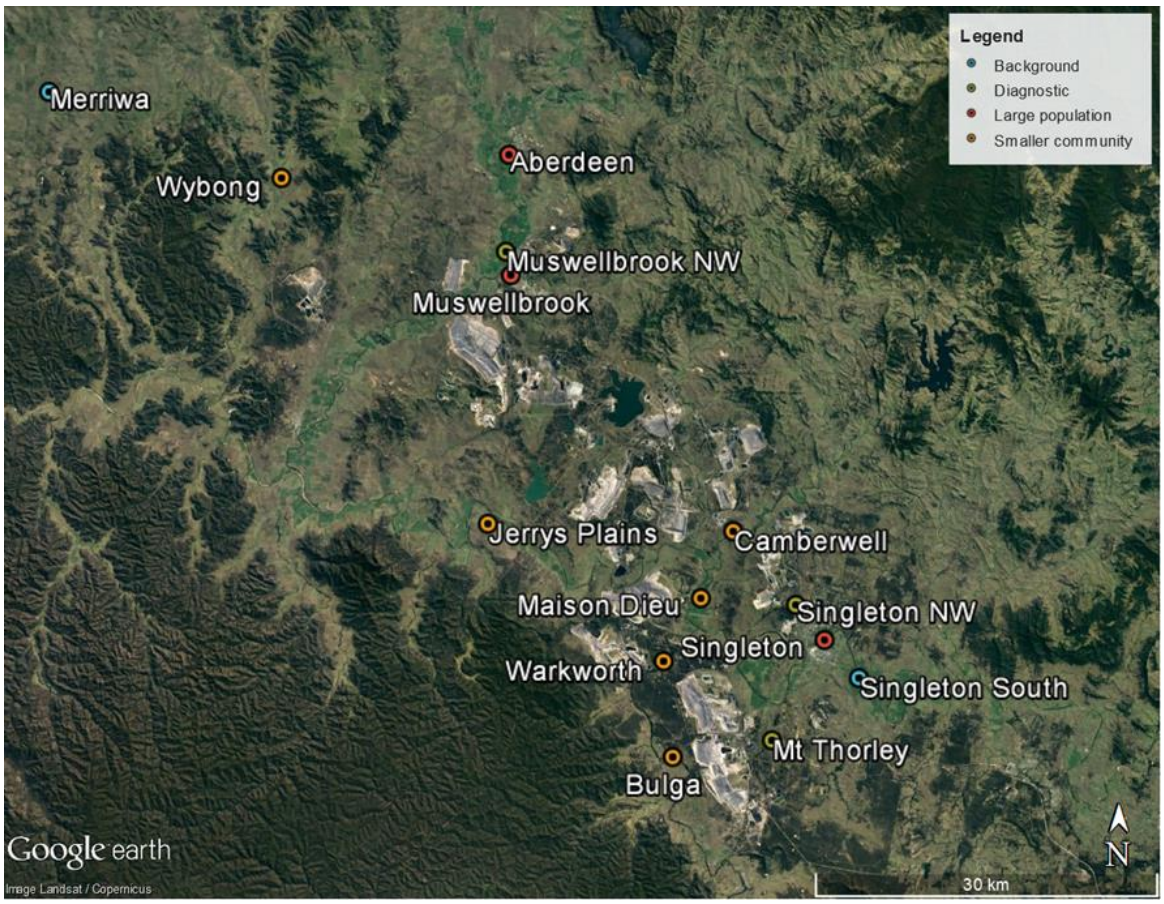

Figure 17 Upper Hunter air quality monitoring stations

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