



Better evidence, stronger networks, healthy communities

Five-year review of the Upper Hunter Air Quality Monitoring Network



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Published by:

Office of Environment and Heritage
59 Goulburn Street, Sydney NSW 2000
PO Box A290, Sydney South NSW 1232
Phone: +61 2 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
Phone: 1300 361 967 (national parks, general environmental enquiries, and publications requests)
Fax: +61 2 9995 5999
TTY users: phone 133 677, then ask for 131 555
Speak and listen users: phone 1300 555 727, then ask for 131 555
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
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Executive summary

The Upper Hunter Air Quality Monitoring Network (UHAQMN; 'the Network') is a high-quality, regional air quality monitoring network that continuously measures airborne particles, gaseous pollutants and meteorological parameters.

The Network provides the evidence base for the NSW Government to lead the assessment and management of air quality impacts from coal mining and power stations, for the protection of communities in the Upper Hunter.

The Network consists of 14 monitoring stations located from Merriwa in the north west (NW) to Singleton South in the south east (SE) (Figure 1):

- Three sites monitor air quality in the larger population centres of Singleton, Muswellbrook and Aberdeen.
- Six sites monitor air quality near smaller communities of Bulga, Camberwell, Warkworth, Maison Dieu, Jerrys Plains and Wybong.
- Three sites monitor air quality close to mining operations at Mount Thorley, Singleton NW and Muswellbrook NW.
- Two sites gather information at Singleton South and Merriwa, to represent air quality entering and leaving the SE and NW extents of the region.

The NSW Office of Environment and Heritage (OEH) established the UHAQMN during 2010 to 2012. The Network is a partnership between the NSW Government and the Upper Hunter coal mining and power generation industries. It is maintained by OEH, administered by the NSW Environment Protection Authority (EPA) and funded by Upper Hunter coal and power industries, in accordance with the Protection of the Environment Operations (General) Regulation 2009 ('the Regulation').

The Regulation defines the Upper Hunter monitoring program as follows:

'Upper Hunter monitoring program' means the environmental monitoring program operated by or on behalf of the EPA in the Muswellbrook, Singleton and Upper Hunter Shire local government areas that monitors air quality in those areas and known as the Upper Hunter Air Quality Monitoring Network, and includes any changes made by the EPA to that program from time to time.

The Regulation specifies the objectives of the Upper Hunter monitoring program as follows:

- (a) to provide government, industry and the community with reliable and up-to-date information on air quality in the Muswellbrook, Singleton and Upper Hunter Shire local government areas
- (b) to enable the air quality in those areas to be assessed against relevant air pollution standards
- (c) to facilitate the identification of sources of air pollution in those areas
- (d) to facilitate the development and implementation of strategies to improve air quality in those areas.

The Regulation requires the EPA to review the Network every five years. This report is the first review, following the initial five years of operation, from 2012 to 2016.

This comprehensive review, undertaken by OEH, set out to answer the following questions:

- Have the objectives of the monitoring program been met?
- Is the program being run efficiently and cost-effectively?
- Can the monitoring program be improved?
- Are there any additional matters in relation to the program to consider?

The review considered:

- five years' air quality and meteorology data collected by the Network and how the data have been used (Sections 2 and 3)
- change in the drivers of the original UHAQMN design, namely, population distribution, emission sources, topography and meteorology, since monitoring commenced (Section 4)
- the findings from an independent audit of the efficiency and cost-effectiveness of the Network (Section 4)
- feedback from stakeholders in the community, industry and government agencies (Section 4).

The review concluded that:

- During the first five years of operation, the extensive data collected by the UHAQMN provides a better understanding of the air quality and meteorology within the Upper Hunter region.
- The objectives of the monitoring program are being met with stakeholders being provided with reliable and up-to-date Network data which are regularly assessed against air quality standards, sources of pollution continue to be identified and EPA strategies continue to be developed and implemented to improve air quality in the region.
- The Network runs efficiently and cost-effectively.
- The minimal change in population distribution, emission sources, topography and meteorology since monitoring commenced, validates maintaining the original network design.

Other recommendations for Network improvement include:

- installation of rain gauges at key monitoring sites to further build on the meteorological data and knowledge in the region
- investigation of the potential for an additional PM_{2.5} particle monitor at the Merriwa monitoring site to better monitor background PM_{2.5} levels.

Additional matters in relation to the air quality monitoring program, addressing stakeholder feedback, will see:

- the EPA continuing to work with the Upper Hunter Air Quality Advisory Committee to develop better ways of communicating information on air quality with all relevant stakeholders
- each five-yearly review of the Network continuing to:
 - consider changes in the mining footprint as an integral component
 - review the cost-effectiveness of the Network independently
 - consider whether any monitors have become redundant
- the OEH continuing to provide access to real-time data to industry when requested, at a cost (required for set-up and telemetry).

The findings of the review are discussed in detail in the report.

1. The Upper Hunter Air Quality Monitoring Network

This section introduces the Upper Hunter Air Quality Monitoring Network (UHAQMN), also referred to as 'the Network' or as an air quality monitoring program, as defined in the Protection of the Environment Operations (General) Regulation 2009 ('the Regulation').

1.1 Why was the Network established?

The UHAQMN was established to provide government, industry and the community with credible, reliable and up-to-date information about air quality and trends in air quality within the Upper Hunter Valley.

This information can be used to:

- assess changes in air quality
- help identify the major sources of the monitored pollutants
- inform regulatory programs in response to long-term trends.

Information from the Network helps to guide specific investigations into the questions raised by the data, such as those about the distribution of particles and the components making up the fine particle fraction of the particle mix. This information helps NSW Government agencies to develop further monitoring and compliance programs to improve Upper Hunter air quality.

1.2 What are the objectives of the Network?

The UHAQMN is operated in accordance with Chapter 5A of the Protection of the Environment Operations (General) Regulation 2009.

The objectives of the Upper Hunter monitoring program are specified under the Regulation, as follows:

79B Objectives of Upper Hunter monitoring program

The objectives of the Upper Hunter monitoring program are as follows:

- (a) to provide government, industry and the community with reliable and up-to-date information on air quality in the Muswellbrook, Singleton and Upper Hunter Shire local government areas,
- (b) to enable the air quality in those areas to be assessed against relevant air pollution standards,
- (c) to facilitate the identification of sources of air pollution in those areas,
- (d) to facilitate the development and implementation of strategies to improve air quality in those areas.

1.3 What is the Network?

The UHAQMN is a high-quality, regional air quality monitoring network that continuously measures particles, meteorology and gases in ambient air. The Network provides the community with hourly updates on current air quality in near real-time via the Office of Environment and Heritage (OEH) Upper Hunter live air quality data webpage.

The Network consists of 14 monitoring stations linked to a central database. From here the data are uploaded hourly to the OEH website.

The Network continuously measures:

- particulate matter PM₁₀ (particles less than or equal to 10 micrometres in diameter), wind speed, wind direction, temperature and humidity at all 14 monitoring sites
- fine particulate matter PM_{2.5} (particles less than or equal to 2.5 micrometres in diameter) at Singleton, Muswellbrook and Camberwell
- the gases sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) at Singleton and Muswellbrook.

The number and location of sites in the Network and the parameters measured were based on independent recommendations made by Holmes Air Sciences (2008) to the then Department of Environment and Climate Change.

Holmes Air Sciences' (2008) recommendations were based on population distribution, location of major emission sources, topography and predominant meteorological conditions. They were used to propose three types of sites in the region:

1. sites in and around population centres
2. background sites located to help determine external particle sources entering the Upper Hunter Valley and particles that leave the valley
3. diagnostic sites located closer to coal mines.

The focus of the Network is on PM₁₀ particles with PM_{2.5} particles, SO₂ and NO₂ monitors at key sites.

The final 14 monitoring sites were determined in consultation with the former Upper Hunter Air Quality Monitoring Network Advisory Committee following further advice from Holmes Air Sciences (2008).

1.4 When was the Network established?

The establishment of the Network commenced in late 2010, with the stations in the large population centres, Muswellbrook and Singleton, first to come online. The Network was fully operational by February 2012.

The daily particle data (as PM₁₀ and PM_{2.5}) are first available from Muswellbrook and Singleton on 8 and 10 December 2010, respectively. This provides six complete years of particle data from these population centres.

Table 1 and Table 2 (in Section 2.1) provide the start dates for the particle and gaseous data respectively, at each site in the Network.

1.5 Who is responsible for the Network?

The UHAQMN is a partnership between the NSW Government and the Upper Hunter coal and power industries. The sites are operated and maintained by OEH using industry contributed funds under Chapter 5A of the Protection of the Environment Operations (General) Regulation 2009.

The Upper Hunter Air Quality Advisory Committee (UHAQAC) advises the NSW Environment Protection Authority (EPA) and OEH on matters specifically related to the design and operation of the Network. The UHAQAC currently has 14 members representing the community, the coal and power generation industries, non-coal industries, local government and NSW Government agencies. More information about the committee is available on the EPA Upper Hunter Air Quality Advisory Committee webpage.

To ensure that high quality data are available from the Network, specialist OEH staff undertake regular maintenance, auditing and quality assurance of the monitoring stations, measuring equipment and data collected.

1.6 Where are the monitoring stations located?

The locations of the UHAQMN sites are shown in Figure 1. Further site details are available on the OEH [Upper Hunter monitoring sites](#) webpage.

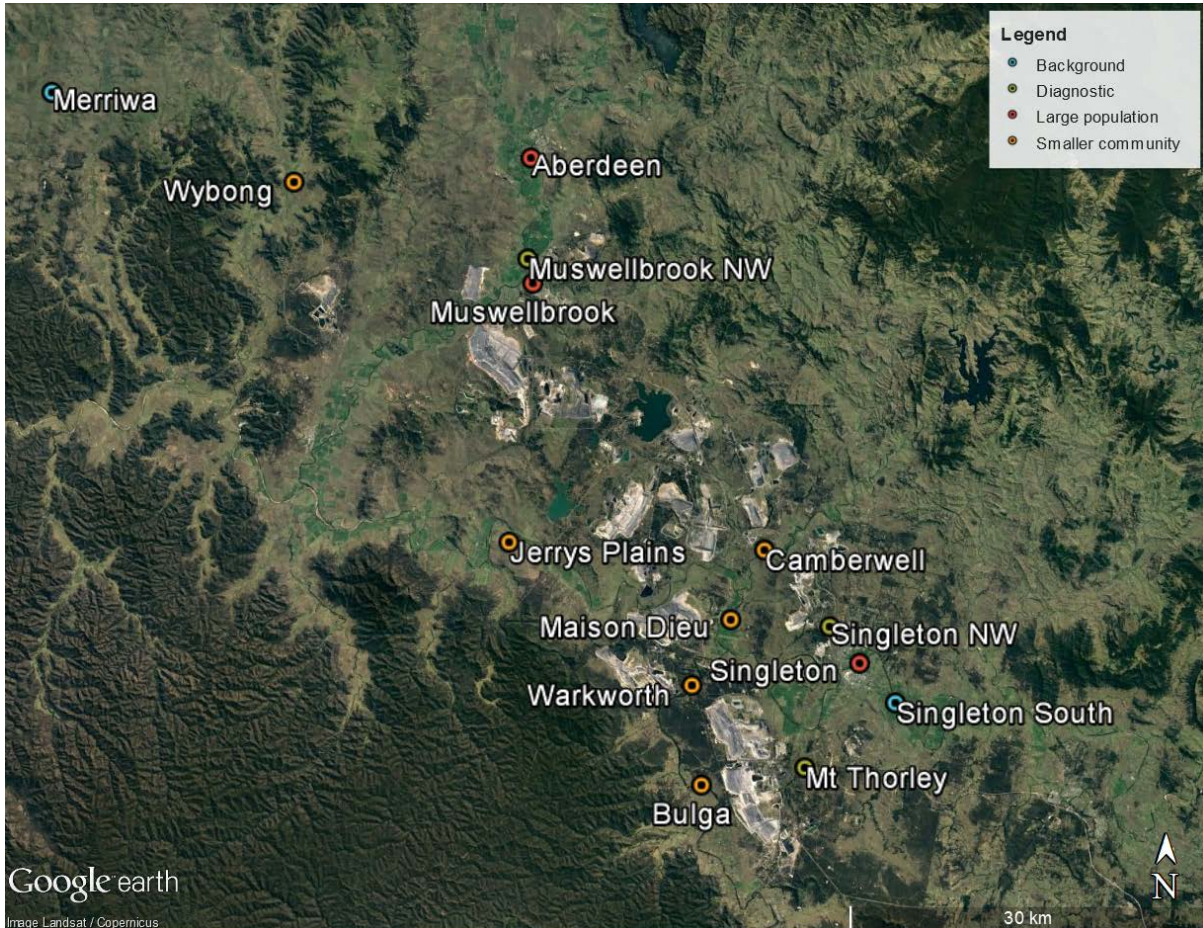


Figure 1 Upper Hunter monitoring station locations

The 14 monitoring stations in the UHAQMN serve different purposes:

- **Monitoring air quality near larger population centres:** Singleton, Muswellbrook and Aberdeen
- **Monitoring air quality near smaller communities:** Bulga, Camberwell, Warkworth, Maison Dieu, Jerrys Plains and Wybong
- **Gathering diagnostic information:** Mount Thorley, Singleton North West (NW) and Muswellbrook NW
- **Gathering background air quality information:** Merriwa and Singleton South.

1.7 Legislative reporting requirements

Under the Regulation, the EPA is required to report on the Upper Hunter monitoring program. Specifically, the Regulation states:

79K EPA to publish results of air quality monitoring in Upper Hunter

The EPA is to make the results of the air quality monitoring carried out under the Upper Hunter monitoring program available on its website.

79L EPA to report on Upper Hunter monitoring program

- (1) The EPA is to prepare a report each year that contains an analysis of the results of the air quality monitoring carried out under the Upper Hunter monitoring program for the year concerned.
- (2) The EPA is also to prepare a report by 1 February 2017, and by 1 February in every fifth year thereafter, that contains the following matters in relation to the Upper Hunter monitoring program:
 - (a) a review of the effectiveness of the Upper Hunter monitoring program in fulfilling its objectives,
 - (b) the results of an independent audit (to be arranged by the EPA) of the efficiency and cost effectiveness of the Upper Hunter monitoring program,
 - (c) any recommendations for improvements to the Upper Hunter monitoring program,
 - (d) any other matters that the EPA considers appropriate or that an advisory committee established to advise the EPA in relation to the program considers appropriate.
- (3) The reports prepared under this clause are to be made available on the EPA's website.

This review by the OEH was undertaken to fulfil the EPA's requirement to report on the Upper Hunter monitoring program following its first five years of operations (section 79L(2) of the Regulation).

2. Learnings since the establishment of the Upper Hunter Network

This section discusses the air quality and meteorology of the Upper Hunter. Since the establishment of the UHAQMN, an extensive and valuable set of air quality and meteorological data have been collected. These data have been used to assess air quality levels against national standards and other regions in New South Wales, determine air quality trends, evaluate meteorological conditions conducive to air pollution, and identify sources of air pollutants within the region.

2.1 Network performance

A network of complex scientific instruments requires regular maintenance and calibration. Maintenance and calibration schedules for the UHAQMN comply with the relevant Australian Standards for servicing the equipment and ensure that data provided to the community are accurate and timely. Maintenance and calibration tasks require about 5% of the Network's operating time. Therefore, an operational aim of the Network is to achieve at least 95% online time for all parameters measured.

The Network has provided an exceptional return of valid data since the commencement of the program. Valid and accurate particle and meteorological data are available for more than 95% of the total operational time at all monitoring sites, since their establishment (Table 1). For the gaseous parameters, the Network has achieved close to this threshold with at least 94% of valid data available at Singleton and Muswellbrook (Table 2). Due to scheduled daily calibrations, the maximum online time that can be attained for NO₂ and SO₂ data is 96%.

Table 1 Online time (%) of particle and wind data from the start date to the end of 2016

Station	Start date	Particles		Meteorology ^a	
		PM ₁₀ daily	PM _{2.5} daily	Wind hourly	Temperature / humidity hourly
Aberdeen	15/12/2011	99	–	99	100
Bulga	13/08/2011	99	–	99	100
Camberwell	26/07/2011	99	95	99	100
Jerrys Plains	16/12/2011	99	–	100	100
Maison Dieu	31/03/2011	98	–	98	99
Merriwa	21/02/2012	98	–	98	99
Mount Thorley	26/07/2011	98	–	98	99
Muswellbrook	08/12/2010	98	95	99	99
Muswellbrook NW	15/12/2011	99	–	99	100
Singleton	10/12/2010	99	97	99	100
Singleton NW	26/07/2011	99	–	100	100
Singleton South	15/12/2011	99	–	95	100
Warkworth	15/12/2011	99	–	98	100
Wybong	16/12/2011	99	–	100	100

– = not monitored.

^a The start dates for some meteorological parameters vary in comparison to the particle data.

Table 2 Online time (%) of NO₂ and SO₂ data from the start date to the end of 2016

Station	Start date	Gases NO ₂ hourly	Gases SO ₂ hourly
Muswellbrook	18/11/2011	94	94
Singleton	17/11/2011	94	95

The annual percentage online times from 2011 to 2015 are published in the [Upper Hunter air quality monitoring network annual reports](#) on the OEH website.

2.2 Assessment of regional air quality and meteorology

2.2.1 Air quality levels against standards

For sites near population centres, air quality data can be compared against relevant [National Environment Protection \(Ambient Air Quality\) Measure \(AAQ NEPM\)](#) standards for PM₁₀, PM_{2.5}, NO₂ and SO₂ (Table 3).

Table 3 AAQ NEPM standards and goals for particles (as PM₁₀ and PM_{2.5}), SO₂ and NO₂

Pollutant	Averaging period	Benchmark (concentration) ^{a b}	Goal: How often can the benchmark be exceeded?
Particles as PM ₁₀	Daily: 1 calendar day (24 hours)	50 µg/m ³	Never ^c
Particles as PM ₁₀	Annual: 1 calendar year (12 months)	25 µg/m ³	Never
Particles as PM _{2.5}	Daily: 1 calendar day (24 hours)	25 µg/m ³	Never ^c
Particles as PM _{2.5}	Annual: 1 calendar year (12 months)	8 µg/m ³	Never
Sulfur dioxide (SO ₂)	Hourly	20 pphm	Maximum one day per year
Sulfur dioxide (SO ₂)	Daily: 1 calendar day (24 hours)	8 pphm	Maximum one day per year
Sulfur dioxide (SO ₂)	Annual: 1 calendar year (12 months)	2 pphm	Never
Nitrogen dioxide (NO ₂)	Hourly	12 pphm	Maximum one day per year
Nitrogen dioxide (NO ₂)	Annual: 1 calendar year (12 months)	3 pphm	Never

^a The concentration of particles in the air is measured as the mass of the particle in micrograms (µg) per volume of air in cubic metres (m³)

^b SO₂ and NO₂ are measured in parts per hundred million (pphm) by volume, i.e. parts of pollutant per hundred million parts of air.

^c Not including exceptional events. An exceptional event is defined in the AAQ NEPM as a fire or dust occurrence that adversely affects air quality at a particular location, and causes an exceedance of 1 day average standards in excess of normal historical fluctuations and background levels, and is directly related to: bushfire; jurisdiction authorised hazard reduction burning; or continental scale windblown dust.

The particle air quality standards do not apply directly to the diagnostic sites (i.e. those monitoring stations that are located solely to enable diagnosis of dust sources). For example, Singleton NW monitoring station measures the quality of air moving towards Singleton from the mining areas to the north-west.

OEH understands the community need for assessing air quality levels against the standards at all sites in the Network, so even those sites away from population centres have been included in this review.

Particle data

There have been a number of days since the establishment of the Network where particle levels have exceeded the relevant standards. For the purpose of this review, exceptional events (that is, those that were a result of bushfires, hazard reduction burns or dust storm events) have been included in the analysis.

Figure 2 shows that all sites recorded elevated particle levels since 2012; however, there is variability between sites in the number of days with levels over the 24-hour (daily) particle benchmarks.

At the larger population centres, the highest number of days over the PM₁₀ daily benchmark occurred in 2013. During this year, Singleton recorded 12 days over the PM₁₀ benchmark, while Muswellbrook recorded three days. There was an increase in the occurrence of bushfires in the region during 2013.

Overall, the larger population centres had fewer days over the PM₁₀ daily benchmark than those stations closer to mining operations. At these other sites, the highest annual number of days over the PM₁₀ benchmark was 36 days (occurring at Camberwell in 2013).

The total number of days over the PM₁₀ daily benchmark has decreased over time. There were 14 distinct days over the PM₁₀ benchmark in 2016, compared with 45 and 46 days in 2012 and 2013, respectively.

For PM_{2.5}, there have been up to three days in a year recorded over the daily benchmark at a large population site, in general with higher numbers of days at Muswellbrook (Figure 2).

The PM₁₀ and PM_{2.5} annual average benchmarks have been exceeded at some sites since the establishment of the Network (Figure 3). The annual PM₁₀ concentrations were over the benchmark at two smaller community sites (Camberwell and Maison Dieu) and one diagnostic site (Singleton NW) in both 2012 and 2013. Annual average PM₁₀ concentrations generally have decreased since 2013 throughout the region.

For PM_{2.5}, the annual benchmark has been exceeded each year at Muswellbrook and in 2013 at Camberwell. Smoke from domestic wood heaters contributes significantly to particle levels at Muswellbrook (as found in the [Upper Hunter Fine Particle Characterisation Study](#)).

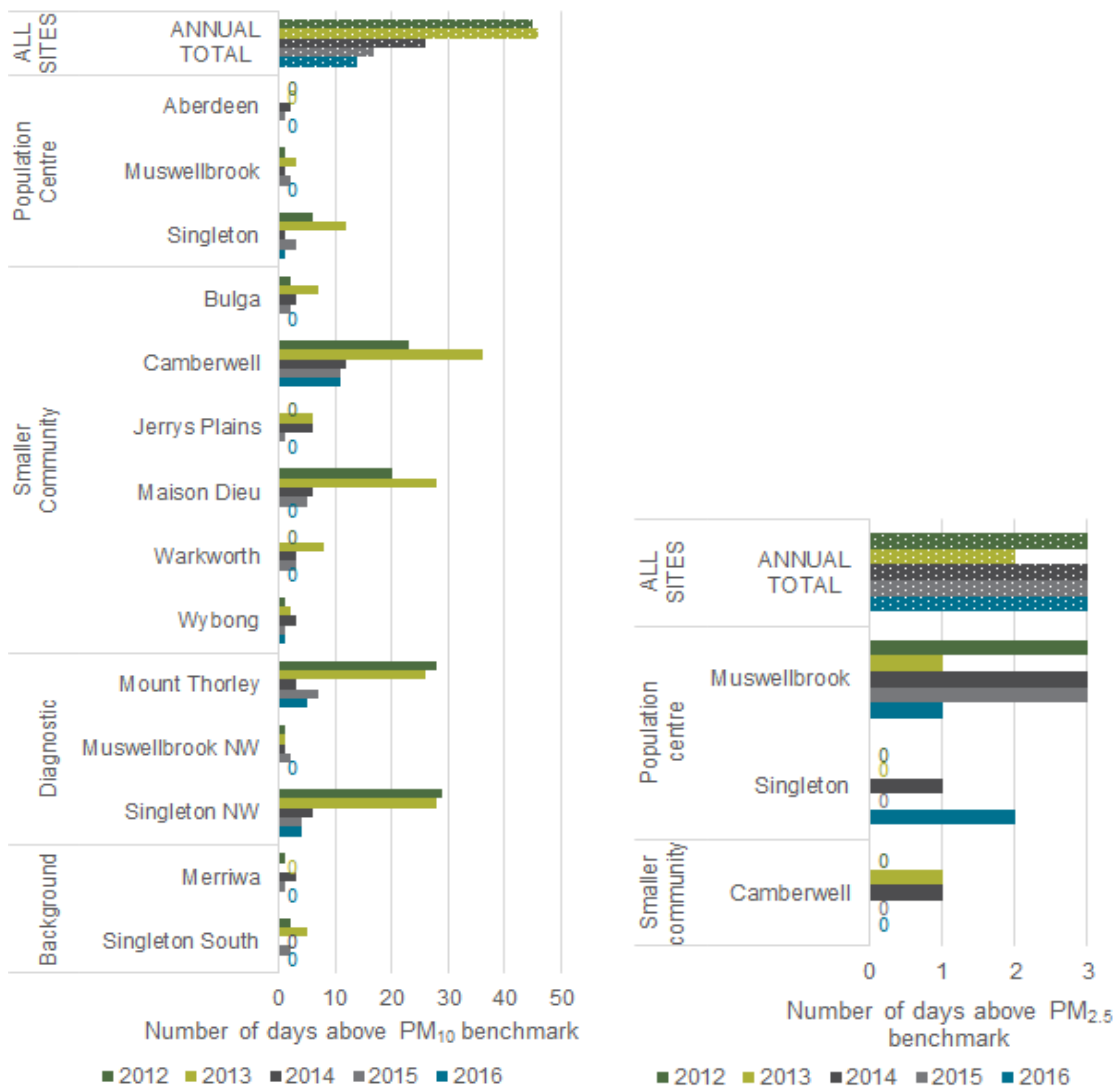


Figure 2 Number of days above the daily PM₁₀ and PM_{2.5} benchmarks from 2012 to 2016

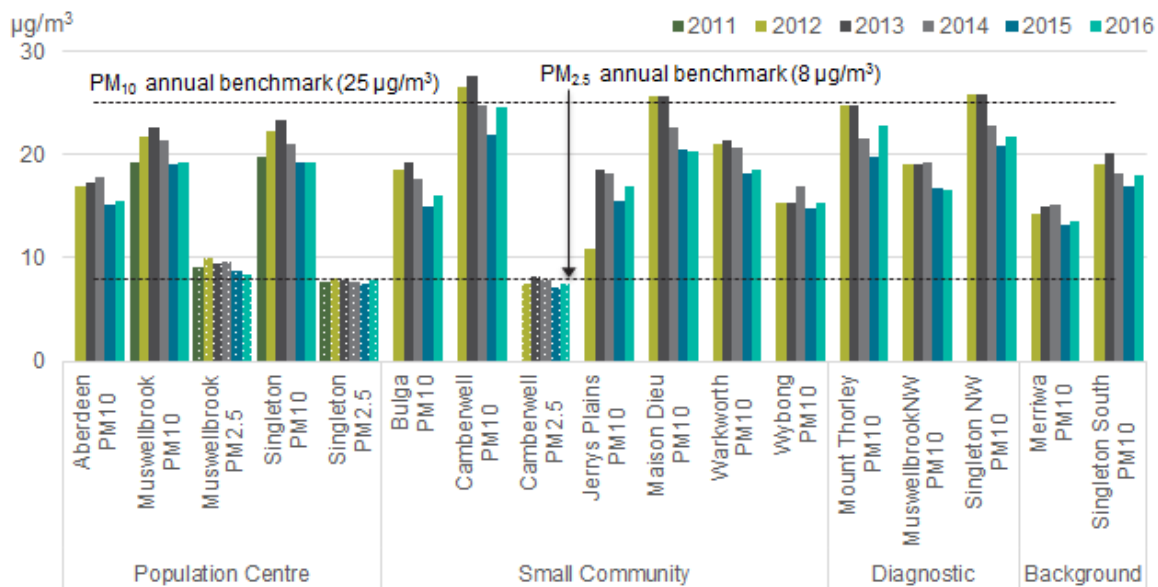


Figure 3 PM₁₀ and PM_{2.5} annual averages from 2011 to 2016

Gaseous parameters

Concentrations of NO₂ and SO₂ measured at Muswellbrook and Singleton have remained below the relevant national benchmarks, except for one-hour SO₂ briefly over the benchmark at Muswellbrook on 23 December 2016. This is the first occasion when hourly SO₂ levels have exceeded the benchmark in the NSW network since 1994.

OEH is currently undertaking dispersion modelling to better understand the meteorological processes leading to this elevated level of SO₂ on 23 December 2016. This modelling will also include days on other occasions when SO₂ levels reached close to the national benchmark. Outcomes of this analysis will be provided to the UHAQAC once available.

2.2.2 Comparison with air quality in other regions in New South Wales

Figure 4 shows the annual average levels of PM₁₀ at the Upper Hunter major population centres of Aberdeen, Muswellbrook and Singleton compared with other NSW regions. None of these stations recorded PM₁₀ levels over the annual benchmark from 2011 to 2016.

The annual PM₁₀ concentrations in the Upper Hunter are observed to be amongst the highest throughout New South Wales. For 2016, many sites from other regions recorded amongst the highest PM₁₀ annual average levels compared to earlier years. This was not the case for the Upper Hunter region, where the PM₁₀ annual averages for 2016 were amongst the lowest since the establishment of the Network.

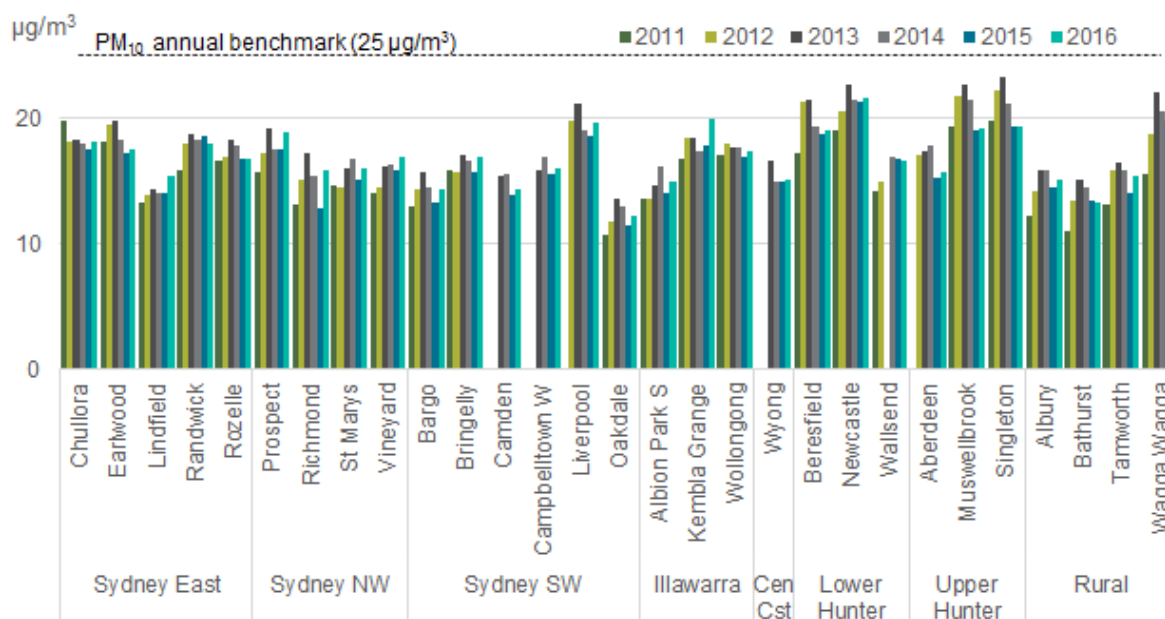


Figure 4 PM₁₀ annual averages by station for all NSW regions from 2011 to 2016

Cen Cst: Central Coast

Figure 5 shows that the highest annual number of days over the PM₁₀ daily benchmark from 2011 to 2016 occurred at Wagga Wagga, where air quality is affected by stubble burning. Singleton recorded the second highest number of days over the PM₁₀ benchmark in 2013. For the remaining years, the Upper Hunter sites had a similar number of days over the PM₁₀ benchmark compared to other regions.

As for the annual averages, many sites in western Sydney recorded amongst their highest number of days over the PM₁₀ daily benchmark in 2016. This was due mainly to extensive hazard reduction burning operations during autumn. However, this was not the case for the Upper Hunter, with the number of days over the PM₁₀ benchmark in 2016 amongst the lowest recorded since the establishment of the Network (Figure 5).

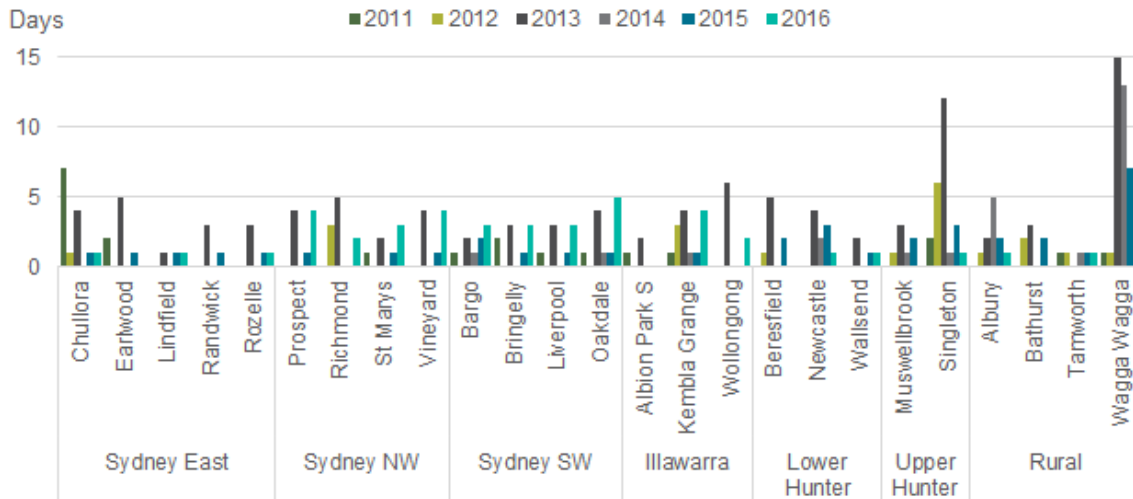


Figure 5 Number of days over the PM₁₀ daily benchmark by station for all NSW regions from 2011 to 2016 (at those sites where data are available since 2011)

A number of sites in New South Wales have recorded annual average PM_{2.5} concentrations over the benchmark (Figure 6). This includes sites in the Upper Hunter, in particular at Muswellbrook. Compared to other regions, Muswellbrook recorded amongst the highest PM_{2.5} annual average concentrations. The next most elevated PM_{2.5} annual average concentrations are seen at Liverpool, in the Sydney south-west region.

The number of days over the PM_{2.5} daily benchmark at Muswellbrook is similar to many other sites in the NSW monitoring network (Figure 7); although, it is the only site to record days over the PM_{2.5} benchmark each year since 2011.

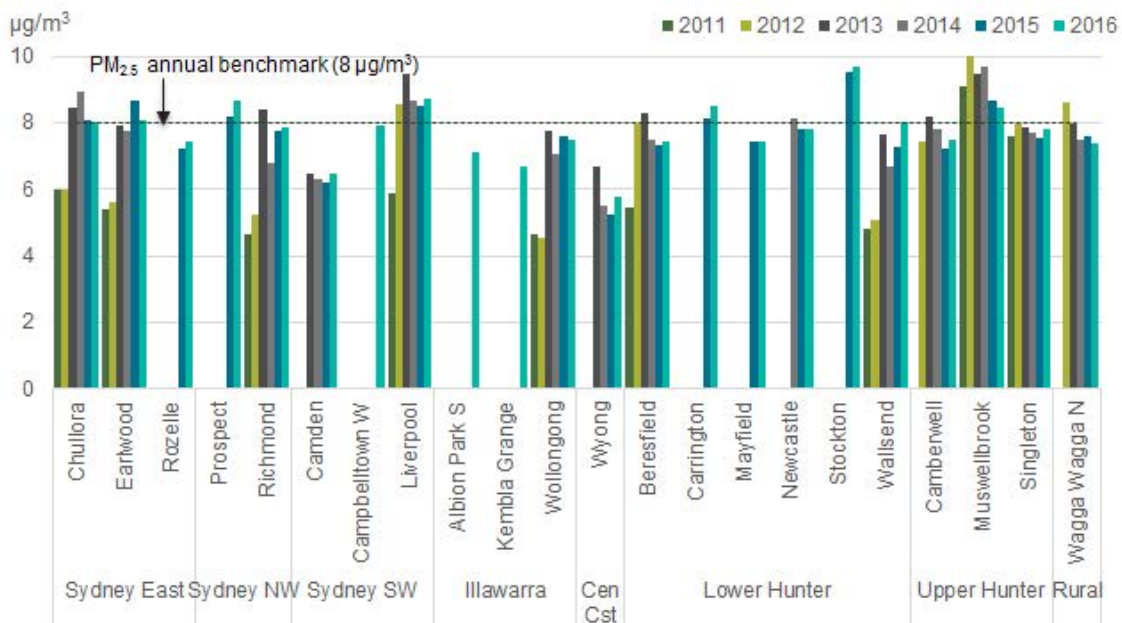


Figure 6 PM_{2.5} annual averages by station for all NSW regions from 2011 to 2016

Note: Cen Cst = Central Coast

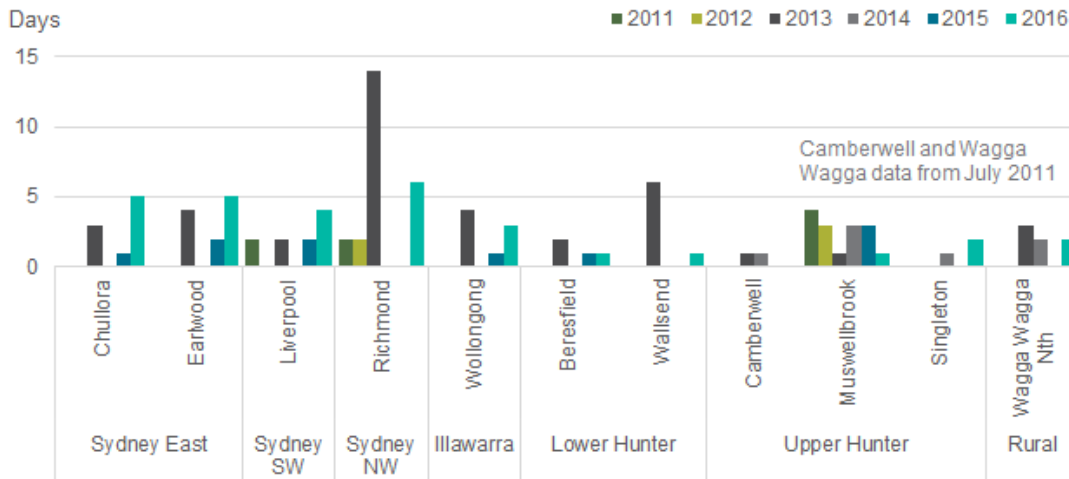


Figure 7 Number of days over the PM_{2.5} daily benchmark by station for all NSW regions from 2011 to 2016 (at those sites where data are available since 2011)

The maximum hourly SO₂ concentrations have been compared for all sites in the NSW network (Figure 8). SO₂ levels at Muswellbrook are consistently higher than other sites and regions. Maximum SO₂ concentrations at Singleton are the second highest in the network, although comparable to sites in the Lower Hunter region.

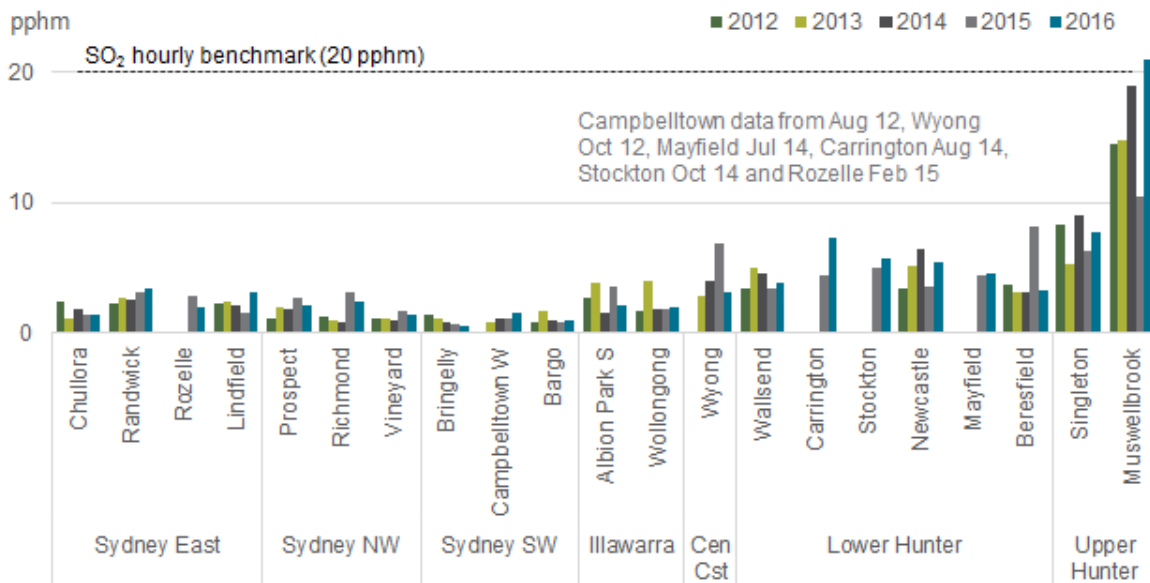


Figure 8 Maximum hourly average SO₂ for all NSW regions from 2012 to 2016
Cen Cst: Central Coast

2.2.3 Annual variability in particle data

There is considerable annual variability in both PM₁₀ and PM_{2.5} pollution in the region.

Since 2012, the majority of days over the PM₁₀ benchmark have occurred during spring (in particular September and October) (Figure 9). The same is evident when considering only the large population centres, although the number of days over the daily benchmark is greatly reduced compared to those sites closer to mines. These days include exceptional events, with bushfires being a source of particles in the warmer months and hazard reduction burns during autumn. The region is also occasionally affected by statewide dust

storms such as from 5–6 May 2015, when all but four sites in the NSW network recorded PM₁₀ levels over the benchmark.

For PM_{2.5}, the highest total number of days over the benchmark from 2012 to 2016 occurred in winter (Figure 10), predominantly due to smoke from domestic wood heaters. The days over the PM_{2.5} benchmark in October and November were predominantly due to bushfires.

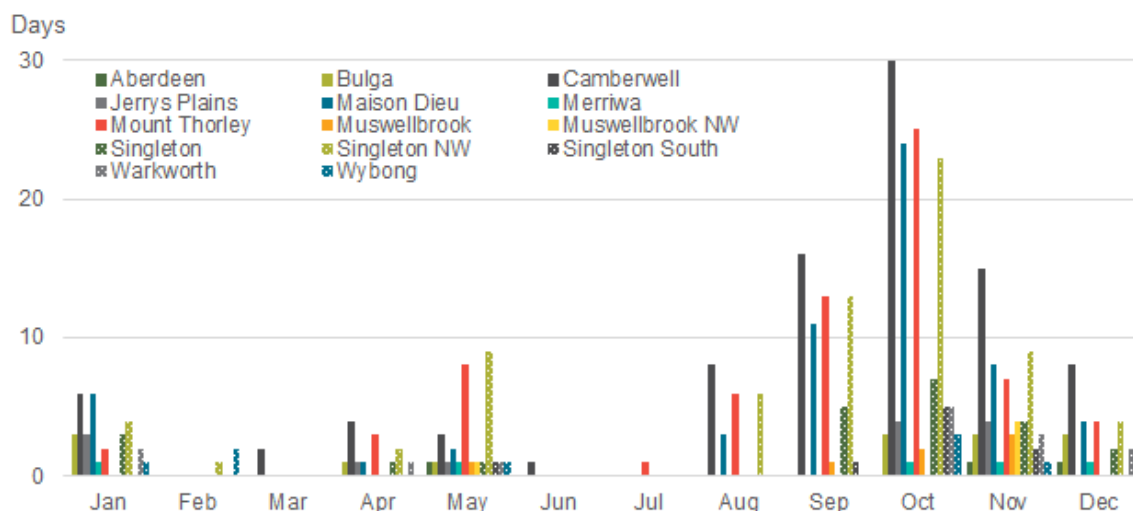


Figure 9 Total number of days per month over the PM₁₀ daily benchmark at all stations from 2012 to 2016

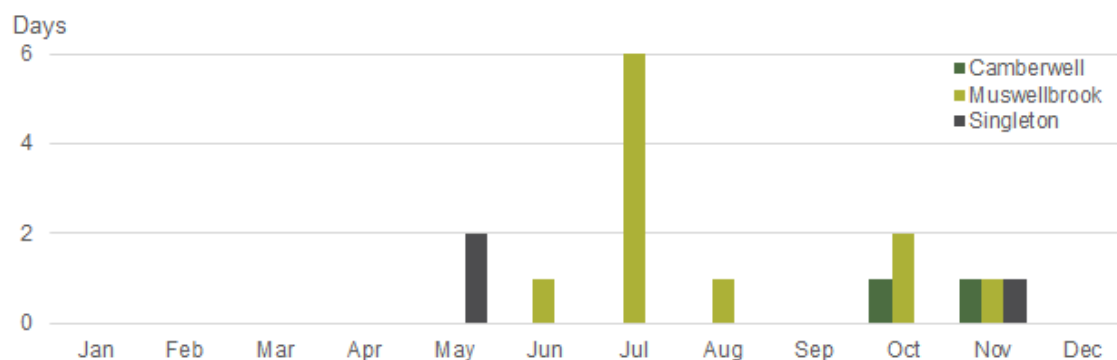


Figure 10 Total number of days per month over the PM_{2.5} daily benchmark at Camberwell, Muswellbrook and Singleton from 2012 to 2016

Further work is being undertaken by OEH to define the meteorological conditions conducive to elevated particle levels in the region. This research also considers, through a sub-region analysis, if particle level relationships exist between sites. Results from this work will be made publicly available once it has been completed.

2.2.4 Meteorology and climate

Meteorological and climatic conditions play an important part in determining the level and distribution of particle pollution in the region.

Wind

The wind rose map from 2011 to 2016 shows that winds flow predominantly north-westerly and south-easterly (Figure 11). Some variability is seen at individual sites due to localised influences, such as topographical effects.

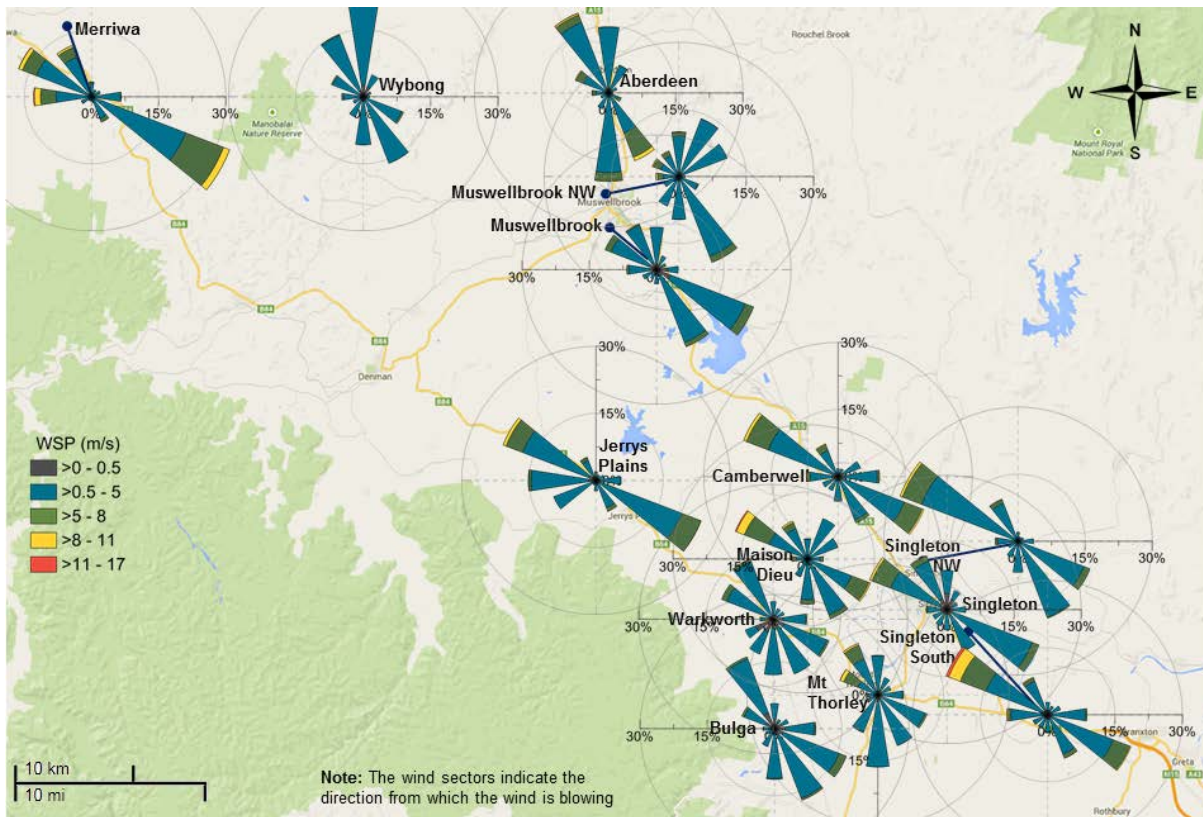


Figure 11 Upper Hunter wind rose map from 2011 to 2016

All available data from 2011 to 2016 from the 14 monitoring stations were analysed to show the seasonal change in wind patterns (Figure 12). In general, winds are predominantly from the south east in summer and north west in winter. During the autumn, winds turn from predominantly south-easterly to north-westerly. In spring winds turn from predominantly north-westerly to south-easterly. Higher wind speeds generally occur from the north west in winter and spring.

In Muswellbrook and Singleton, higher wind speeds occur in the afternoon and early evening in summer at both sites and also in spring at Singleton (Figure 13). Wind speeds during the day are the lowest in autumn and winter at Muswellbrook and autumn at Singleton. Overnight wind speeds are generally light, particularly in the cooler months and at Muswellbrook.

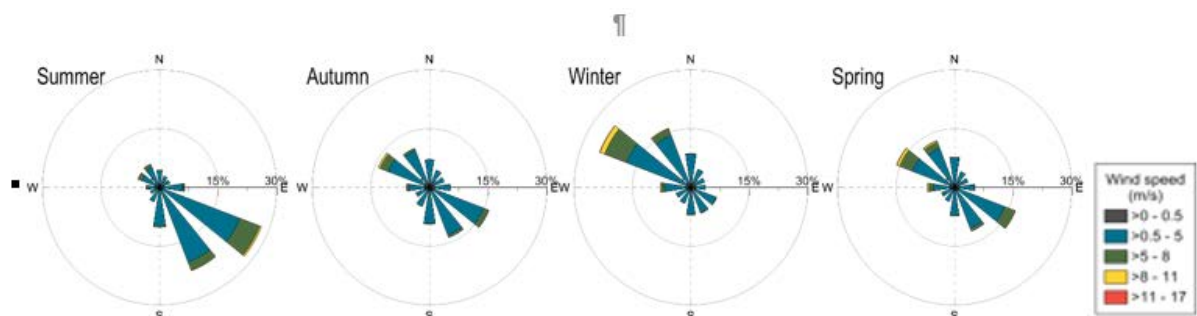


Figure 12 Seasonal wind roses using pooled wind data from all the Upper Hunter sites from 2011 to 2016

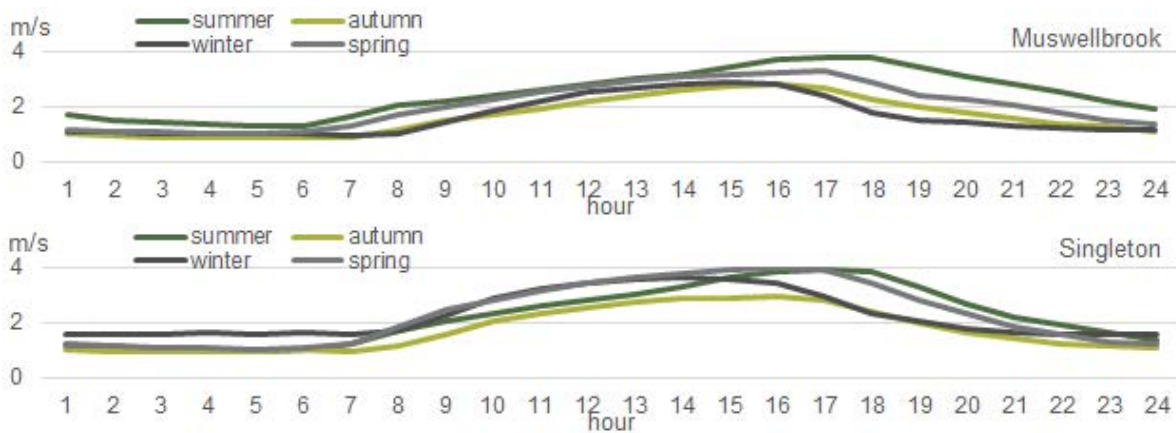


Figure 13 Muswellbrook (top) and Singleton (bottom) pooled hourly average wind speed plots from 2011 to 2016, by season

Temperature

Temperatures vary considerably throughout the year in the region, as shown by the Muswellbrook monthly minimum and maximum temperatures from 2011 to 2016 (Figure 14). Temperatures peak in November to February, with hot to very hot temperatures experienced. The lowest temperatures are experienced from May to August with sub-zero temperatures recorded.

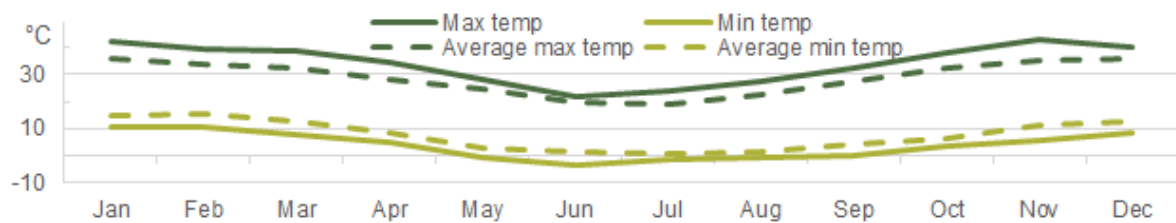


Figure 14 Muswellbrook monthly maximum and minimum temperatures from 2011 to 2016

Precipitation

A review of monthly rainfall levels in the region shows variability across seasons and years (Figure 15). Higher rainfall tends to occur in summer and early autumn (November to April). In contrast, there is consistently low rainfall between mid to late winter and early to mid-spring.

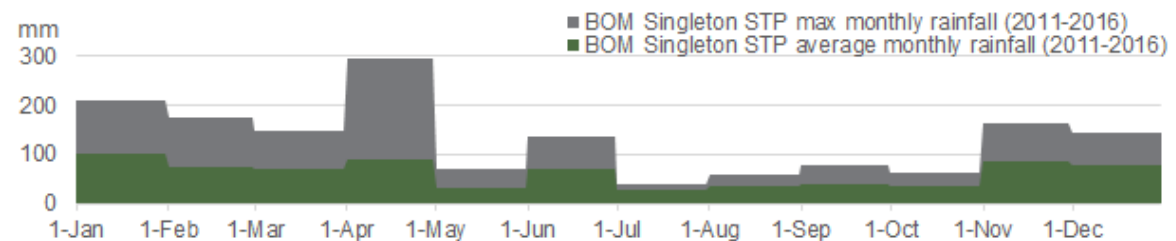


Figure 15 Bureau of Meteorology Singleton STP¹ maximum and average monthly rainfall from 2011 to 2016

¹ Sourced from the Bureau of Meteorology [Climate Data Online](#) website (accessed April 2017).

2.2.5 Meteorology and particles

Analysis of all Upper Hunter Network data shows that elevated PM₁₀ levels occur more often during spring. During this time of the year, winds are variable, changing from typical winter north-westerlies to typical summer south-easterlies. With the onset of onshore south-easterlies, wind speeds in the afternoon increase, with Singleton experiencing the highest wind speeds in the afternoons in spring and summer. Temperatures in the region warm significantly with hot days experienced by the end of spring. The region becomes drier as low rainfall is typically experienced. These conditions are conducive to elevated particle levels as dust is more likely to be generated and transported throughout the region.

Elevated PM_{2.5} levels occur more often in winter, in particular at Muswellbrook. Very cold temperatures are experienced in the region during winter (reaching sub-zero temperatures) and winds are calm overnight. These cold, calm conditions are conducive to trapping wood smoke near ground level, leading to elevated PM_{2.5} levels.

2.3 Emission sources within the region

2.3.1 Identified sources

Emission source data are available through the [EPA 2008 Air Emissions Inventory](#)² and the [National Pollutant Inventory](#) (which is updated annually). Studies in the region have also been undertaken to further assess particle sources in the region.

PM₁₀ emissions

Industry is the main contributor to PM₁₀ emissions in the Upper Hunter region. The [Air Emissions in My Community web tool](#) reports that, based on the latest inventory, coal mining contributes 88%, on average, of PM₁₀ emissions to the combined Muswellbrook, Singleton and Upper Hunter local government areas (LGAs) (Figure 16). This is followed by 5.7% from electricity generation and 3.2% from non-road vehicles and equipment.

Natural sources, such as bushfires and windblown dust, contribute approximately 2% to PM₁₀ emissions.

² Figures from the EPA 2008 Air Emissions Inventory were accessed in May 2017.

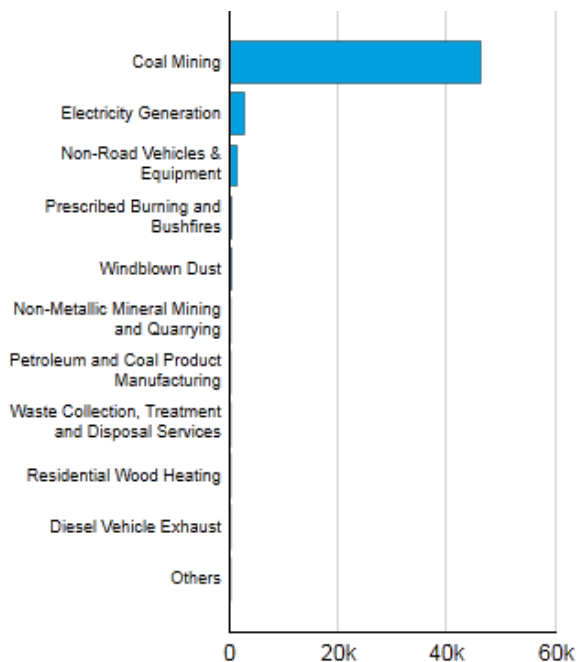


Figure 16 EPA Air Emissions Inventory web tool graph – PM₁₀ emissions by activity for the combined Muswellbrook, Singleton and Upper Hunter LGAs (tonnes per year)

PM_{2.5} emissions

Industry is also the main contributor to PM_{2.5} emissions in the Upper Hunter region (Figure 17). The [Air Emissions in My Community web tool](#) reports that coal mining contributes 66% of PM_{2.5} emissions, non-road vehicles and equipment contribute 14%, electricity generation contributes 13% and prescribed burning and bushfires contribute 4%. Windblown dust contributes less than 1%.

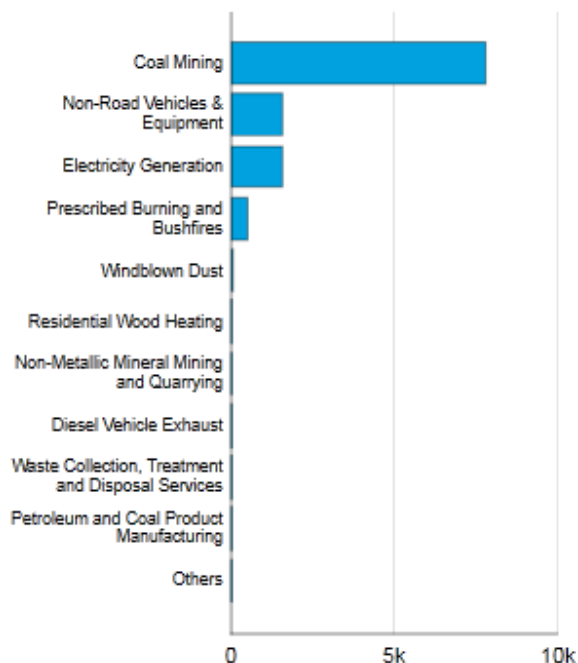


Figure 17 EPA Air Emissions Inventory web tool graph – PM_{2.5} emissions by activity for the combined Muswellbrook, Singleton and Upper Hunter LGAs (tonnes per year)

However, PM_{2.5} emissions in Muswellbrook have a strong seasonal variation, with peak levels occurring in winter. The Upper Hunter Fine Particle Characterisation Study (UHFPCS) found that the highest contributor to annual PM_{2.5} concentrations at Muswellbrook was smoke from domestic wood heaters (contributing around 30% annually and 62% in winter) (Figure 18). The study also found that wood heaters contributed around 14% of total annual PM_{2.5} concentrations at Singleton (and 38% in winter) (Hibberd et al. 2013).

At Muswellbrook and Singleton, secondary sulphate (from local and regional sources of SO₂ such as power stations) and industry aged sea salt (sea salt combined with local and regional sources of SO₂, such as power stations) were major contributors to total annual PM_{2.5} concentrations.

Minor sources of PM_{2.5} include vehicle and industrial emissions, smoke from bushfires and hazard reduction burns, soil and coal dust, and secondary nitrate from motor vehicles and power stations.

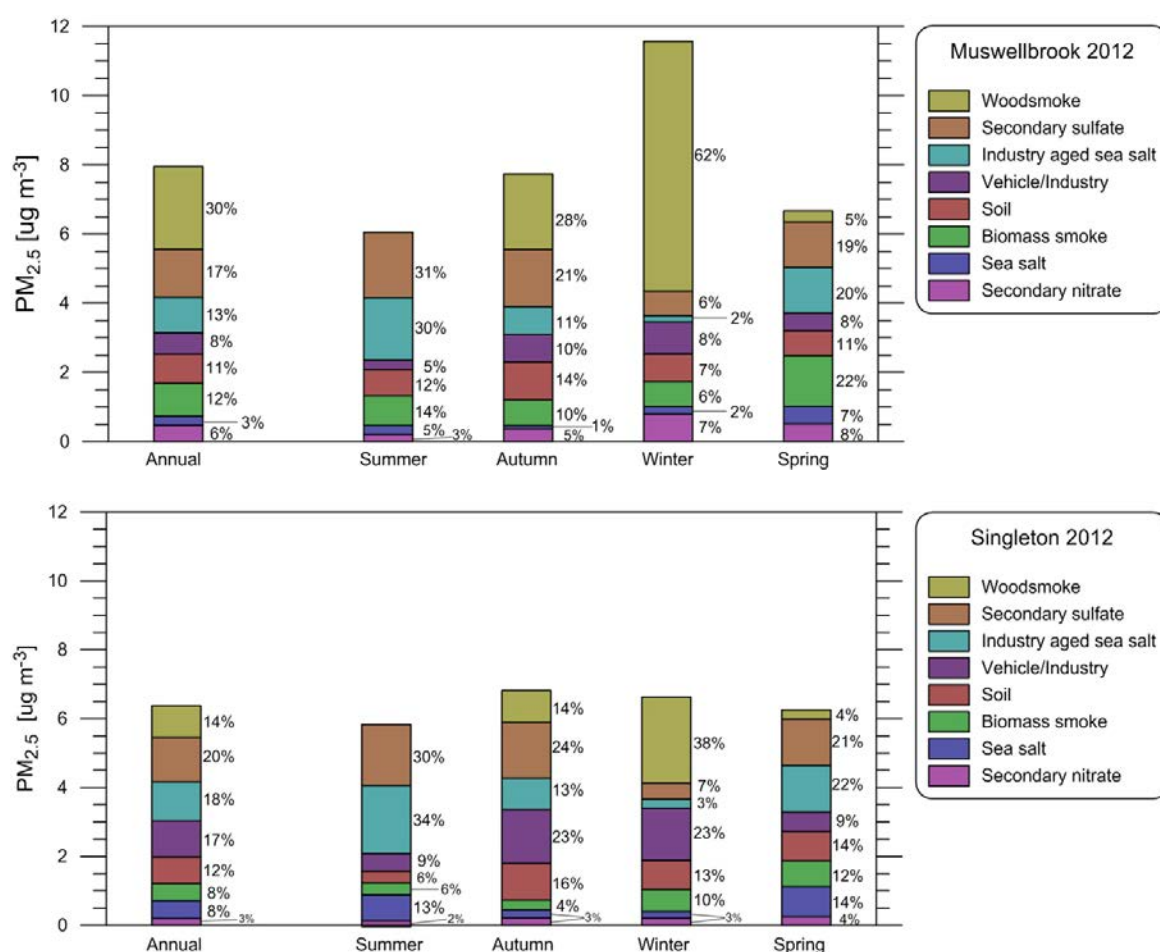


Figure 18 Annual and seasonal source contributions to PM_{2.5} concentrations in Muswellbrook (above) and Singleton (below)

Source: extracted from the UHFPCS report (Hibberd et al. 2013)

Sulfur dioxide emissions

The main source of SO₂ 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 SO₂ in the Muswellbrook LGA (126 kilotonnes per year) and 92.9% in the Singleton LGA (1.7 kilotonnes per year) (Figure 19).

Minor sources of SO₂ at Singleton are coal mining (4.8%) and non-road vehicles and equipment (2%).

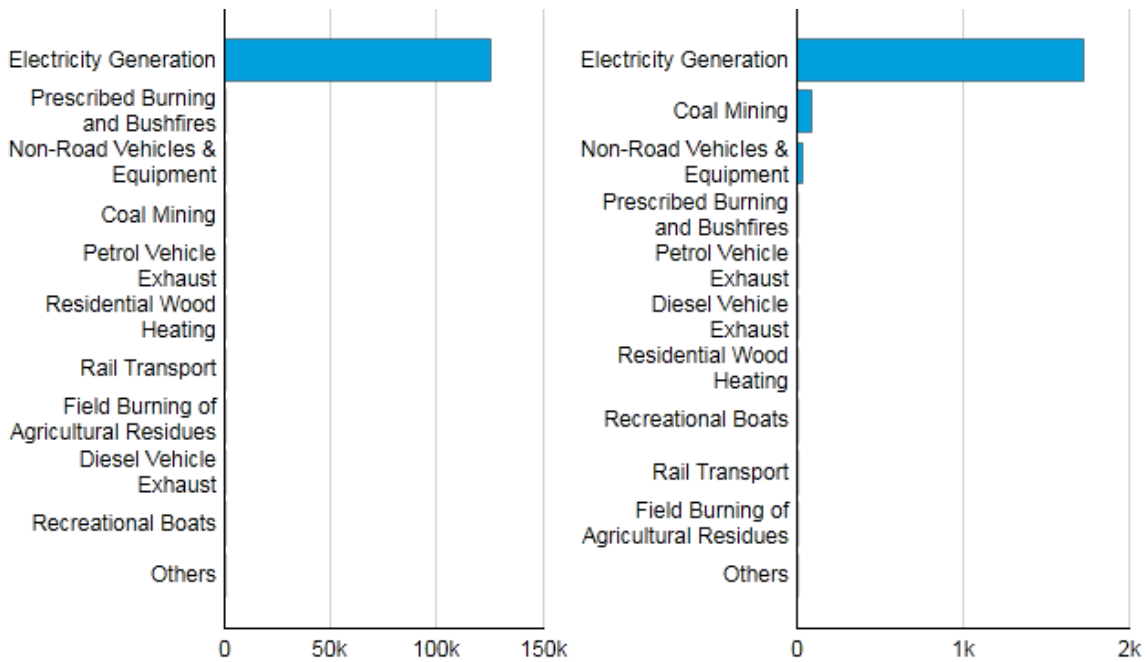


Figure 19 EPA Air Emissions Inventory web tool graph – SO₂ emissions by activity for Muswellbrook LGA (left) and Singleton LGA (right)

Nitrogen dioxide emissions

Levels of NO₂ in ambient air measured at Muswellbrook and Singleton have remained consistently low since the establishment of the Network.

The [Air Emissions in My Community web tool](#) reports that in the Muswellbrook LGA, power stations contribute 89.7% of emissions of oxides of nitrogen (NO_x) (64.1 kilotonnes), while non-road vehicles and equipment contribute 8.0% of NO_x emissions (Figure 20). In contrast, in the Singleton LGA, 80.2% of NO_x is emitted by non-road vehicles and equipment (18.3 kilotonnes), followed by 8.4% from coal mining.

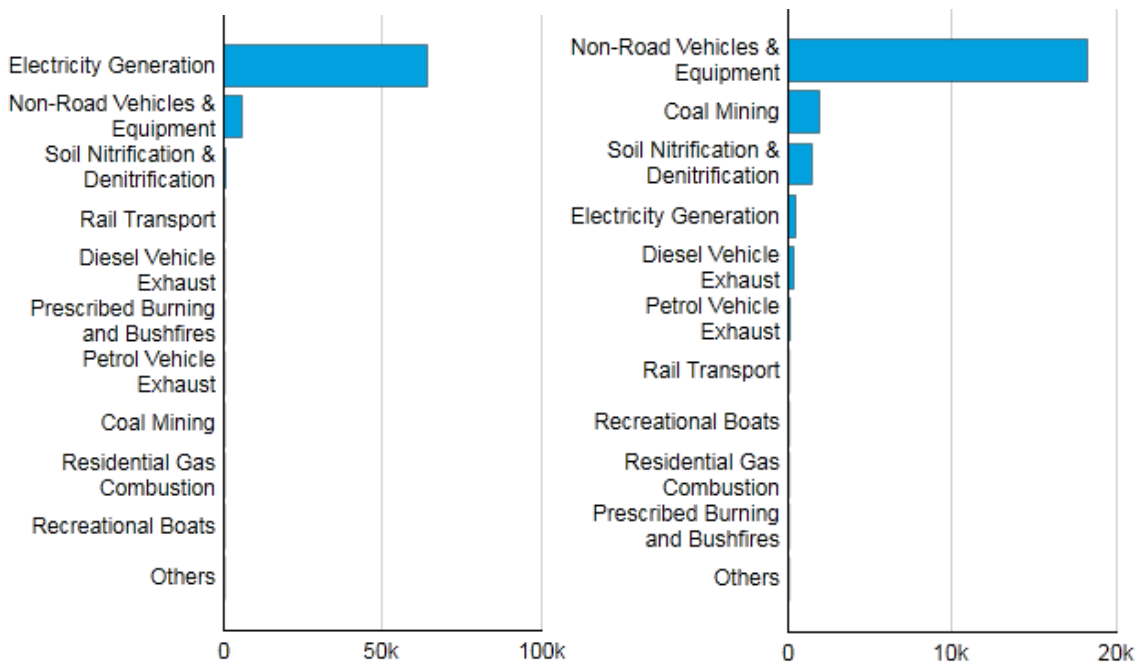


Figure 20 EPA Air Emissions Inventory web tool graph – NO_x emissions by activity for Muswellbrook LGA (left) and Singleton LGA (right)

3. How have the Upper Hunter Network data been used?

OEH has collected over four million air quality and meteorological records for the Upper Hunter from establishment of the first Network sites in late 2010 to the end of 2016. This section reports on how these data have been used extensively by many program stakeholders.

3.1 Provision of air quality data and information to the community

Data collected from the Network are readily available to the public. Air quality information is provided through a number of means, with regular updates advised typically through media releases to the community.

3.1.1 OEH website

The Network provides the community with hourly updates on current air quality in near real-time via the OEH [Upper Hunter live air quality data](#) webpage.

The webpage, which is updated hourly, provides facilities for viewing the Upper Hunter air quality monitoring data. Anyone visiting the webpage can view and download the hourly PM₁₀, PM_{2.5}, NO₂, SO₂, wind direction and wind speed data and create their own graphs of hourly data.

The website provides a search facility for downloading historical data and comparing Upper Hunter data to those for other sites in the NSW air quality monitoring network.

The number of unique page views³ for the period 1 January 2012 to 31 December 2016 for the [OEH Upper Hunter](#) map webpage is shown in Figure 21. During this period, the number of daily visits cycled up to 188, with a total of 36,371 unique page views. The higher number of views occurred in late 2013 during an extensive bushfire period.



Figure 21 Unique page views for the UHAQMN map webpage from 2012 to 2016

3.1.2 SMS and email alerts

The UHAQMN triggers automatic Short Message Service (SMS) text messages and email alerts to inform the community when air quality is 'poor'⁴. This is designed to allow members of the community who may be susceptible to air pollution (e.g. asthmatics, people with heart disease) to subscribe to these automatic alerts and to take actions for protecting their health.

³ Unique page views are based on the number of unique visits in each 30-minute session.

⁴ For particles, an alert is triggered when the *rolling* 24-hour average exceeds the daily benchmark. Since the daily benchmark is based on the 24-hour average from midnight to midnight, an alert may not result in an exceedence of the national benchmark.

The OEH has promoted this service via its website, through community meetings and communication with stakeholders, and through the media. Subscription to the alerts is available online at [SMS and email alerts](#).

The numbers of subscribers to the UHAQMN alerts from 2012 to 2016 are shown in Figure 22. The majority of subscriptions began in 2012 and 2013, the first years of the Network's operations. Annual subscription numbers since then have been fairly consistent, although new subscriptions are still occurring each year. Some sites received more new subscriptions in 2016 compared to 2014 and 2015.

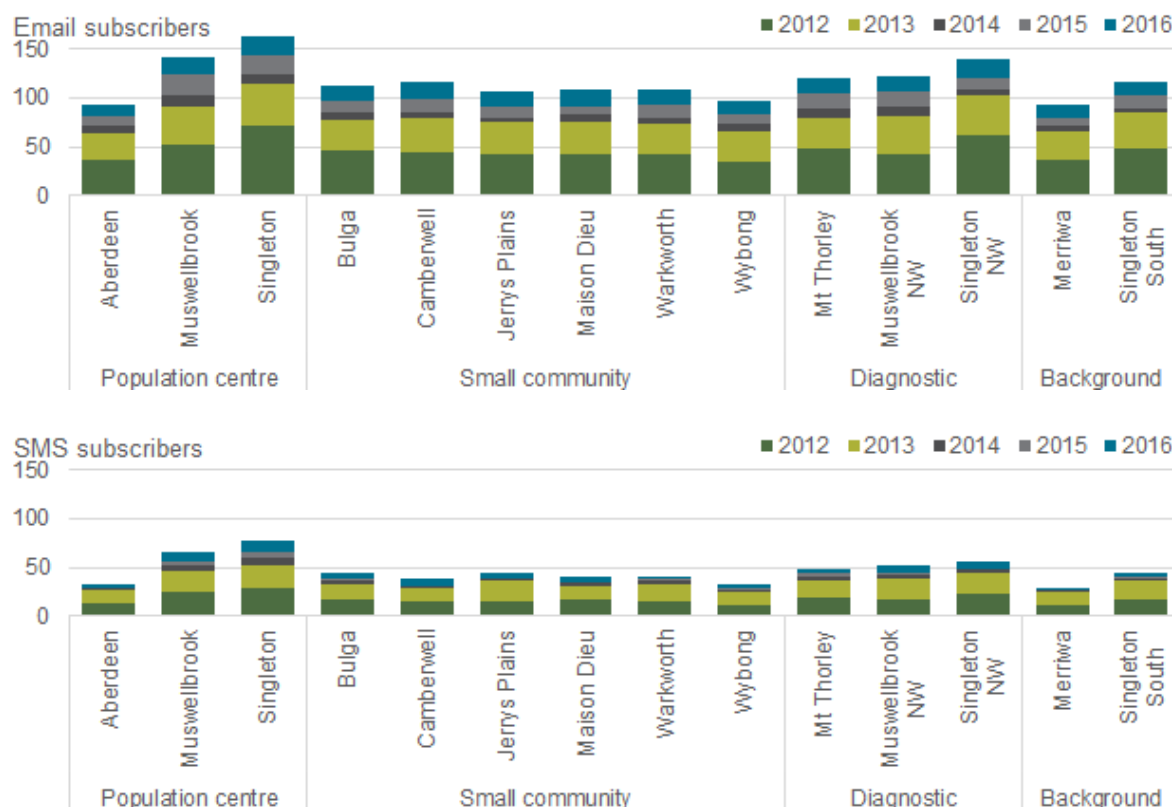


Figure 22 Numbers of public subscribers to email (top) and SMS (bottom) alerts for each air quality monitoring station (as of 31 December 2016)

3.1.3 Upper Hunter monitoring reports

OEH reports regularly to the community on air quality in the region.

Seasonal newsletters

OEH analyses data from the Network each season and presents a summary newsletter, to the UHAQAC. OEH developed the format of the newsletter in consultation with the committee. OEH publishes the newsletters on its website and the EPA releases a media statement informing the community.

Seasonal newsletters from autumn 2015 onwards are available on the OEH [Upper Hunter air quality monitoring reports](#) webpage.

The seasonal newsletters provide:

- annual trends of particle (PM₁₀ and PM_{2.5}) data
- daily time series plots of particle and gaseous data
- number of days above benchmark concentrations
- pollution and wind roses

- seasonal comparisons and trends
- meteorological summary
- Network performance over the season.

The information included in the seasonal newsletters has changed over time to take into account stakeholder needs, with feedback provided through the UHAQAC.

Annual reports

OEH consolidates data each year into an annual report for the Network. Information provided in the seasonal newsletters is incorporated in these reports, with the addition of event analyses.

The annual reports from 2012 to 2015 are available on the OEH [Upper Hunter air quality monitoring reports](#) webpage.

3.1.4 NSW annual air quality statements

Each year, OEH releases an annual air quality statement for the whole of the NSW air quality monitoring network. This statement is released soon after the end of the year to inform the community with summary air quality information for New South Wales.

These statements include:

- comparisons of air quality levels for all NSW regions
- information on days above national standards
- a focus on air quality in the Hunter Valley to address additional community needs.

The [NSW Annual Air Quality Statements](#) from 2012 to 2016 are available on the OEH website.

3.1.5 Hunter Valley Annual Air Quality 2012

Prior to the development of the NSW annual air quality statements, OEH and the EPA compiled a summary report specifically for the Hunter Valley. This report focused on PM₁₀ and PM_{2.5} particles in the region. It provided information on the days above the national standard during 2012.

The [Hunter Valley Annual Air Quality 2012 – Fine Particles \(PDF\)](#) report is available on the OEH [Upper Hunter air quality monitoring reports](#) webpage.

3.2 Provision of air quality data to external stakeholders

3.2.1 Industry

Since October 2015, the data monitored at Maison Dieu, Warkworth and Jerrys Plains have been provided directly to Rio Tinto Coal Australia. OEH provides these data by direct feed to supply industry with real-time information from monitoring stations near their operations.

Glencore Australia is provided with all available hourly data from all Upper Hunter sites automatically each hour. These data have been provided since September 2015.

3.2.2 Local government

Muswellbrook Shire Council is provided with all available hourly data from Muswellbrook, Muswellbrook NW, Wybong, Merriwa, Aberdeen and Jerrys Plains automatically each month. OEH has been providing these data since October 2014.

3.3 Air quality research projects and initiatives

A number of projects in the Upper Hunter region have used data from the Network to add to the evidence base for air quality management in general and to develop pollution reduction initiatives.

3.3.1 Upper Hunter Fine Particle Characterisation Study

A research study by OEH, NSW Health and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) focused on PM_{2.5} particle pollution in the Upper Hunter region. Sampling during 2012 and detailed analysis in 2013 determined the sources of PM_{2.5} particles measured in ambient air at Muswellbrook and Singleton.

This study was initiated to better understand the elevated PM_{2.5} concentrations seen at Muswellbrook in winter during the first nine months of the operation of the UHAQMN.

The Upper Hunter Fine Particle Characterisation Study found that the largest source of PM_{2.5} at Muswellbrook in winter (62%) was smoke from domestic wood heaters. The study also found that wood heaters contributed around 38% of PM_{2.5} in winter at Singleton.

Other main sources of PM_{2.5} at the sites included power stations, sea salt, soil dust, wildfires and hazard reduction burns.

3.3.2 NSW Government programs and initiatives

The extensive information collected from the UHAQMN has been used to inform numerous programs and initiatives undertaken by the NSW Government. These include:

- Upper Hunter air particles action plan
- Upper Hunter wood smoke community research project
- Managing particles and improving air quality in NSW
- Wood smoke reduction strategy
- Clean air for NSW consultation paper
- Air: NSW overview
- Minimising air pollution from coal mines (including dust stop).

These programs were considered as part of an independent external review of the Network. The review found that the UHAQMN '*assists with the development of air quality programs*' in the region (Jacobs Group Australia 2017).

In addition, OEH and the EPA have developed a dust risk forecast scheme for the Upper Hunter to further reduce dust from mining operations in adverse weather conditions. The scheme is being trialled in spring 2017.

3.4 Upper Hunter data used by external organisations

Data collected from the UHAQMN have been used in various ways by external organisations.

3.4.1 Senate enquiry on the impacts on health of air quality in Australia

A senate inquiry occurred in 2013 reviewing the impacts on health of air quality in Australia. This inquiry considered:

- particulate matter, its sources and effects
- those populations most at risk and the causes that put those populations at risk
- the standards, monitoring and regulation of air quality at all levels of government
- any other related matters.

Coal mining in the Upper Hunter was specifically addressed as part of this inquiry, with data from UHAQMN reported.

3.4.2 Hunter Valley Dust Forecast

In the Hunter region, Jacobs maintains the Hunter Valley Dust Forecast that provides daily forecasts for dust transport, concentrations and meteorological conditions in the valley. Specifically, the forecast predicts PM₁₀ concentrations at Singleton and Muswellbrook for the next two days.

This project was funded by the Australian Coal Association Research Program and developed in association with NH2 Dispersion Sciences.

Data from the UHAQMN Muswellbrook and Singleton sites were used to evaluate the performance of the forecast model (Lakmaker 2015).

3.4.3 Air quality impact assessment for industrial development

Proponents for new industrial developments in the Upper Hunter use data from the Network to prepare air quality impact assessments. These studies are required as part of the development approval process for proposed developments.

3.4.4 Online references

In addition to the use of UHAQMN data reported above, several references to the UHAQMN can be found online. This includes media reports, community group sites, industry sites, consultant reports, research projects, international sites and government sites (Figure 23).

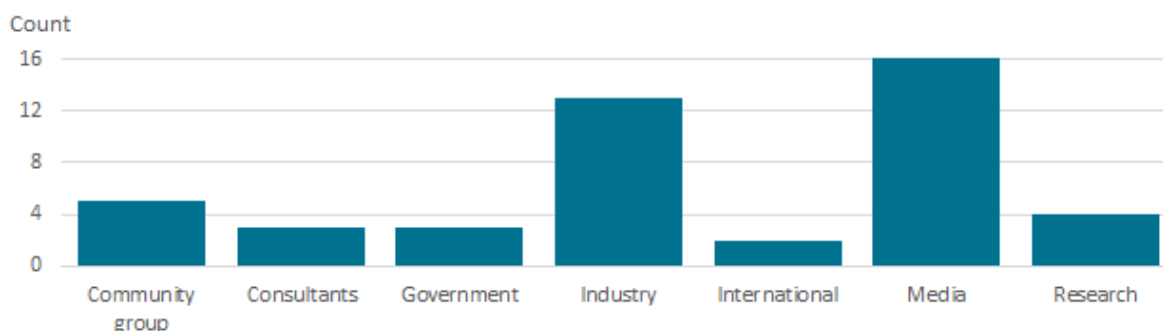


Figure 23 Number of online websites that include references to the UHAQMN⁵

3.5 Future potential uses for the UHAQMN data

The EPA has implemented a number of pollution reduction programs (PRPs) in the Upper Hunter region to minimise pollution from coal mining operations. At present, additional measures are being considered to further reduce dust emissions. The data collected from the Network provide valuable information to assist in the development and assessment of these future programs. For example, the EPA and OEH are trialling a new dust risk forecasting method in spring 2017, when particle levels are highest in the region.

⁵ Note: This graph was compiled through a Google website search and may not include all online sites.

4. Review findings

This section presents an analysis of Sections 2 and 3 above, and considers feedback from stakeholders in the community, industry and government agencies. The focus questions address the legislative reporting requirements in the Regulation, as listed in Section 1.7.

4.1 Have the objectives of the monitoring program been met?

Objective 1

To provide government, industry and the community with reliable and up-to-date information on air quality in the Muswellbrook, Singleton and Upper Hunter Shire local government areas.

Objective 1 is being met.

Evidence of this objective being met includes:

- The Network design was developed to take into account population centres and emission sources within the Muswellbrook, Singleton and Upper Hunter shires.
- The region incorporates a high density of sites compared to other regions in the OEHS NSW monitoring network, with one-third of the total network stations located in the Upper Hunter.
- Data collected from the 14 Upper Hunter monitoring sites are available in near real-time on the OEHS website.
- SMS and email alerts are available that provide the community with up-to-date information on elevated air quality levels at monitoring sites in their area of interest.
- The Network is robust and reliable, shown by the high online times for particle, gaseous and meteorological data measured throughout the Network.
- The NSW Government and the community have gained extensive knowledge on air quality and meteorological processes in the region since the establishment of the Network.
- Industries and local governments in the region are provided with data regularly to better inform their operations.

Objective 2

To enable the air quality in those areas to be assessed against relevant air pollution standards.

Objective 2 is being met.

Evidence of this objective being met includes:

- The near real-time data on the website are shown as an air quality index (AQI), which allows easy comparison against the national benchmarks.
- The Network data online can be readily compared to other sites in the statewide air quality monitoring network.
- Annual reports are regularly provided to the community on the OEHS website, incorporating the assessment of data against air quality benchmarks.

- Additional seasonal newsletters are available from autumn 2015 on the OEH website, also providing assessment against air quality benchmarks.
- The Hunter region is a focus in the NSW annual air quality statements, provided to the community via the OEH website early in January each year.
- Long-term trends can be established from the data.

Objective 3

To facilitate the identification of sources of air pollution in those areas.

Objective 3 is being met.

Evidence of this objective being met includes:

- An extensive meteorological network has provided valuable information on conditions conducive to elevated particle pollution and the transport of pollutants.
- Event analyses are provided in regular reports to the community, with source types (such as bushfires, dust storms, wood heaters and industrial emissions) identified through the analysis of particle levels and corresponding meteorological data.
- The Upper Hunter Fine Particle Characterisation Study (Hibberd et al. 2013) used data from the Network to assist in identifying the contributions of air pollution sources to levels of PM_{2.5} measured at Muswellbrook and Singleton.

Objective 4

To facilitate the development and implementation of strategies to improve air quality in those areas.

Objective 4 is being met.

A number of strategies have been put in place by the EPA to minimise particulate pollution from coal mines and other sources of particulate matter in the region. These include:

- The EPA's Dust Stop program required coal mines to undertake a series of pollution reduction programs (PRPs) to reduce particle levels:
 - PRP1: Mines improved water spraying of haul roads to reduce wheel generated dust.
 - PRP2: Mines introduced modifications to mining activities to reduce dust in adverse weather typically associated with elevated particle levels.
 - PRP3: Mines introduced methods to reduce dust when handling overburden.
 - PRP4: Mines maximised stabilisation of land after mining to reduce dust from wind erosion.
- Research by the EPA and OEH uses Network data to develop methods to improve dust risk forecasting for the Upper Hunter. The study uses the difference in daily levels of PM₁₀ at Merriwa in the north-west, compared to Singleton in the south east, to identify days with high dust emissions within the valley.
- The EPA is working with local councils and communities to raise awareness about the impact of wood smoke on PM_{2.5} levels in Singleton and Muswellbrook. Strategies for wood smoke reduction include community education on efficient operation of wood heaters and incentives for replacing wood heaters with electric heaters.

The Upper Hunter Air Quality Advisory Committee (UHAQAC) reviewed the draft five-year review of the Upper Hunter Air Quality Monitoring Network. The Committee agreed that the

Upper Hunter air monitoring program met Objectives 1 and 2, to provide reliable air quality data, assessed regularly against relevant standards. While some members of the UHAQAC questioned the effectiveness of some EPA programs for improving air quality in the Upper Hunter, it is clear that the data provided by the monitoring network has been fundamental in the development of these strategies.

4.2 Is the Network being run efficiently and cost-effectively?

4.2.1 How much has the monitoring program cost?

The cost of the Network includes assets and ongoing operating costs (including maintenance, calibrations, audits, quality assurance and reporting). In addition, there is a cost for the EPA to administer the regulation and support the advisory committee.

These costs are recovered annually through levies to the coal mining and power generation industries in the Upper Hunter. These levies are based on the annual individual emissions from each industry. The calculation of the levy is specified within the Regulation.

The total annual capital and operating costs for the NSW Government to establish and maintain the Network from 2010 to 2016 are outlined in Table 4.

Table 4 Total capital and operating costs from financial years 2011 to 2016

Expenses	Costs to FY16
Capital (including site construction costs)	\$2,230,029
Operational	\$709,347
Labour	\$2,023,055
TOTAL	\$4,962,431

4.2.2 Independent review of efficiency and cost-effectiveness

This section reports on the independent audit of the efficiency and cost-effectiveness of the Network, required by the Regulation.

Jacobs Group (Australia) Pty Ltd⁶ reviewed Network reports and costs to conduct the independent audit of the efficiency and cost-effectiveness of the Upper Hunter monitoring program (Jacobs Group Australia 2017).

The independent audit found that:

Overall the UHAQMN is considered to be efficient and cost effective in providing reliable and accurate air quality monitoring data that can be available in near-real time to the EPA, OEH, community, industry and other stakeholders.

The independent audit also noted that:

Overall, the data capture from the network has been very high since inception. This indicates responses to equipment faults and scheduling of maintenance and calibration procedures are conducted efficiently by OEH. An increase in webpage views over time and during periods of known pollution episodes indicates there is a

⁶ Jacobs Group (Australia) Pty Ltd was selected to undertake the independent review due to their expertise in the field and as they have not been involved in the operation of the Network.

growing number of stakeholders that value and potentially utilise the air quality information produced by the network.

The conclusions of the independent audit are that:

The Upper Hunter Air Quality Monitoring Network:

- Provides reliable and up-to-date information on air quality in the region
- Allows for assessment of air quality against relevant standards
- Allows for identifying sources of air pollution
- Assists with the development of air quality programs.

Table 5 presents the considerations provided in the independent audit for future efficiency improvements and cost-effectiveness of the UHAQMN.

Table 5 Recommendations of the independent audit of the efficiency and cost-effectiveness of the Upper Hunter air quality monitoring program

Source: Jacobs Group Australia (2017)

Number	Independent audit recommendation
1	Consider moving the Muswellbrook NW monitoring station from the current location in north-west Muswellbrook. Originally intended as a diagnostic site that is dedicated to resolving likely sources of dust measured at Muswellbrook (Central), a high-level review suggests both locations are measuring similar sources of particulate matter. Re-establishing the monitoring station in a small community would improve the network's efficiency in meeting the monitoring objectives.
2	A suggested location for a seventh 'smaller community' monitoring location is Denman to the west of Muswellbrook. The town is located in reasonably close vicinity to open-cut coal mining operations and is situated in an area where establishment of a monitoring program would improve overall network coverage.
3	Maintain the relatively high density of monitoring stations situated around the Singleton area. The monitoring network was originally designed to understand a range of conditions, including air quality in larger communities, near emissions sources and in background locations. The monitoring conducted in and around Singleton is currently considered consistent with these objectives. Regular reassessment of monitoring outcomes against the objectives of the network will determine whether the monitoring operation remains consistent with the UHAQMN aims.
4	Further, results from some monitoring locations (i.e. Aberdeen, Merriwa and Jerrys Plains) are indicating low air quality impacts in more remote areas of the region. These monitoring locations are providing valuable information on background concentrations, transport of emissions and in some cases may be situated in areas projected to be impacted by future coal mining operations, so should be maintained in their current position. Proposed and approved changes to industry in the region should be regularly reviewed to ensure the network has adequate coverage for areas that may, in the future, be impacted by industry. OEH could consider including a comment on any industry closures or approvals in the discussion in the Annual Report to document these considerations.
5	Consideration should be given to reviewing and developing a mechanism where industry can apply to decommission monitoring locations that overlap with UHAQMN locations. This process represents an opportunity to improve the design of the network as a whole for both industry and OEH monitoring, and could potentially reduce costs to industry and thereby improve the cost-effectiveness of the UHAQMN.

4.2.3 Consideration of changes in Network design recommended by the independent audit and stakeholder feedback

Each of the recommendations provided within the independent audit (Table 5) have been considered below. These responses include the feedback received from stakeholders.

Audit recommendation 1 – Move the Muswellbrook NW air quality monitoring station

The independent audit recommended considering moving the Muswellbrook NW diagnostic station to instead serve as a smaller community station in another location. The audit analysis suggested that the air monitors at Muswellbrook NW and Muswellbrook measured the same sources of air pollution. On the two occasions from autumn 2015 to spring 2016 when daily PM₁₀ exceedances were measured at Muswellbrook, PM₁₀ exceedances were also recorded at Muswellbrook NW. The audit acknowledged that Mount Pleasant coal mine commenced early works in 2017.

Stakeholder feedback noted the importance of the Muswellbrook NW for monitoring the impacts of mining at Mount Pleasant. Mount Pleasant commenced works in 2017 and expects the first coal production in early 2018. The mine's Environment Protection Licence conditions are linked to the Muswellbrook NW monitor.

This report recommends the retention of the Muswellbrook NW diagnostic air monitoring station to monitor air quality impacts of mining at Mount Pleasant.

Audit recommendation 2 – Install an additional air quality monitor at Denman

The independent review suggested Denman as a location for an additional smaller community monitoring location. Denman is close to another small community, Sandy Hollow, and is located reasonably close to open-cut mining operations. For example, Mangoola Coal Operations is approximately 9 km to the north and Hunter Valley Energy Coal (formerly Mt Arthur Coal) is approximately 14 km to the east north east.

This report does not support the need for an additional air quality monitoring station at Denman. Under north-westerly winds, Denman's air quality is not influenced by Hunter Valley coal mines. The Jerrys Plains air monitoring station, approximately 30 km south east, provides a sentinel for Denman when south-easterly winds may transport dust from mining operations in the south of the region.

Audit recommendation 3 – Maintain existing monitors in the southern part of the Network

Small community air quality monitoring stations at Camberwell, Jerrys Plains, Maison Dieu, Warkworth, Bulga and diagnostic monitoring station at Mount Thorley

The most significant change in the mining footprint in the southern extent of the Upper Hunter is the movement of mining operations towards Bulga (refer to details in Section 4.3).

The independent audit recommended retaining this high density of monitoring stations located between communities and mining operations (Jacobs Group Australia 2017).

The number of days with air quality levels above the PM₁₀ daily benchmark recorded at these five small community sites, from 2012 to 2016, ranged from 13 days in total at Jerrys Plains to 93 days at Camberwell (Figure 2). The Mount Thorley diagnostic monitor recorded 69 days above the PM₁₀ benchmark from 2012 to 2016 (Figure 2).

This report supports the recommendation of the independent audit to maintain this dense network of monitoring stations in the southern extent of the region.

Network monitors at Singleton NW, Singleton and Singleton South

The Singleton monitoring station continues to provide valuable air quality information to the large population centre. PM_{2.5} monitoring at the station continues to be important due to the impact of wood smoke on the community.

Singleton NW continues to provide valuable information about air quality transported toward Singleton in prevailing north-westerly winds.

Singleton South continues to provide valuable information as a background monitoring station to identify the transport of particles from outside of the region.

Audit recommendation 4 – Retention of stations in more remote areas of the region and reviewing proposed and approved changes to industry in the region

This report supports the recommendation that the monitoring stations at Aberdeen and Jerrys Plains be retained despite their good air quality monitoring results, as these stations are located close to the edge of the existing mining footprint.

Changes in the mining footprint are an important consideration in the five-yearly review of the Network.

The Merriwa monitoring station is located in a rural area away from the township of Merriwa. Its purpose is to provide essential information on the transport of particles into the Hunter Valley from the west. This report supports its retention.

Audit recommendation 5 – Review existing industry monitoring

The EPA has recently completed a program of optimising the ambient air quality monitoring carried out by Hunter Valley coal mines. Existing monitoring has been replaced with continuous PM₁₀ monitors that are located upwind and downwind of each mine in the direction of the prevailing strong winds. The data collected from this optimised monitoring will allow the EPA to differentiate between the emissions from each mine.

This program has been implemented by updating the monitoring required by the EPA under Environment Protection Licences. This has removed the requirement for industry to undertake monitoring that duplicates the UHAQMN.

4.3 Can the monitoring program be improved?

The original Network design (Holmes Air Sciences 2008), took into consideration the location of major pollution sources, population centres, the topography of the Hunter Valley and its influence on air movement. These drivers have not changed significantly since the Network was established, resulting in no need to change its fundamental design. Evidence for this finding is presented below.

4.3.1 Topography and meteorology

The original siting of the 14 monitoring stations considered local topography and the north-west to south-east alignment of prevailing winds along the Upper Hunter Valley (Holmes Air Sciences 2008).

The extensive wind data collected by the Network from 2011 to 2016 confirmed that winds flowed predominantly north-westerly and south-easterly in the region (Figure 12).

The topography of the 14 monitoring sites remains unchanged.

4.3.2 Changes in population distribution

The population distribution in the Upper Hunter region changed minimally from 2011 to 2016. A comparison of the Australian Bureau of Statistics⁷ (ABS) Census data for 2011 and 2016 (Table 6 and Table 7) identified the following:

- Population in the local government areas increased by 1.3% in the Singleton Shire, 1.9% in the Muswellbrook Shire and 2.6% in the Upper Hunter Shire (Table 6).
- Population decreased in three of the four small communities included in the Network (with comparable data available between 2011 and 2016) (Table 7).

Table 6 Upper Hunter population by local government area

Population centre	Population 2011	Population 2016	Population net change 2011–2016	Population % change
Singleton	22,694	22,987	+293	+1.3 %
Muswellbrook	15,791	16,086	+295	+1.9 %
Upper Hunter	13,754	14,112	+358	+2.6 %

Table 7 Upper Hunter population in smaller communities

Small community	Population 2011	Population 2016	Population net change 2011–2016	Population % change
Bulga	358	354	–4	–1.1%
Camberwell	181	83	–98	–54.1%
Jerrys Plains	688	385	–303	–44.0%
Maison Dieu	162	181	+19	+11.7%
Warkworth	Not available	49	Not available	Not available
Wybong	Not available	125	Not available	Not available

4.3.3 Changes in the location of major emission sources

The main source of particulate matter in the Hunter Valley is coal mining. The footprint of coal mining operations, in general, extended only marginally from 2011 to 2016. The main areas of expansion are the Mt Pleasant coal mine to the north and the expansion of mining towards Bulga in the south.

Figure 24⁸ shows the region at the end of 2010 compared to the end of 2016. From these maps, visual changes can be seen with:

- commencement of mining at Mt Pleasant (with the first coal production expected in early 2018⁹), north west of Muswellbrook
- growth in the mining area of Mangoola Coal Operations to the south and north west (located between Wybong and Denman)

⁷ Australian Bureau of Statistics [2011 and 2016 census data](#) (accessed September 2017)

⁸ [Google Earth](#) maps

⁹ [MACH Energy Mount Pleasant operation](#)

- growth in the mining area of Muswellbrook Coal (located north east of Muswellbrook)
- growth in the southern part of the mining area of Mt Arthur Coal (located south of Muswellbrook)
- decrease in the mining area of Glendell Mine (located north of Camberwell)
- rehabilitation of open cut mining areas at Ashton Coal Mine north west of Camberwell
- growth in mining area of Rix's Creek Colliery operations (north west of Singleton NW)
- extensive growth in the mining area to the south around Bulga and Warkworth, with Warkworth Coal Mine, Mt Thorley Operations and Bulga Coal Complex mining operations extending further west.

In October 2016, the Department of Planning and Environment released the Hunter Regional Plan 2036, outlining the 20-year plan for the region (DPE 2016). The Department sees coal mining remaining significant in the region and growth occurring in mining equipment, technology and services.

The plan highlights the potential for future expansion in mining operations, with a number of exploration titles current in the region. Although mining activities cannot take place without formal applications, Figure 25 shows the potential extent of mining in the region in the future.

Specifically, for Muswellbrook, the Department highlights the need to manage residential development in the context of potential mining activity in the area.

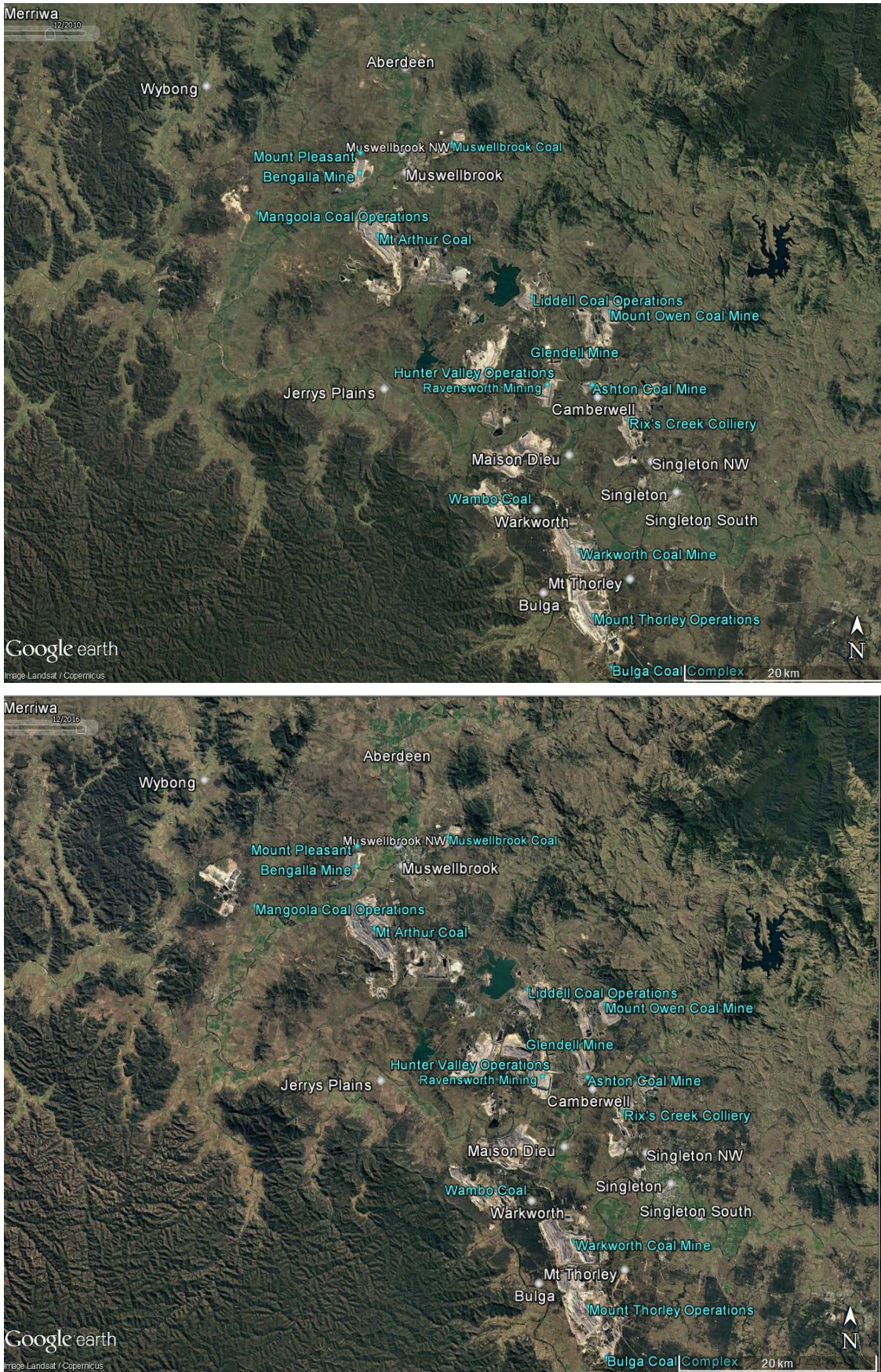


Figure 24 Historic map of the Upper Hunter region with current mining operations (as of 31/12/2010) (top) compared to the current map of the region (as of 31/12/2016) (bottom)

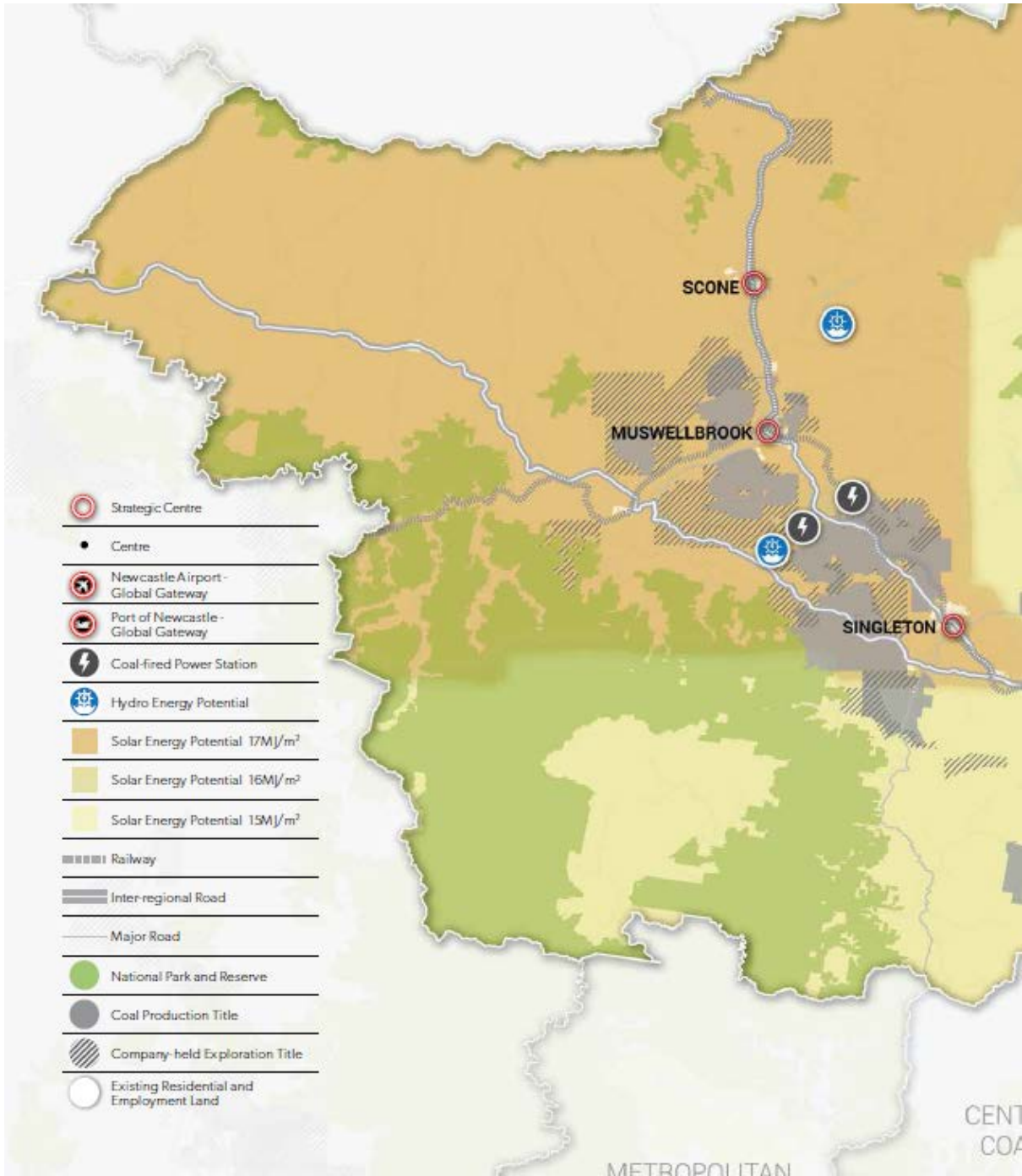


Figure 25 Department of Planning and Environment: Hunter Regional Plan 2036 coal mining and renewable energy map

Source: DPE (2016)

4.3.4 Other improvements to the Network monitoring program

This report supports, in principle, the following additional improvements, proposed by the stakeholders, to ensure that the UHAQMN continues to meet its objectives and provides the best regional air quality information available:

- Install rain gauges at key monitoring sites to further build on the meteorological data and knowledge in the region.
- Investigate the potential for an additional PM_{2.5} particle monitor at the Merriwa monitoring site to better monitor background PM_{2.5} levels.

4.4 Are there any additional matters in relation to the program to consider?

4.4.1 Additional considerations for the program in the next five years

Feedback from stakeholders in the community, industry and government agencies raised the following additional considerations. A response has been provided for each consideration.

- Consider a presentation on the previous year's UHAQMN air quality results provided annually to the Muswellbrook and Singleton communities via a public forum.
 - The EPA will continue to work with the UHAQAC to develop better ways of communicating information on air quality to all relevant stakeholders.
- Better inform the community on changes of sources in the region by incorporating a comment on any new industry closures or approvals in each Upper Hunter annual report.
 - Changes in the mining footprint are an integral consideration in the five-yearly review of the Network.
- Improve access to real-time data for industry to aid them to incorporate these data into models or trigger response action plans in a suitable timeframe.
 - OEH can provide access to real-time data for industry at a cost (required for set-up and telemetry).
- Consider benchmarking the cost of the Network against others or competitively testing the work and including in the budget reports to the UHAQAC.
 - The cost-effectiveness of the network is independently reviewed as part of the five-yearly review.
- Consider setting guidelines around the longevity of monitors that are complementary or play an investigative role when they are implemented, to aid in removing redundant monitors once their specific purpose has been met.
 - The five-yearly review will continue to consider whether any monitors have become redundant.
- Work with councils to raise community awareness of air quality monitoring reporting.
 - The EPA will continue to work with the UHAQAC to develop better ways of communicating information on air quality to all relevant stakeholders.

References

DPE 2016, *Hunter Regional Plan 2036*, Department of Planning and Environment, Newcastle.

Hibberd MF, Selleck PW, Keywood MD, Cohen DD, Stelcer E & Atanacio AJ 2013, *Upper Hunter Particle Characterisation Study*, CSIRO, Australia.

Holmes Air Sciences 2008, *Upper Hunter Valley Monitoring Network Design*, Holmes Air Sciences, Eastwood.

Jacobs Group Australia 2017, *Independent Review of Efficiency and Cost Effectiveness – Upper Hunter Air Quality Monitoring Network*, Project number IA143100, Jacobs Group Australia, Sydney.

Lakmaker S 2015, Dust Forecasting in the Hunter Valley, Australia, *WIT Transactions on Ecology and Environment*, vol.198, pp.275–286.

Protection of the Environment Operations (General) Regulation 2009, historical version for 31 March 2017 to 18 May 2017, www.legislation.nsw.gov.au/#/view/regulation/2009/211 [accessed 7 December 2017].