NSW GOVERNMENT Office of Environment & Heritage

Upper Hunter Air Quality Monitoring Network

2012 Annual Report

Front cover: Muswellbrook North-west site, Upper Hunter Air Quality Monitoring Network.
Photo: Office of Environment and Heritage.

Acknowledgements

The following open-source statistical software was used in the data analysis for this report:

R:
R Development Core Team (2011). *R: A language and environment for statistical computing*.
R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, http://www.R-project.org/.

Openair:
Carslaw, D.C. and K. Ropkins, (2012). *openair - an R package for air quality data analysis.*
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About this report

This is the first calendar year annual report on the Upper Hunter Air Quality Monitoring Network (UHAQMN). It covers the period from 1 January 2012 to 31 December 2012.

The network (with a full complement of 14 monitoring stations) was completed on 20th February 2012 when the monitoring site at Merriwa was finally brought online. Although Merriwa is the only site that does not have a complete 12 month complement of data, there should be enough 2012 data from the network to allow for a sufficiently robust assessment of regional air quality in the Upper Hunter and to begin to discern seasonal trends. An analysis of the variation in weather conditions will require at least three years of data.

This report describes the network performance for 2012 and provides some analysis of the air quality data gathered for the 12-month period to the end of December 2012.

Executive summary

The Upper Hunter Air Quality Monitoring Network (UHAQMN) was established to provide the community with information about levels of particles in the air, to aid in identifying emission sources, and, on a long-term basis, to inform regulatory programs that may be required if these emissions need to be reduced. Hourly updated air quality data from the network are presented on the Office of Environment and Heritage (OEH) website.

The 14 monitoring stations in the UHAQMN serve various purposes:

- **Air quality near larger population centres:** Singleton Central, Muswellbrook Central and Aberdeen
- **Air quality near smaller communities**: Bulga, Camberwell, Warkworth, Maison Dieu, Jerrys Plains and Wybong
- **Diagnostic information**: Mount Thorley, Singleton North West and Muswellbrook North West
- **Background air quality information:** Merriwa and Singleton South.

Monitors in the UHAQMN continuously measure particles (as PM_{10}), wind speed and wind direction at each of the monitoring sites, finer particles (as $PM_{2.5}$) at Singleton, Muswellbrook and Camberwell, and sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) at Singleton and Muswellbrook.

This report provides a review of the Upper Hunter air quality monitoring network for the 12-month period to 31 December 2012. The review includes a basic analysis of air quality compared against national standards, and a few case studies on processes impacting the regional air quality.

Days above benchmark concentrations

Details on days above the benchmark for PM_{10} are set out in Tables 3, 4 and 5 in the main report and for $PM_{2.5}$ in Table 7. A monthly breakdown is provided in Appendix 2.

Daily average PM_{10} and $PM_{2.5}$ levels and daily maximum hourly NO_2 and SO_2 levels are measured against benchmark values of 50 µg/m^3, 25 µg/m^3, 12 pphm and 20 pphm respectively. Days above these national benchmarks during 2012 are outlined in Table ES1.

Of the major population centres, PM_{10} at Muswellbrook and Aberdeen, NO_2 and SO_2 at Singleton and Muswellbrook and $PM_{2.5}$ at Singleton met the relevant benchmarks. Singleton did not meet the annual NEPM goal for PM_{10} as there were 6 days above the national standard of 50 mg/m^3; for $PM_{2.5}$, Muswellbrook experienced 3 days above the national advisory reporting standard of 25 mg/m^3 and exceeded the annual NEPM

standard of 8 $\mu g/m^3$. Potential issues with $PM_{2.5}$ in Muswellbrook identified in previous performance reports remain.

Sources of $PM_{2.5}$ have been further investigated at Singleton and Muswellbrook in a particle characterisation study undertaken for OEH and NSW Health during 2012 (the final report is available at www.environment.nsw.gov.au/aqms/uhaqmnfpcs.htm) .

Of the smaller community sites, PM_{10} levels at Maison Dieu and Camberwell were above the benchmark concentration on 20 and 23 days respectively.

For the diagnostic sites, PM_{10} levels at Mount Thorley and Singleton North West were above the benchmark concentration on 28 and 29 days respectively.

Table ES1: Number of days above the PM_{10}, $PM_{2.5}$, NO_2 and SO_2 benchmark concentrations (1 January 2012 – 31 December 2012)

Parameter	Purpose	2012 Months in Operation	Station	Days above benchmark concentrations
PM_{10}	Population centre	12	Muswellbrook central	1
		12	Singleton central	6
		12	Aberdeen	0
	Smaller community	12	Maison Dieu	20
		12	Camberwell	23
		12	Jerrys Plains	0
		12	Bulga	2
		12	Wybong	1
		12	Warkworth	0
	Diagnostic	12	Singleton NW	29
		12	Mount Thorley	28
		12	Muswellbrook NW	1
	Background	12	Singleton South	2
		11	Merriwa	1
$PM_{2.5}$	Population centre	12	Muswellbrook central	3
		12	Singleton central	0
NO_2/SO_2	Population centre	12	Muswellbrook central	0
		12	Singleton central	0

Population centres: days above benchmark

Particles ≤ 5, > 5

NO_2/SO_2 ≤ 1, > 1

Diagnostic sites: days above benchmark

Particles

NOTE: NEPM goals not intended to apply to diagnostic sites

NOTE: some of the days above benchmark may be common to multiple sites.

Online performance of the UHAQMN

An operational aim of the network is to achieve at least 95% online time for all parameters measured, allowing for maintenance and calibration. During 2012, the network met the 95% online requirement with the exceptions of NO_2 at Singleton and Muswellbrook, and SO_2 at Muswellbrook (Table ES2).

Table ES2: Online performance of the UHAQMN (1 January 2012 – 31 December 2012)

Site	Start date	PM_{10}	$PM_{2.5}$	Wind direction	Wind speed
Muswellbrook Central	9/12/2010	✻✻✻✻	✻✻✻✻	✻✻✻✻	✻✻✻✻
Singleton Central	9/12/2010	✻✻✻✻	✻✻✻✻	✻✻✻✻	✻✻✻✻
Maison Dieu	1/04/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Camberwell	25/07/2011	✻✻✻✻	✻✻✻✻	✻✻✻✻	✻✻✻✻
Mount Thorley	25/07/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Singleton NW	25/07/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Bulga	12/08/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Aberdeen	15/12/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Jerrys Plains	15/12/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Muswellbrook NW	15/12/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Singleton South	15/12/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Warkworth	15/12/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Wybong	15/12/2011	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻
Merriwa	20/02/2012	✻✻✻✻	NA	✻✻✻✻	✻✻✻✻

Site	Start date	NO_2	SO_2
Muswellbrook[(1)]	18/11/2011	✻✻✻ (94%)	✻✻✻ (94%)
Singleton[(1)]	18/11/2011	✻✻✻ (94%)	✻✻✻✻

[(1)] Gaseous monitors for NO_2 and SO_2 undergo daily calibrations, so the potential online time is only 96%.

Key

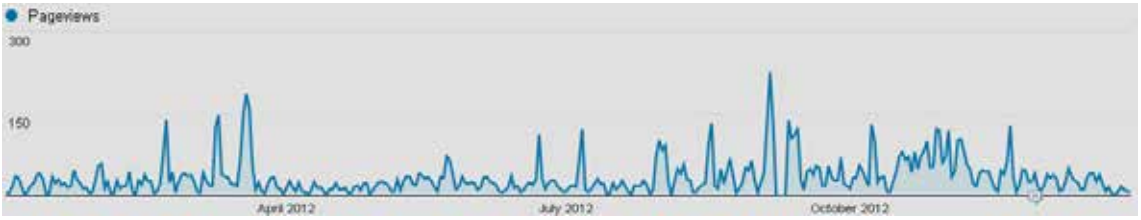
NA	Not applicable
✻✻✻✻	≥ 95 % online
✻✻✻	90 – 94% online
✻✻	85 – 89% online
✻	< 75% online

Webpage activity for the UHAQMN

For the map webpage (www.environment.nsw.gov.au/aqms/uhunteraqmap.htm), the number of page views for the period 1 January 2012 – 31 December 2012 is shown in Figure ES1 below.

The number of visits cycles between 0 – 40 during the week from Saturday to Thursday with large spikes in pages being viewed coinciding with days when particulate matter levels were elevated.

Figure ES1: Page views for the UHAQMN map webpage (1 January 2012 – 31 December 2012)



The website, which is updated hourly, provides facilities for viewing Upper Hunter air quality data. Anyone visiting the website can view the hourly PM_{10}, $PM_{2.5}$, wind direction and wind speed data, create their own graphs of the hourly data, download historical data and compare Upper Hunter values to those for the rest of NSW.

SMS and email alerts

As with OEH's main Air Quality Monitoring Network, readings from the UHAQMN trigger automatic SMS and email alerts to inform the community when air quality is 'poor'. This is designed to allow those members of the community who may be susceptible to air pollution (e.g. asthmatics, people with heart disease) to subscribe to these automatic alerts.

OEH promotes this service via its website, through community meetings and communication with stakeholders and through the media. You can subscribe to the alerts at www.environment.nsw.gov.au/aqms/subscribe.htm.

Numbers of subscribers to the UHAQMN alerts (as at 31 December 2012) are shown in Table ES3.

Table ES3: Numbers of subscribers to the alerts (as at 31 Dec 2012)

Subscription type	Site	Date online	Number of public subscribers
Email alerts	Muswellbrook Central	9/12/2010	109
	Singleton Central	9/12/2010	126
	Maison Dieu	1/04/2011	62
	Camberwell	25/07/2011	62
	Mt Thorley	25/07/2011	66
	Singleton NW	25/07/2011	83
	Bulga	12/08/2011	60
	Aberdeen	15/12/2011	46
	Jerrys Plains	15/12/2011	49
	Muswellbrook NW	15/12/2011	53
	Singleton South	15/12/2011	55
	Warkworth	15/12/2011	50
	Wybong	15/12/2011	40
	Merriwa	20/02/2012	41
SMS alerts	Muswellbrook Central	9/12/2010	46
	Singleton Central	9/12/2010	50
	Maison Dieu	1/04/2011	29
	Camberwell	25/07/2011	25
	Mt Thorley	25/07/2011	31
	Singleton NW	25/07/2011	34
	Bulga	12/08/2011	27
	Aberdeen	15/12/2011	20
	Jerrys Plains	15/12/2011	24
	Muswellbrook NW	15/12/2011	24
	Singleton South	15/12/2011	25
	Warkworth	15/12/2011	24
	Wybong	15/12/2011	17
	Merriwa	20/02/2012	18

large population centre
small population centre
diagnostic site
background site

NOTE: Alerts are provided when **rolling 24-hour averages** for PM_{10} or $PM_{2.5}$ concentrations are above the benchmark concentrations of 50 µg/m^3 and 25 µg/m^3 respectively.

1 About the Upper Hunter Air Quality Monitoring Network

1.1 What is the network?

The Upper Hunter Air Quality Monitoring Network (UHAQMN) is a high-quality, regional air quality monitoring network that continuously measures dust particles, meteorology and gases in the 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) website.

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

The network continuously measures:

- particles (as PM_{10}), wind speed and wind direction at all 14 monitoring sites
- finer particles (as $PM_{2.5}$) at Singleton, Muswellbrook and Camberwell, and
- the gases sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) at Singleton and Muswellbrook.

1.2 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 staff using funds contributed by industry under Chapter 5A of the *Protection of the Environment (General) Regulation* 2009.

The Upper Hunter Air Quality Monitoring Network Advisory Committee was established to advise OEH (now it advises the NSW Environmental Protection Authority [EPA]) on matters specifically related to the design and operation of the network. The Advisory Committee has 13 members representing the community, the coal and power generation industries, local government and NSW government agencies.

The Advisory Committee met twice during 2012, monitoring the operation of the network.

1.3 What can the network tell us?

The network provides 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:

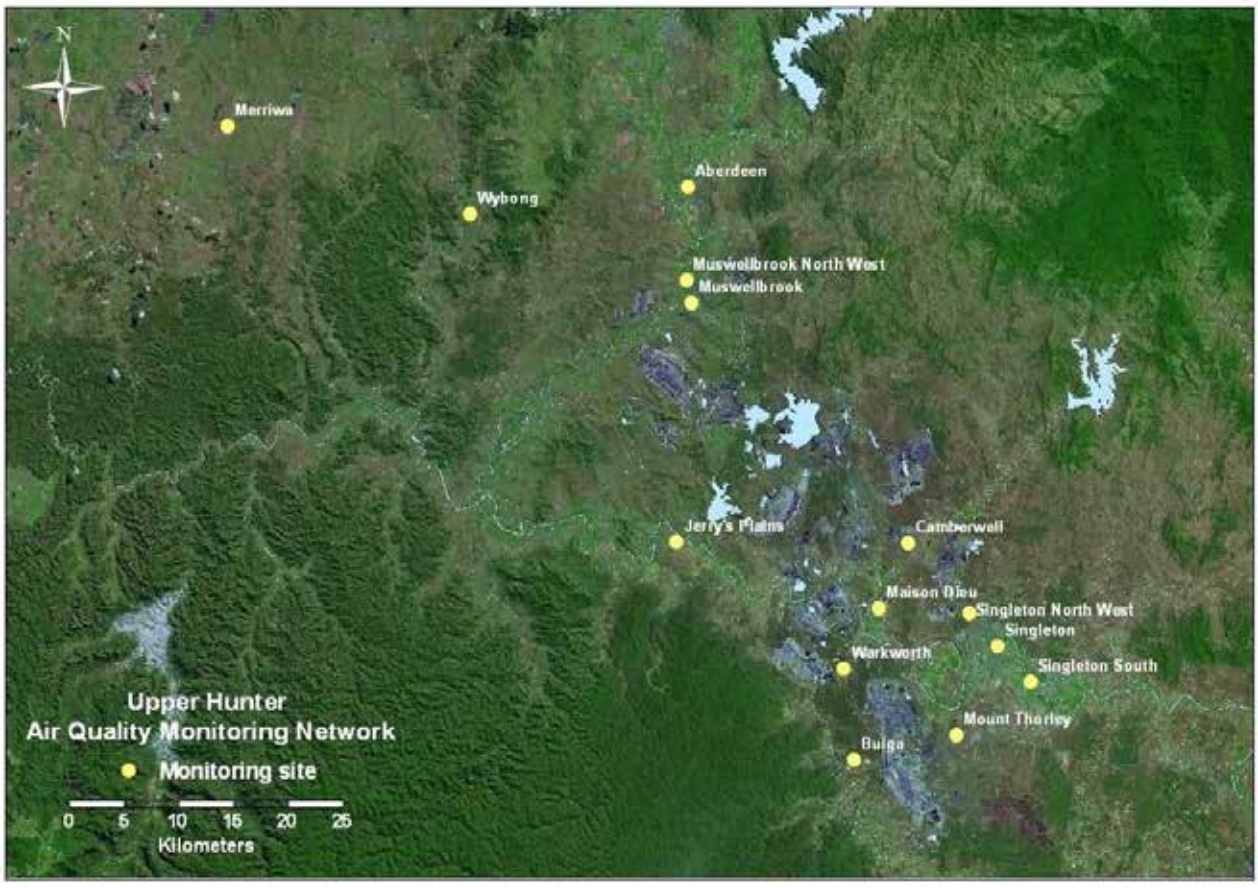
- assess changes in air quality
- help identify the major sources of the monitored pollutants, and
- inform regulatory programs in response to long-term trends.

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

1.4 Where are the monitoring stations located?

The locations of the UHAQMN sites are shown in Figure 1.

Figure 1: Monitoring station locations



1.5 Do all the monitoring stations serve the same purpose?

The monitoring network is based on a design developed by Holmes Air Sciences in 2008. The 14 monitoring stations have been located to serve different purposes (see Table 1).

- **Larger population centres:** the stations near the larger population centres monitor the air quality in these centres.
- **Smaller communities:** the stations located in smaller communities monitor the air quality at those locations.
- **Diagnostic:** these sites provide data that can help to diagnose the likely sources and movement of particles across the region as a whole; they don't provide information about air quality at population centres.
- **Background:** the stations near Merriwa and Singleton South are at both ends of the valley and provide background data, measuring the quality of air entering and leaving the Hunter Valley under predominant winds (south-easterlies and north-westerlies).

Table 1: Purposes of the monitoring stations in the UHAQMN

Purpose	Stations	
Monitoring air quality in the larger population centres	Muswellbrook Central	The intention of the network design is that data gathered from the UHAQMN as a whole can be analysed to provide insights about Upper Hunter regional air quality and long-term trends in air quality.
	Singleton Central	
	Aberdeen	
Monitoring air quality in the smaller communities	Maison Dieu	
	Camberwell	
	Jerrys Plains	
	Bulga	
	Wybong	
	Warkworth	
Providing diagnostic data	Singleton NW	
	Mount Thorley	
	Muswellbrook NW	
Providing background data	Singleton South	
	Merriwa	

1.6 How is the network performing?

For particle, wind speed and direction data during 2012, the network provided valid and accurate data in excess of 95% of the time; for nitrogen dioxide at Muswellbrook and Singleton there was 94% valid data and for sulfur dioxide at Muswellbrook and Singleton there was greater than 95% and 94% valid data respectively (Table ES2).

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 to ensure that data provided to the community are accurate and timely. Maintenance and calibration tasks require approximately 5% of the network's running time. An operational aim of the network then, is to achieve at least 95% online time for all parameters measured.

Gaps in hourly data

Under national air quality guidelines and protocols, an 'average' is deemed valid only when at least 75% of data during the averaging period is valid. (Therefore, a valid rolling 24-hour average or daily 24-hour average is only calculated when at least 18 valid hourly averages are available). As a consequence, where hourly data values are marked invalid, there may be periods when daily averages are not reported on the OEH website.

Gaps in data can be due to:

- **scheduled maintenance and calibration where the following are carried out on a regular basis:**

  For particles:
  - quarterly: clean sample head and inlet and replace filters; leak check (1–2 hours)
  - 6-monthly: flow audit (1–2 hours)
  - annual: software (1–2 hours) and hardware calibration (1–2 hours); zero stability check (at least 8 hours); site audit (1–2 hours)

  For NO_2/SO_2:
  - daily: overnight zero span calibration (1 hour)
  - monthly: replace filters (approx. 1 hour)
  - quarterly: clean sample head and inlet (approx. 1 hour)
  - 6 monthly: linearity check/calibration (2–3 hours)

- **equipment failure at site or communications failure between instrument and data logger (variable)**: data can be lost for either of these reasons – there will be gaps in the database and on the web
- **power outages at site (variable)**: data is lost as equipment is powered off during the outage

- **telecommunication problems (variable)**: data will not be loaded to the website during this period; however, the data is not lost but downloaded to the database and uploaded to the web once communication is re-established
- **website maintenance (variable)**: data is not lost because it is stored locally until the website is up and running again.

However, in spite of this potential for data loss, the network is maintaining the 95% benchmark for online performance.

1.7 What are the national benchmarks for air quality?

The Australian benchmarks for air quality are set in the Ambient Air Quality National Environment Protection Measure (the Air NEPM). The Air NEPM defines the national ambient air quality standards and goals for various pollutants, including the concentration of particles.

Table 2: NEPM standards and goals for dust particles, sulfur dioxide and nitrogen dioxide

Pollutant	How often is the average measured?	Benchmark (concentration)	Goal: how often can the concentration exceed this benchmark?
Particles as PM_{10}	Daily: 1 calendar day (24 hours)	50 µg/m^3	Maximum 5 days a year
Particles as $PM_{2.5}$	Daily: 1 calendar day (24 hours)	25 µg/m^3	The goal is to gather sufficient information to allow a standard to be set for $PM_{2.5}$ when the Air NEPM is reviewed. These benchmarks are an Australia-wide advisory reporting standard, in use until a standard has been set.
	Annual: 1 calendar year (12 months)	8 µg/m^3	
Sulfur dioxide (SO_2)	Hourly	20 pphm	Maximum 1 day a year
	Daily: 1 calendar day (24 hours)	8 pphm	Maximum 1 day a year
	Annual: 1 calendar year (12 months)	2 pphm	Never
Nitrogen dioxide (NO_2)	Hourly	12 pphm	Maximum 1 day a year
	Annual: 1 calendar year (12 months)	3 pphm	Never

For example, this means that the daily average concentration of PM_{10} particles should not exceed 50 µg/m^3 more than five days a year.

Note that SO_2 and NO_2 are measured in parts per hundred million (pphm) where pphm = parts per million by volume, i.e. parts of pollutant per hundred million parts of air.

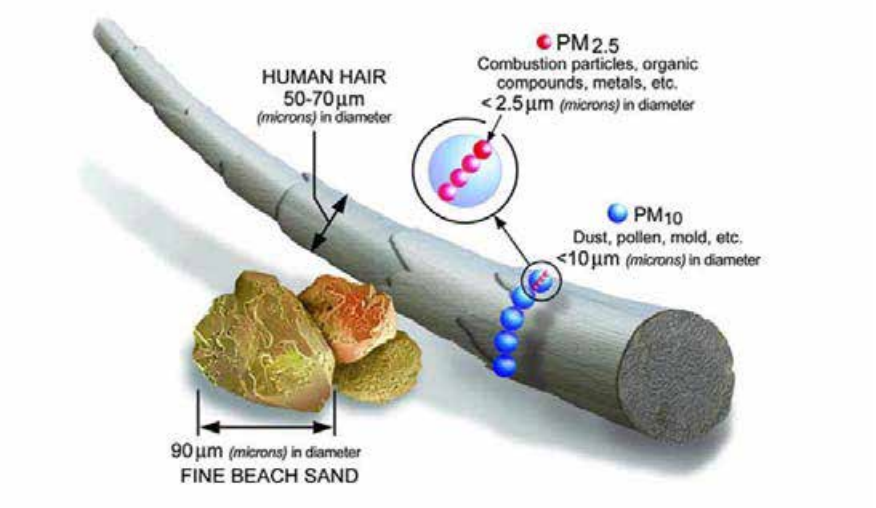
Measuring dust particles

Particle size (µm)

Particles are measured as:

- PM_{10} (particles 10 micrometres in diameter and smaller), and
- $PM_{2.5}$ (finer particles 2.5 micrometres in diameter and smaller).

1 micrometre (µm) = one millionth of a metre (also called a 'micron').



Particulate matter (reproduced with permission from the US EPA, Office of Research and Development)

Particle concentration (µg/m^3)

The concentration of dust particles in the air is measured as the mass of the particle in micrograms (µg) per volume of air in cubic metres (m^3).

1 microgram (µg) = one millionth of a gram.

1.8 How do these benchmarks apply to the Upper Hunter region?

For sites near population centres, air quality data can be compared against the relevant Air NEPM concentration values for PM_{10} (50 µg/m^3 averaged over 24 hours). Although there is no national goal for $PM_{2.5}$, data from the network can be compared to the advisory reporting standard of 25 µg/m^3 (averaged over 24 hours).

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

Measurements of NO_2 and SO_2 (at Muswellbrook Central and Singleton Central) can be compared to the national benchmarks for these pollutants (Table 2).

2 Upper Hunter air quality during 2012

2.1 PM_{10} monitoring data

PM_{10} in larger population centres

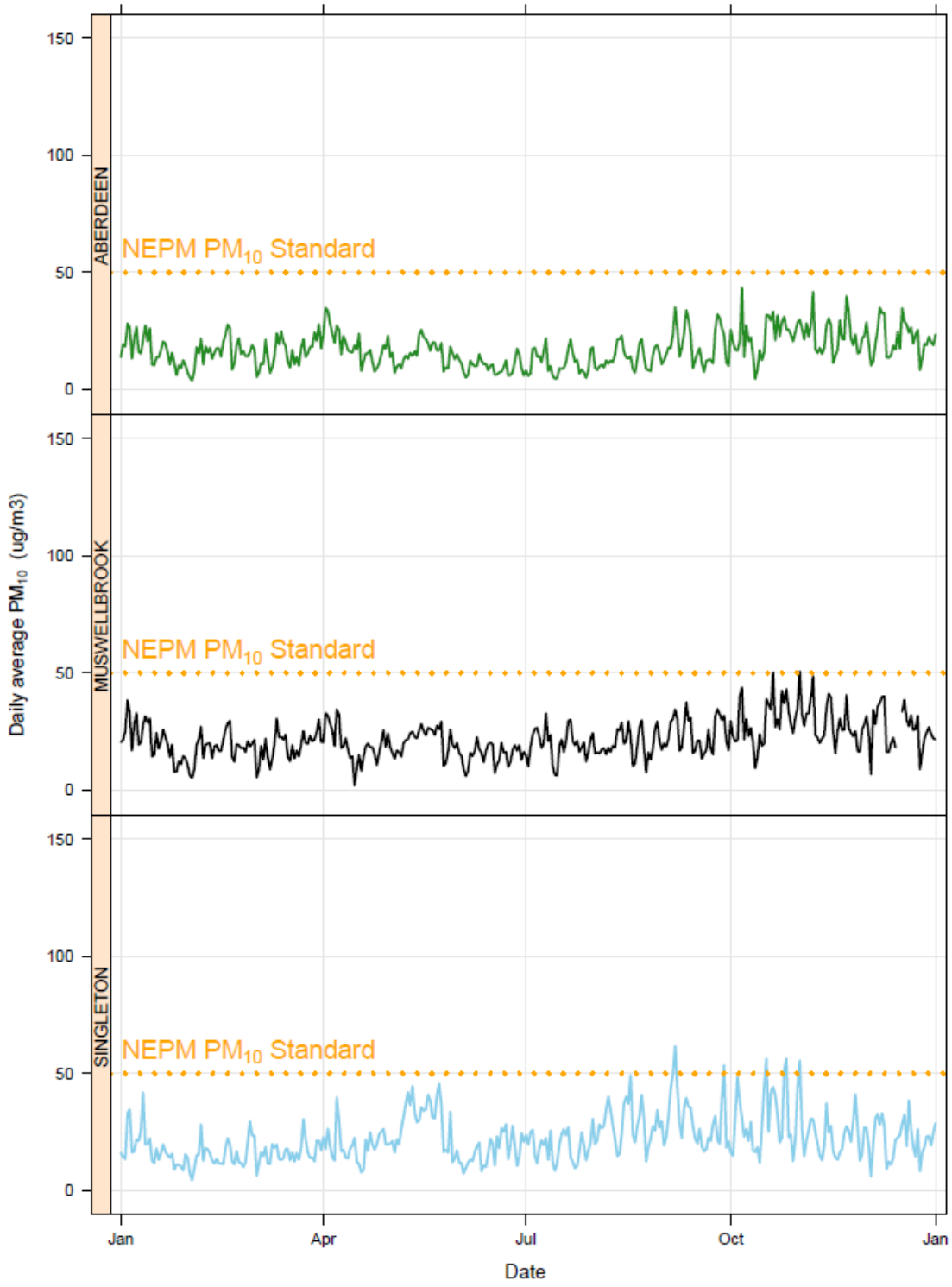
The NEPM goal for PM_{10} is for no more than five days over the benchmark in a 12-month period. Table 3 shows sites, days and associated daily conditions during the reporting period where the daily average PM_{10} exceeded the 50 µg/m^3 benchmark. Muswellbrook Central and Aberdeen monitoring sites achieved the Air NEPM goal during 2012 (Figure 2).

- Daily average PM_{10} levels at Aberdeen were less than the 50 µg/m^3 benchmark throughout the reporting period.
- Daily average PM_{10} levels at Muswellbrook Central were less than the 50 µg/m^3 benchmark throughout the reporting period except for one day (20 October 2012) with a PM_{10} daily average of 51.0 µg/m^3. Conditions on this day and the preceding were hot (33-35°C maximum temperature) with slightly windy conditions (approximately 23 km/h around midday) preceding a change in direction to the south-east from the north-west.
- Daily average PM_{10} levels at Singleton Central were below the 50 µg/m^3 benchmark throughout the reporting period except for six days during 2012. See Table 3 for details on levels and meteorological conditions for these days.

Table 3: Larger population centres – days above the PM_{10} benchmark (1 January 2012 – 31 December 2012)

Station	Daily average concentration (µg/m^3)	Date	Comments (including wind direction associated with elevated hourly values)
Muswellbrook Central	51.0	20/10/2012	Hot conditions for two days with moderate NW to SE winds
Singleton Central	63.6	6/09/2012	Warm conditions for two days with moderate NW winds.
	53.3	28/09/2012	Hot conditions for two days with moderate NW winds
	54.7	17/10/2012	Hot conditions for two days with moderate winds from the NW swinging to SE.
	52.1	25/10/2012	Hot conditions for two days with moderate NW winds
	54.7	26/10/2012	Hot conditions for two days with slight to moderate NW winds.
	55.5	1/11/2012	Hot conditions for two days with moderate winds from the NW.

Figure 2: Larger population centres – daily average PM_{10} levels (1 January 2012 – 31 December 2012)



PM_{10} in smaller communities

Daily average PM_{10} levels at Jerrys Plains and Warkworth were less than the 50 µg/m^3 benchmark throughout 2012. Daily average PM_{10} levels at Bulga, Camberwell, Maison Dieu and Wybong were above the 50 µg/m^3 benchmark on 2, 23, 20 and 1 day/s respectively (Figure 3).

Table 4 lists sites, days and associated daily conditions during the 2012 reporting period where the daily average PM_{10} exceeded the 50 µg/m^3 benchmark.

Figure 3: Smaller communities – daily average PM_{10} levels (1 January 2012 – 31 December 2012)

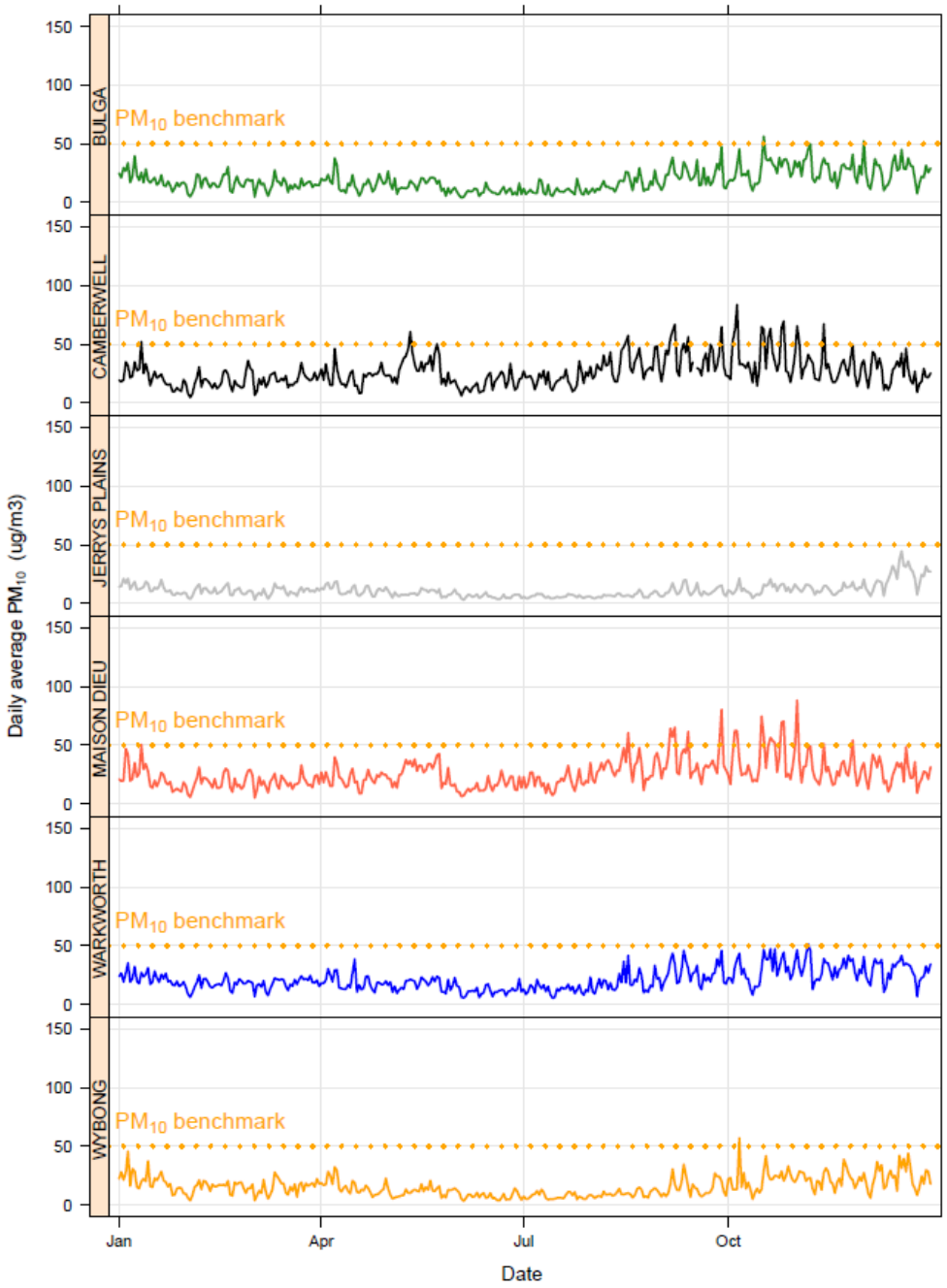


Table 4: Smaller communities – days above the PM_{10} benchmark (1 January 2012 – 31 December 2012)

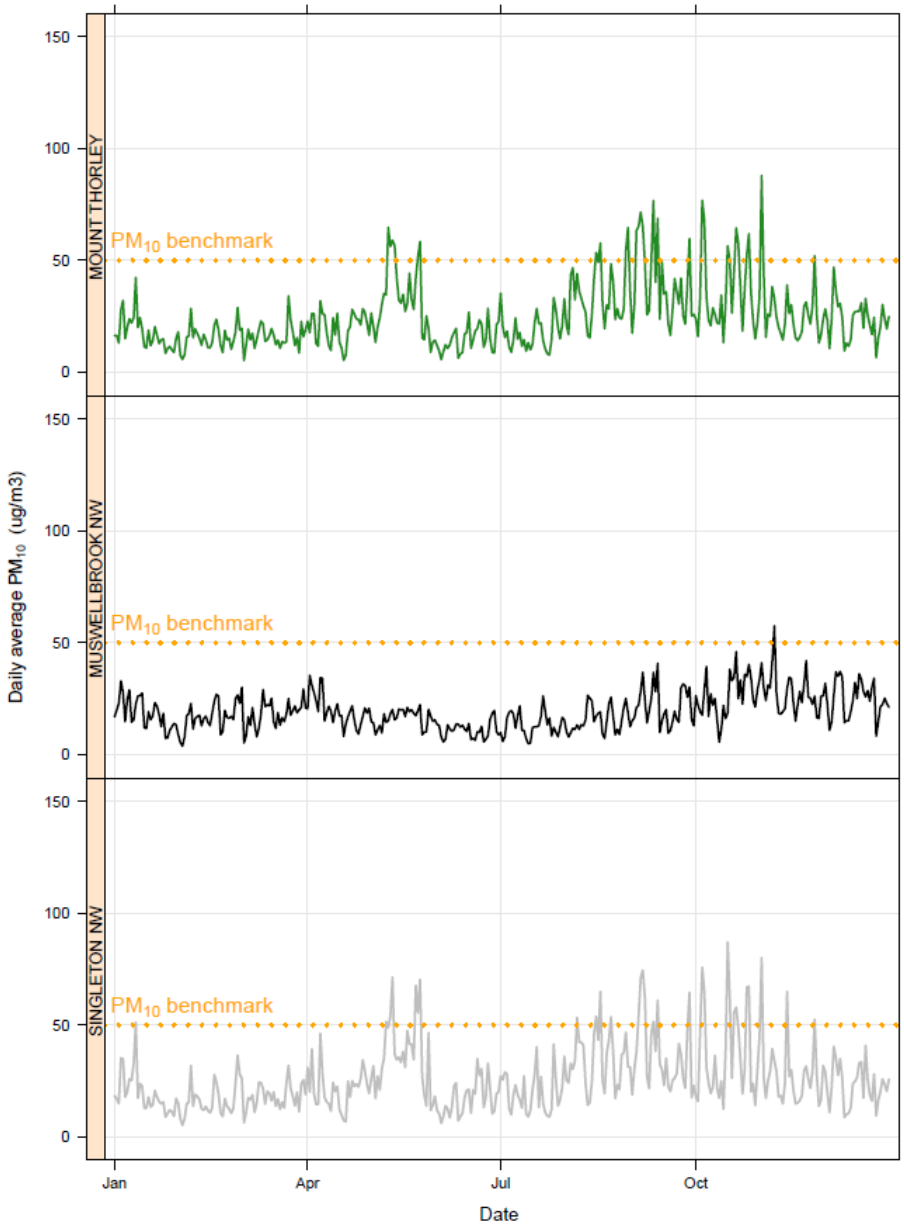
Station	Daily average concentration ($\mu g/m^3$)	Date	Comments (including wind direction associated with elevated hourly values)
Camberwell	52.4	11/01/2012	Daily, elevated hourly values associated with moderate winds from NW–NNW
	60.4	11/05/2012	Daily, winds from WNW
	51.5	16/08/2012	Overnight, winds from WNW
	57.6	17/08/2012	Daily, elevated hourly values associated with moderate WNW winds
	56.8	05/09/2012	Daily, winds from the NW
	60.6	06/09/2012	Daily, winds from the NW
	65.9	07/09/2012	Daily, winds from the NW
	50.1	11/09/2012	Daily, winds from the ESE
	55.2	13/09/2012	Daily, moderate winds from the WNW
	51.9	23/09/2012	Overnight, winds from the WNW
	65	28/09/2012	Daily, winds from the WNW
	57.6	03/10/2012	Overnight, winds from the NW
	59.9	04/10/2012	Overnight, winds from the NW
	81.6	05/10/2012	Overnight, winds from the NW
	67	16/10/2012	Overnight, winds from the W
	60.9	17/10/2012	Overnight, moderate winds from NW
	57.8	19/10/2012	Daily, winds from the NW
	61.5	20/10/2012	Daily, winds from the NW
	67.5	25/10/2012	Overnight, winds from the W-NW
	67.2	26/10/2012	Overnight, winds from the W-NW
	64.5	01/11/2012	Daily, winds from the W-NW
	51.5	02/11/2012	Daily, winds from the SW-W
	66.2	13/11/2012	Daily, winds from the SW-NW
Maison Dieu	50.6	11/01/2012	Daily, moderate to strong SW-NW winds
	59.6	17/08/2012	Daily, moderate to strong NW-NNW winds
	66.7	05/09/2012	Daily, moderate to strong NNW winds
	55.9	06/09/2012	Daily, moderate to strong NNW winds
	64.2	07/09/2012	Daily, moderate to strong winds from NNW
	60	13/09/2012	Daily, moderate to strong winds from NNW
	53.9	27/09/2012	Daily, winds from the NNW
	81.6	28/09/2012	Daily, moderate winds from the NNW

	62.2	04/10/2012	Daily, moderate winds from the NNW
	60.6	05/10/2012	Daily, moderate winds from the NNW
	76	16/10/2012	Winds from NNW
	56.2	17/10/2012	Winds from NNW
	50.2	19/10/2012	Winds from NNW
	56	20/10/2012	Daily, moderate winds from the NNW
	55.9	21/10/2012	Daily, winds from the NNW
	74.7	25/10/2012	Winds from the NNW
	64.7	26/10/2012	Overnight winds from NW through to SE
	87.7	01/11/2012	Moderate winds from the NW
	51.3	13/11/2012	Daily, moderate winds from SW through to NW
	53.4	26/11/2012	Overnight, moderate winds from the E
Bulga	55.1	17/10/2012	Winds from the NW
	53.2	01/12/2012	Daily, winds from the SE
Wybong	54.4	6/10/2012	Overnight, winds from the SSE

PM_{10} at diagnostic sites

These sites, operating close to existing mines, are intended to provide information on trends and likely sources of dust to assist in the interpretation of elevated particle levels in population centres.

Figure 4: Diagnostic sites – daily average PM_{10} levels (1 January 2012 – 31 December 2012)



For the Muswellbrook NW site there was one day above the 50 µg/m^3 PM_{10} benchmark, while for Singleton NW and Mount Thorley there were 29 and 28 days respectively above this benchmark.

Table 5 lists the days when elevated particle levels were recorded and provides information on the governing weather conditions on these days.

Table 5: Diagnostic sites – days above the PM_{10} benchmark (1 January 2012 – 31 December 2012)

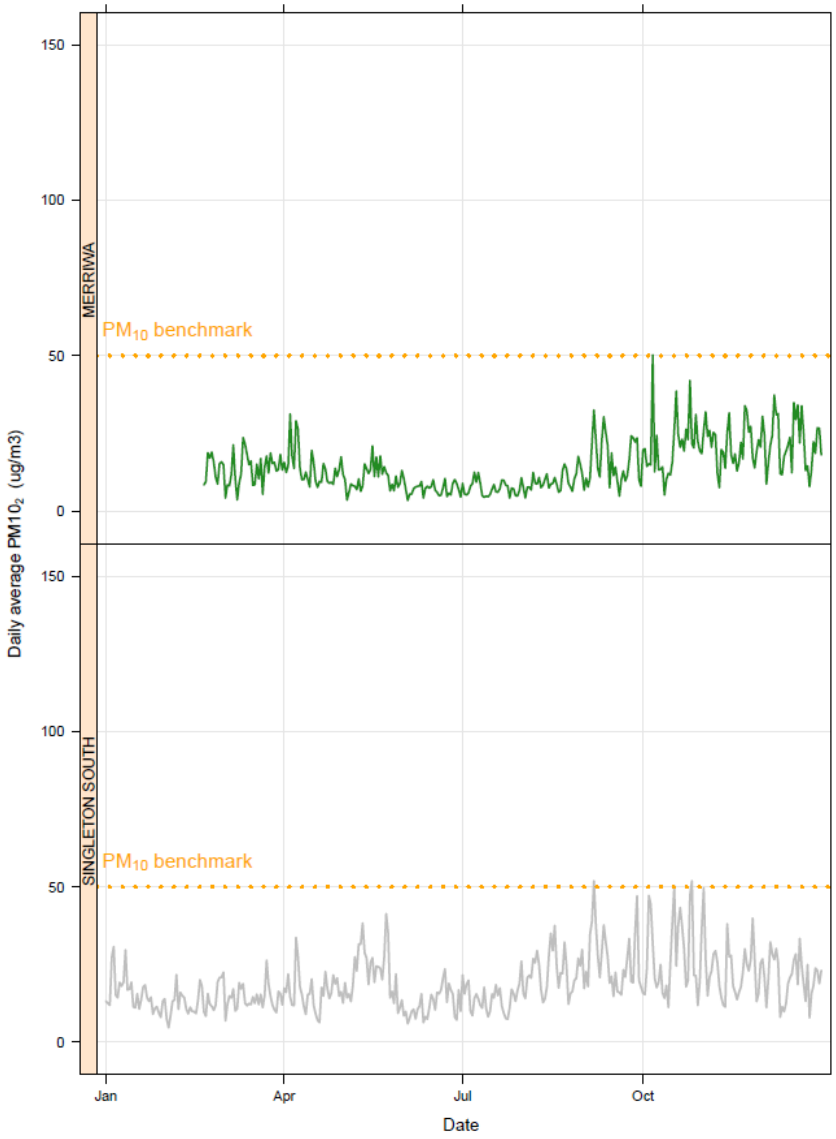
Station	Daily average concentration ($\mu g/m^3$)	Date	Comments (including wind direction associated with elevated hourly values)
Mount Thorley	65.7	9/05/2012	Overnight, winds from S
	54.7	10/05/2012	Overnight, winds from S
	61.7	11/05/2012	Overnight, winds from SSW
	54.0	12/05/2012	Overnight, winds from SSW
	53.7	23/05/2012	Overnight, winds from S
	55.1	24/05/2012	Overnight to midday, winds from S and swinging from N to S
	56.4	15/08/2012	Overnight, winds from S and swinging from N to S
	56.7	17/08/2012	During day, winds from WSW through to N
	54.1	29/08/2012	Overnight, winds from S
	65.0	30/08/2012	Overnight, winds from S and during day moderate winds from NW
	67.1	3/09/2012	Overnight, winds from N through to S
	61.9	4/09/2012	Overnight, calm to very light winds from S
	70.9	5/09/2012	Overnight, winds from S and during day from WNW
	63.0	6/09/2012	Overnight, moderate winds from WNW
	51.0	10/09/2012	Overnight, winds from S and during day from N through to S
	75.9	11/09/2012	Overnight from S through to NW
	67.9	13/09/2012	Overnight, winds from S and during day moderate winds from WNW
	50.9	15/09/2012	Overnight, winds from S through to WNW
	60.7	28/09/2012	Overnight, winds from N to NW and moderate WNW winds during day
	71.1	4/10/2012	Overnight, winds from SSW and from WNW through to N
	68.1	5/10/2012	Overnight, winds from SSE
	56.9	16/10/2012	Overnight, winds from S and WNW
	64.0	20/10/2012	Overnight, winds from S to WNW
	58.8	21/10/2012	During morning, winds from WNW
	56.0	25/10/2012	During day and overnight, winds from WNW
	59.3	26/10/2012	Overnight, winds from WSW
	88.7	1/11/2012	Overnight, winds from S and evening, winds from WNW
	51.4	26/11/2012	Overnight, winds from S to SSW and SSW during afternoon

Singleton NW	52.9	8/05/2012	Morning and evening, winds from the NW
	58.6	10/05/2012	Daily, winds from the NW
	67.5	11/05/2012	Daily, winds from the NW
	67.8	22/05/2012	Morning and evening, winds from the NW
	55.4	23/05/2012	Daily, winds from the NW
	69.4	24/05/2012	Morning, winds from the NW swinging to N
	54.6	6/08/2012	Morning, moderate winds from the NW
	52.8	15/08/2012	Morning and afternoon, winds from the NW
	64.0	17/08/2012	Afternoon to evening, strong winds from the NW
	54.9	22/08/2012	Morning and evening, winds from the NW
	54.7	4/09/2012	Morning and evening, winds from the NW
	72.0	5/09/2012	Daily, moderate winds from the NW
	74.8	6/09/2012	Daily, strong winds from the NW
	59.8	7/09/2012	Morning and evening, strong winds from the NW
	50.9	11/09/2012	Morning, winds from the NW swinging to the SE
	61.0	13/09/2012	Morning, winds from the NW
	63.5	28/09/2012	Daily, strong winds from the NW
	51.3	3/10/2012	Morning and evening, winds from the NW
	73.2	4/10/2012	Morning and evening, winds from the NW
	63.5	5/10/2012	Morning and evening, winds from the NW
	85.3	16/10/2012	Morning and evening, winds from the NW
	59.6	17/10/2012	Morning through to afternoon, winds from the NW swinging to the SE
	57.4	19/10/2012	Daily, winds from the NW
	56.8	20/10/2012	Morning and evening, winds from NW swinging to SE
	71.0	25/10/2012	Morning and evening, winds from the NW
	62.8	26/10/2012	Morning and evening, winds from the NW swinging to the SE
	79.1	1/11/2012	Morning and evening, moderate winds from the NW
	64.8	13/11/2012	Morning and afternoon, winds from the NW swinging to the SE
	52.1	26/11/2012	Daily, winds swinging from NW to SE
Muswellbrook NW	55.8	7/11/2012	Morning and evening, winds swinging from NW to NE

PM_{10} at background sites

Background monitoring sites were placed at the northern and southern ends of the Upper Hunter Valley (Merriwa and Singleton South) to provide information on levels of particles in air travelling into and out of the valley.

Figure 5: Background sites – daily average PM_{10} levels (1 January 2012 – 31 December 2012)



The predominant wind pattern for the upper Hunter Valley during summer is from the south-east, during winter winds are predominantly from the north-west and during autumn and spring wind patterns can vary between north-west and south-east. The daily PM_{10} benchmark of 50 mg/m3 was exceeded on 2 days (one in September and one in October) at Singleton South when winds were from the north-west and on one day in October at Merriwa when winds were from south-east (see Table 6).

Table 6: Background sites – days above the PM_{10} benchmark (1 January 2012 – 31 December 2012)

Station	Daily average concentration ($\mu g/m^3$)	Date	Comments (including wind direction associated with elevated hourly values)
Merriwa	50.4	06/10/2012	Overnight and during day with moderate SE winds
Singleton South	52.3	06/09/2012	Moderate to high NW winds during day
	50.5	25/10/2012	Moderate to high NW winds during day

Summary - PM_{10} monitoring in 2012

§ **Larger population centres**

All except Singleton Central complied with the Air NEPM goal for 24-hour PM_{10} (less than 5 days above 50 $\mu g/m^3$) during 2012. The six exceedence days at Singleton Central co-incided with exceedence days at Camberwell and Maison Dieu. Consecutive hot days during the spring season, combined with down-valley (north-westerly) winds were associated with these events. Overall, the larger population centres had fewer exceedences than smaller communities within the centre of the Upper Hunter Valley.

§ **Smaller community sites**

Camberwell and Maison Dieu recorded the highest frequency of days above the PM_{10} benchmark (23 and 20 days respectively). These events were common during the spring season, and associated with winds from the north-west sector, but also from various other directions.

§ **Diagnostic sites**

Singleton NW and Mount Thorley had the highest frequency of days above the PM_{10} benchmark (29 and 28 days respectively). These events were observed during the spring season, combined with northern sector winds for Singleton NW and during winter and spring for Mt Thorley with winds from south, westerly and north-westerly directions.

§ **Background sites**

There were 2 exceedence days (one in September and one in October) at Singleton South when winds were from the north-west and on one day in October at Merriwa when winds were from south-east

CASE STUDIES

Case Study I: PM_{10} at Maison Dieu

During most of 2012, daily average PM_{10} levels at the Maison Dieu monitoring station remained below the PM_{10} benchmark until hot and dry conditions prevailed during August to October (Figure 6a).

Maison Dieu station is surrounded by coal mines to the west, north, east, south-west and south. Figures 6b and 6c indicate that higher levels of PM_{10} (> 100 ug/m^3) were associated with moderately strong winds from the NW and W during the daytime.

The pollution rose in Figure 6d also indicates that throughout 2012 in general very high hourly levels were associated with winds directly from the west and south and from the NW and NE sectors.

Figure 6a: Maison Dieu – daily average PM_{10} levels (1 January 2012 – 31 December 2012)

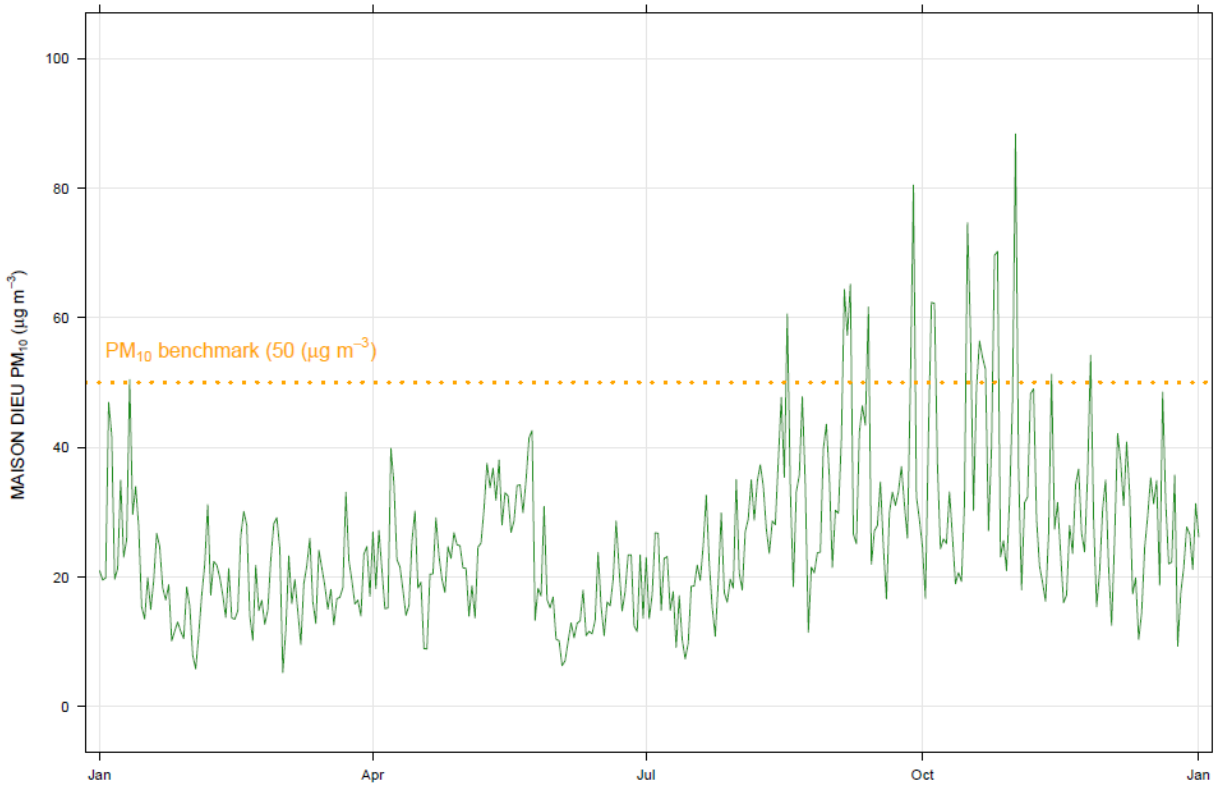


Figure 6b: Maison Dieu – hourly average PM_{10} levels and wind conditions (5–28 September 2012)

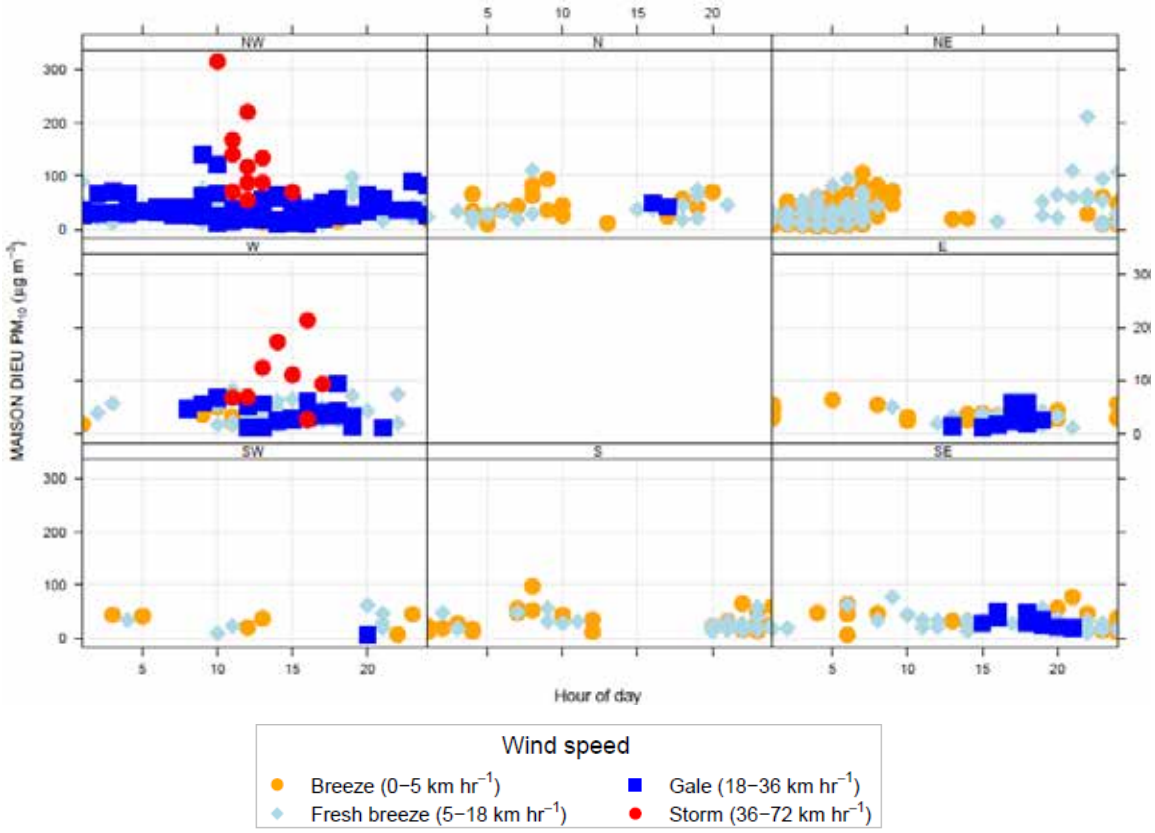


Figure 6c: Maison Dieu – hourly average PM_{10} levels and wind conditions (16–21 October 2012)

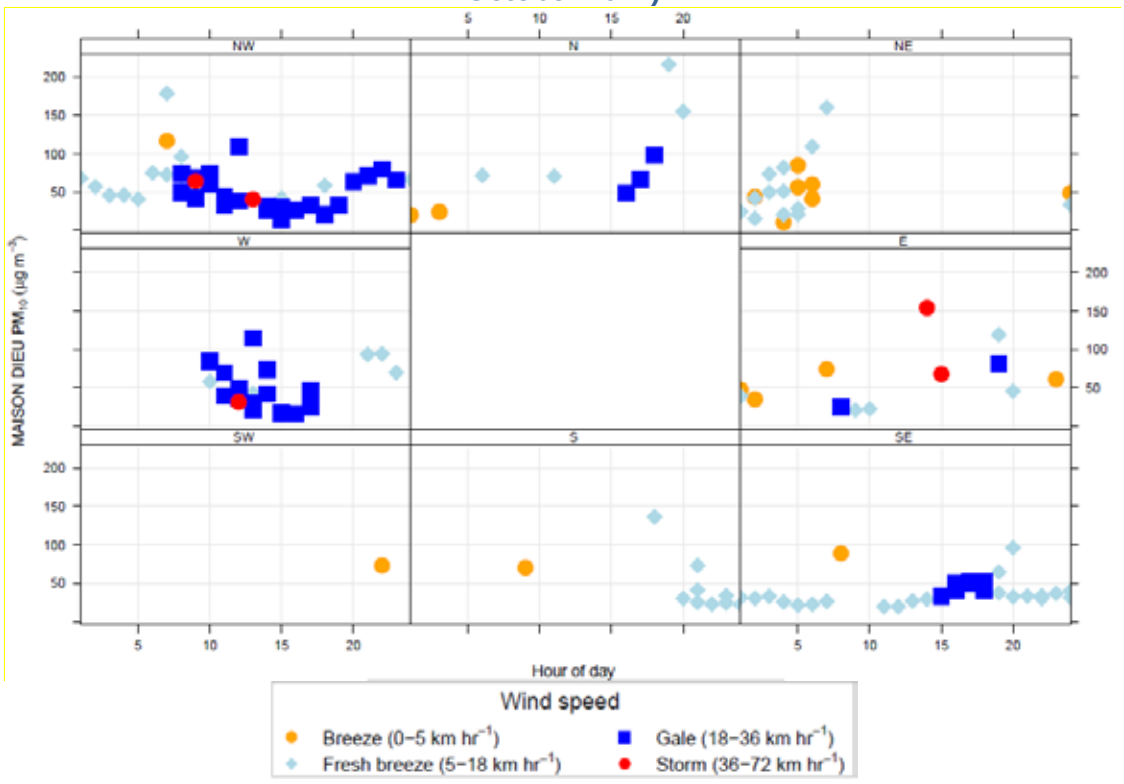
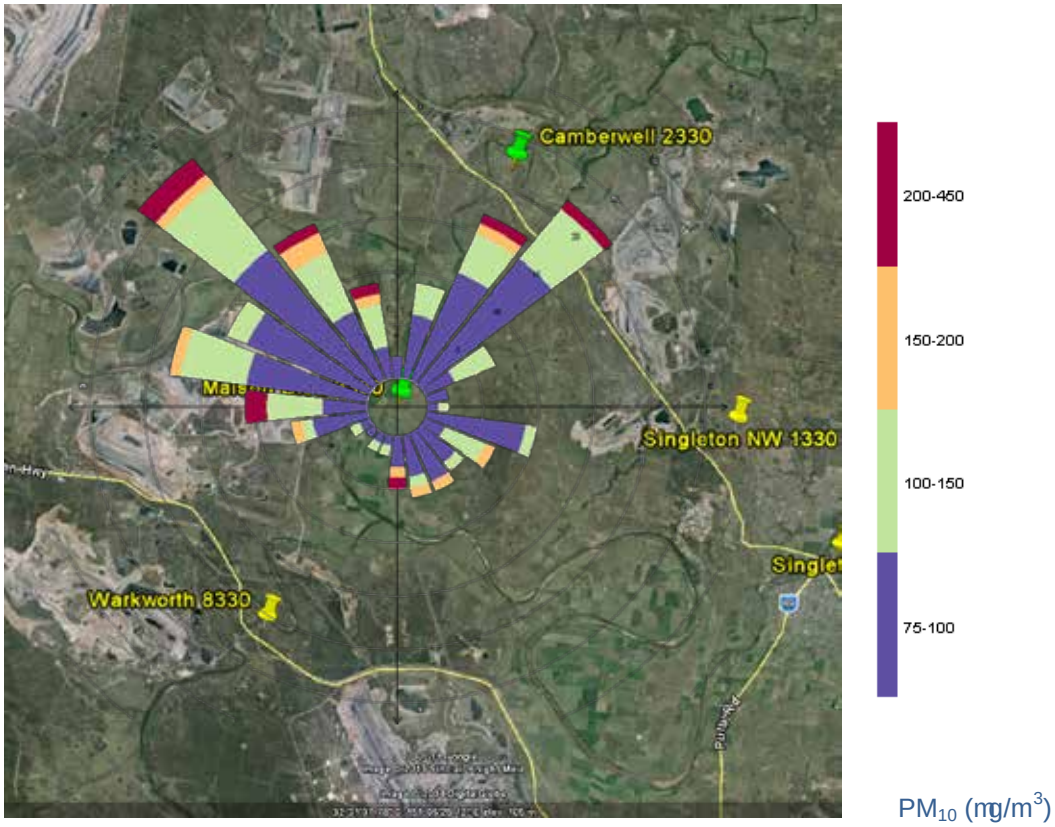


Figure 6d is a plot of the number of hours above 75 µg/m^3 during 2012 categorised by wind direction. It shows that the greater proportion of hourly PM_{10} values above 75 µg/m^3 are associated with wind directions from the north-east and north-west sectors around the monitoring station.

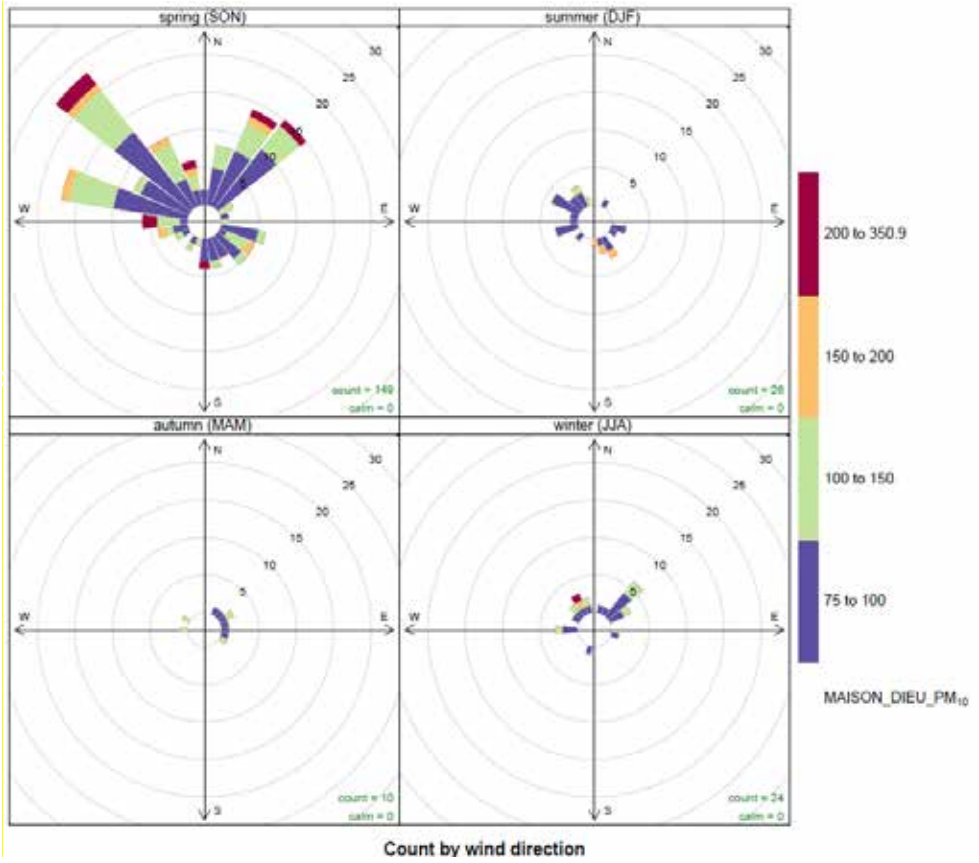
The seasonal breakdown in Figure 6e shows that nearly all of these higher levels occur during spring.

Figure 6d: Maison Dieu pollution rose – counts of hourly average PM_{10} levels > 75 µg/m^3 by wind direction (1 January 2012 – 31 December 2012)



NOTE that 75 µg/m^3 was chosen for a lower cut-off point to highlight only those hours with relatively elevated hourly PM_{10} levels.

Figure 6e: Maison Dieu – hourly average PM_{10} > 75 ug/m^3 (1 January 2012 – 31 December 2012) by season



Case Study II: PM_{10} at Mount Thorley

The Mount Thorley monitoring station is located to the south-east and east of coal mines and to the north of a coal handling and preparation facility. As one of the diagnostic sites, while days above the 50 $\mu g/m^3$ benchmark are indicated, it is not appropriate to compare the number of these days with the Air NEPM goal that applies to population centres. The primary purpose of this site is to provide information on likely dust sources within the upper Hunter valley.

Figure 7: Mount Thorley – daily average PM_{10} levels (1 January 2012 – 31 December 2012)

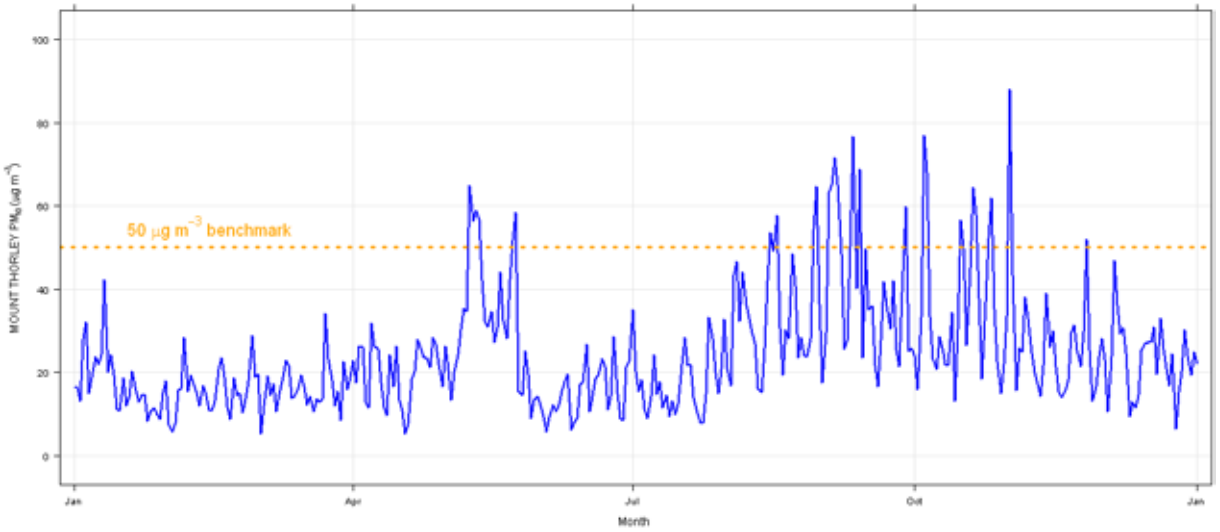


Figure 7a: Mount Thorley pollution rose – counts of hourly average PM_{10} levels > 75 µg/m^3 by wind direction (1 January 2012 – 31 December 2012)

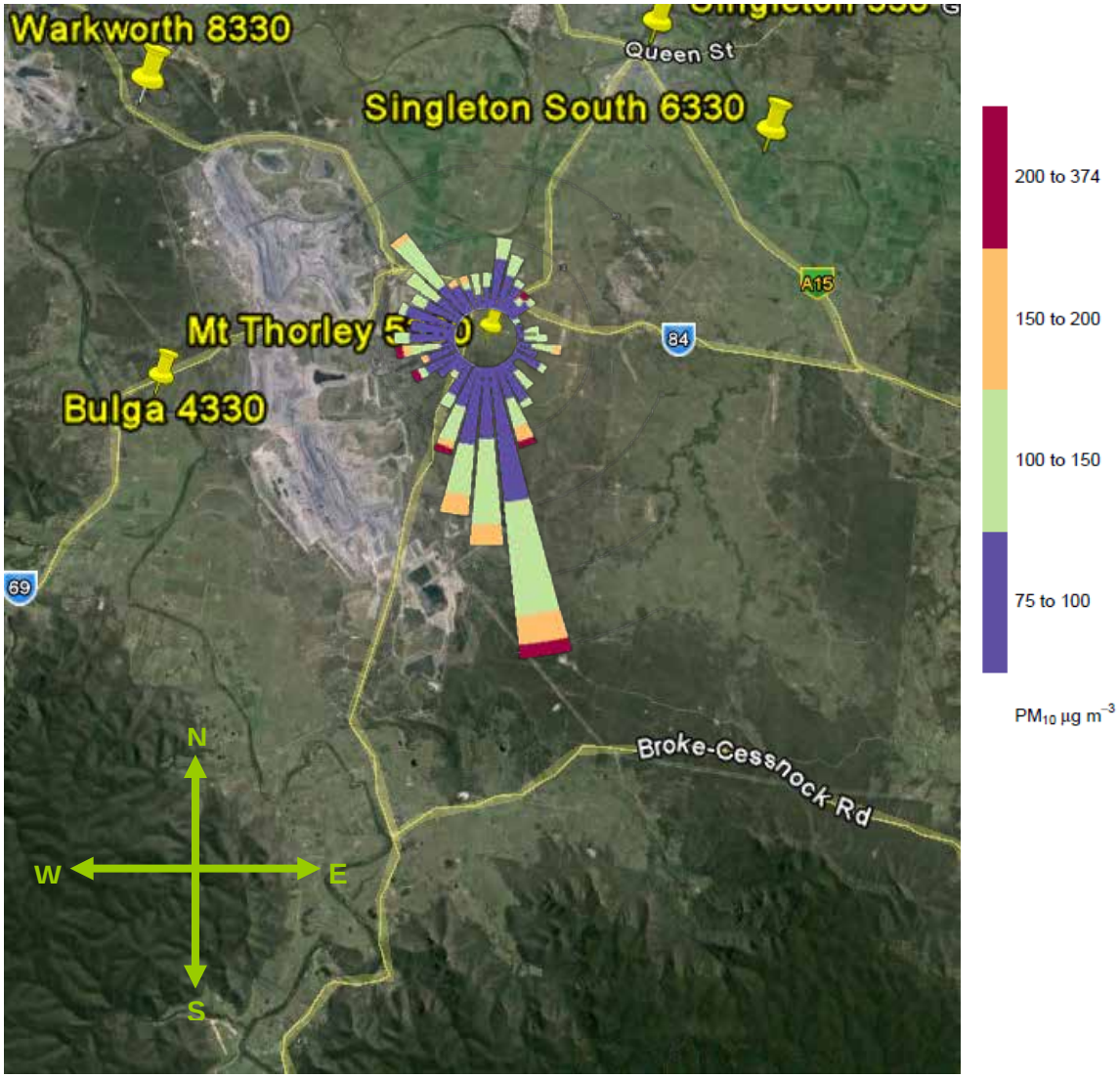
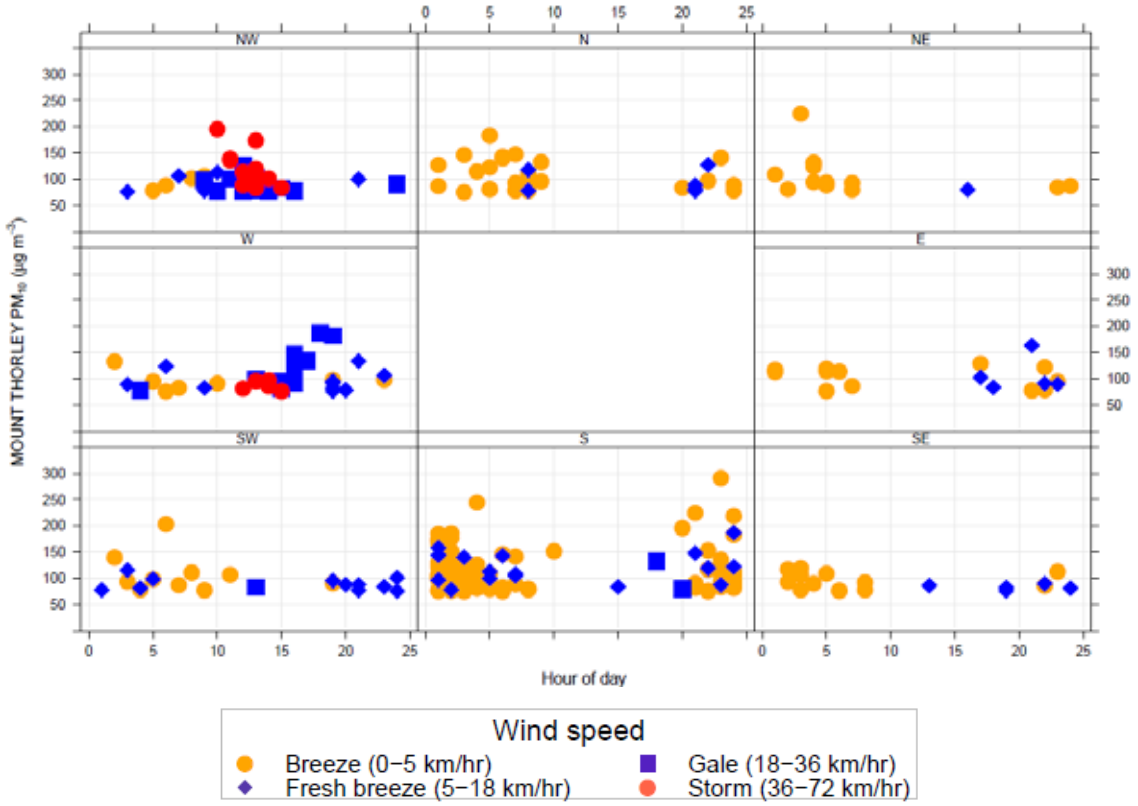


Figure 7a shows pollution roses at Mount Thorley monitoring site with counts of hourly PM_{10} levels above 75 mg/m^3 from various wind directions. The majority of these elevated hourly values at Mount Thorley appear to come from a source to the south of the monitoring site and the remainder from the west and north-west. A break-down of the elevated levels into time of day and wind direction (Figure 7b) also indicates a large proportion of these high levels originating from the south of the monitoring site and additionally almost always occurring overnight between 8pm and 8am. Similar situations are found in all of the easterly sectors and from the north. High daytime values are associated with winds from the north-west and west sectors. The source of the elevated PM_{10} levels from the south requires investigation. Concurrent monitoring undertaken by industry in November-December 2012 corroborated wind direction values and associated PM_{10} levels.

Figure 7b: Mount Thorley – hourly average PM_{10} levels > 75 µg/m^3 by wind direction and time of day (1 January 2012 – 31 December 2012)



Outcomes – how are dust emissions in the Upper Hunter being reduced?

Dust Stop

The Dust Stop program aims to reduce dust emissions by ensuring that best practice dust control options are implemented by coal mines throughout NSW. Under this program, all coal mines have compared their current operation with international best practice and were required to recommend how their dust controls can be improved.

The mine's reports confirm that wheel-generated dust is the primary source of PM_{10} on open cut mine sites, followed by the handling of overburden, and wind erosion of bare areas. To ensure that coal mines are implementing best practice dust controls, all open cut mines are now required to achieve 80% control of dust from their haul roads, and to cease or modify their overburden handling operations during adverse weather conditions. The mines are also required to investigate better ways of controlling dust from operations such as digging and dumping overburden.

All open cut coal mines are being required to monitor and report on these improved controls.

2.2 $PM_{2.5}$ monitoring data

Figure 9: Singleton, Muswellbrook and Camberwell – daily average $PM_{2.5}$ levels (1 January 2012 – 31 December 2012)

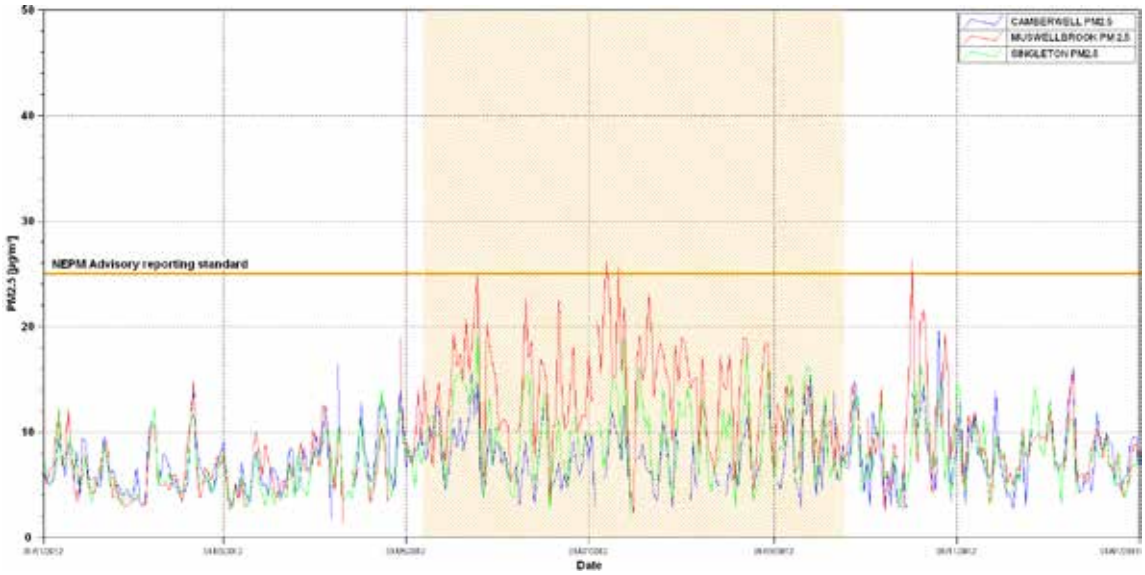
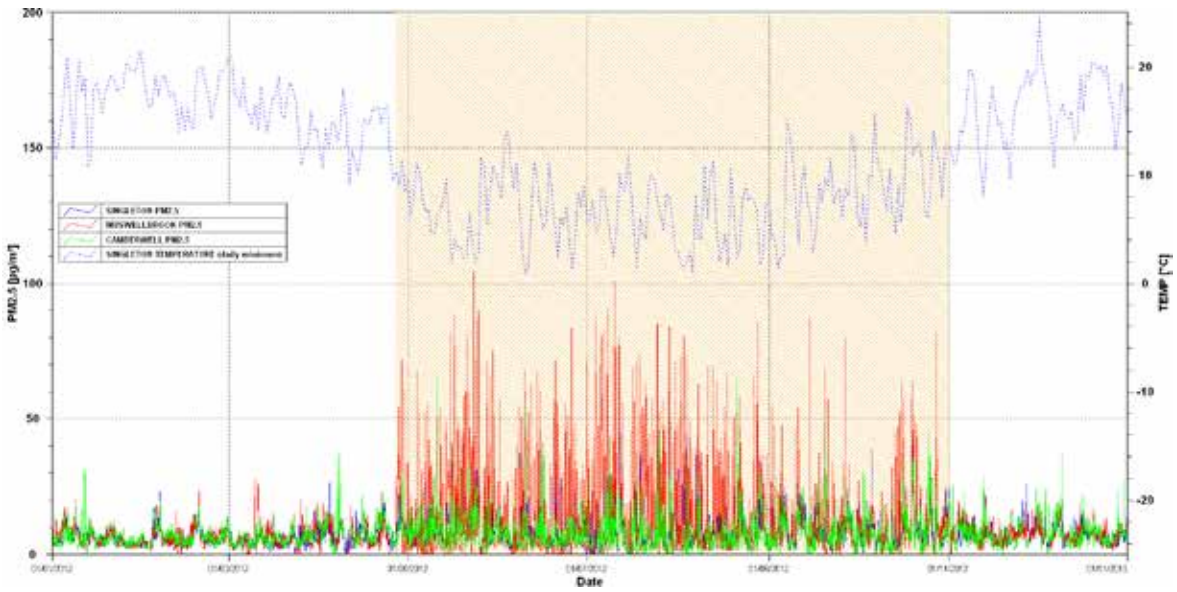


Figure 10: Singleton, Muswellbrook and Camberwell – hourly average $PM_{2.5}$ levels (1 January 2012 – 31 December 2012)



$PM_{2.5}$ data is gathered at the Camberwell, Singleton Central and Muswellbrook Central monitoring stations. As can be seen from Figures 9 and 10, both daily average values and hourly average values of $PM_{2.5}$ are elevated in during the cooler winter months compared to levels occurring throughout the warmer summer and autumn months (orange area).

Camberwell

Daily and annual average $PM_{2.5}$ levels at Camberwell were less than the 25 µg/m^3 and 8 µg/m^3 benchmarks throughout the reporting period (Figure 9).

Singleton Central

Daily and annual average $PM_{2.5}$ levels at Singleton Central were less than the 25 µg/m^3 and 8 µg/m^3 benchmarks throughout the reporting period (Figure 9).

Muswellbrook Central

Daily average $PM_{2.5}$ levels at Muswellbrook Central were less than the 25 µg/m^3 benchmark throughout the reporting period except for two days in July and one day in October coinciding with overnight, cold and calm conditions (Figure 9 and Table 7).

Table 7: Events above national $PM_{2.5}$ benchmarks (1 January 2012 – 31 December 2012)

Station	Average	Standard (µg/m^3)	$PM_{2.5}$ (µg/m^3)	Date	Comments (including wind direction associated with elevated hourly values)
Muswellbrook central	Daily	25	26.2	6/7/2012	Light winds overnight from N through to SE
			25.7	10/7/2012	Light winds overnight winds swinging through SE to N
			26.4	16/10/2012	Light winds overnight winds swinging to SE from NW
	Annual	8	10.1		

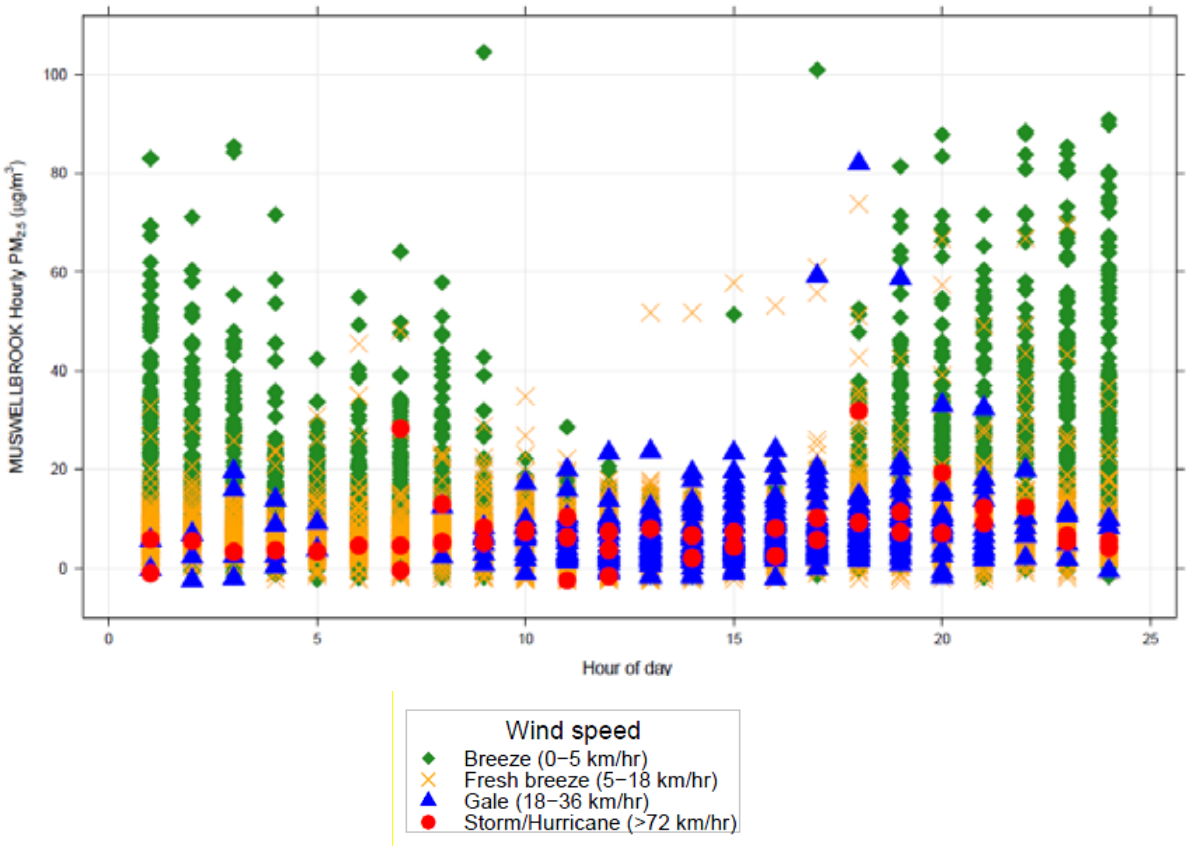
CASE STUDY

$PM_{2.5}$ at Muswellbrook Central

Analysis of the data for 2012 revealed similar patterns to those found in previous reports after taking wind direction and temperature into account. Namely, higher levels of $PM_{2.5}$ were found overnight during the cooler months.

Figures 10a and 10b display hourly $PM_{2.5}$ values grouped by hour of day, wind speed, wind direction and by month. In Figure 10a, all of the elevated hourly $PM_{2.5}$ values were associated with wind speeds less than 5 km/h and with hours overnight during mornings and evenings.

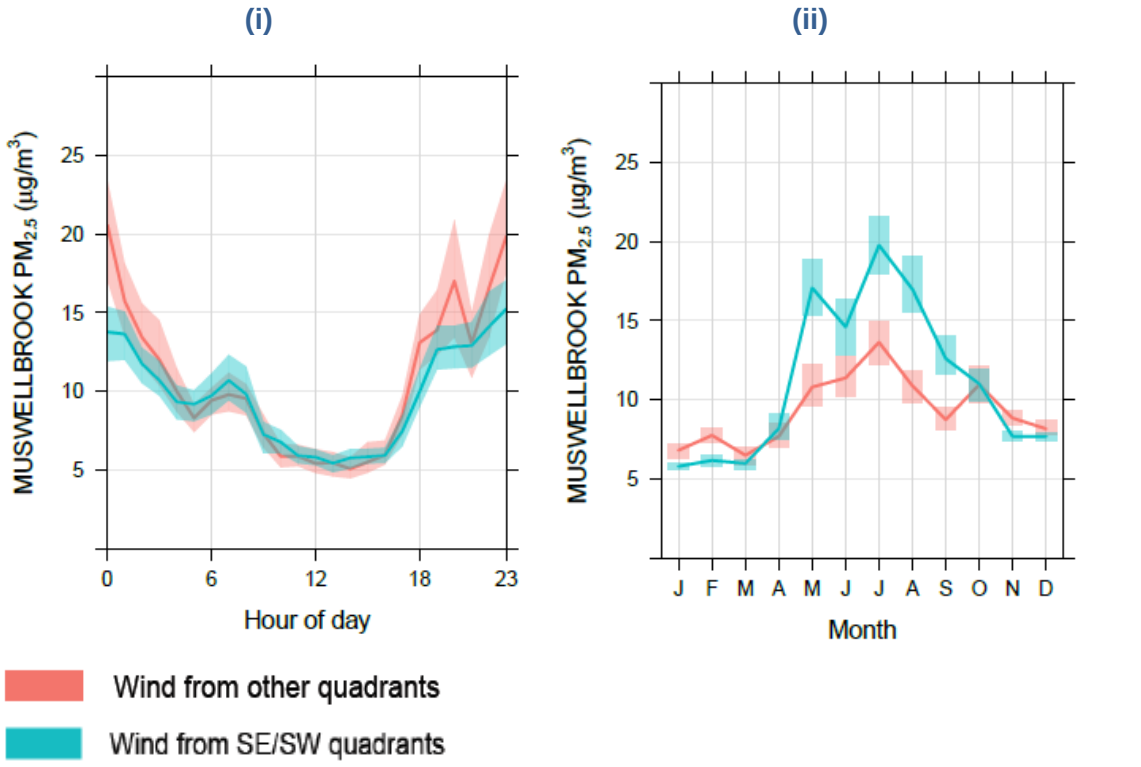
Figure 10a: Muswellbrook Central – daily variation in hourly average $PM_{2.5}$ levels in relation to wind speed (1 January 2012 – 31 December 2012)



The monthly plot in Figure 10b(ii) also shows that elevated $PM_{2.5}$ levels occurred only during the winter months starting from May through to August. At the same time, the pollution roses in Figures 10c and 10d indicate that the predominant wind direction associated with hourly $PM_{2.5}$ levels > 35 µg/m^3 is from the south-east and again that higher levels of $PM_{2.5}$ occur during the cooler winter months.

The Muswellbrook Central monitoring site and most of the surrounding residential area sit in the Hunter River Valley. As stated in previous performance reports (http://www.environment.nsw.gov.au/aqms/uhaqmnmonitoring.htm), during winter months, cooler heavier night-time air flows from higher ground to pool in low lying areas. Particles can then be trapped in the valley until the sun warms the air and normal convection processes during the day dilute the particles with fresh air and $PM_{2.5}$ levels drop. This is exactly the scenario demonstrated in Figure 10b(i) for 2012 which plots $PM_{2.5}$ concentrations against hour of the day; the higher $PM_{2.5}$ levels are found during the early morning (hours 0 - 6) and late at night (hours 18 -23). During the warmer daytime hours (hours 6 -18), particle levels drop.

Figure 10b: Muswellbrook Central 2012 – daily variation in all hourly average $PM_{2.5}$ levels in relation to wind direction and (i) time of day and (ii) month of the year



NOTE: The coloured lines indicate the mean $PM_{2.5}$ levels averaged for each hour of the day. The coloured areas for wind directions denote the 95% confidence intervals around the mean $PM_{2.5}$ values.

Figure 10c: Muswellbrook Central pollution rose – counts of hourly average $PM_{2.5}$ levels > 35 µg/m^3 for all months (1 January 2012 – 31 December 2012)

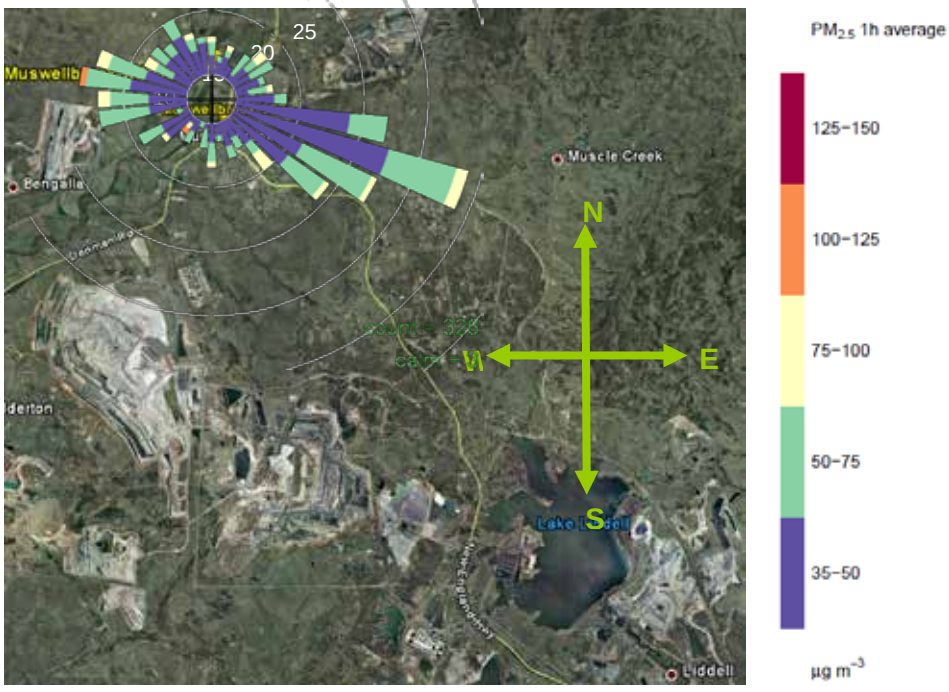
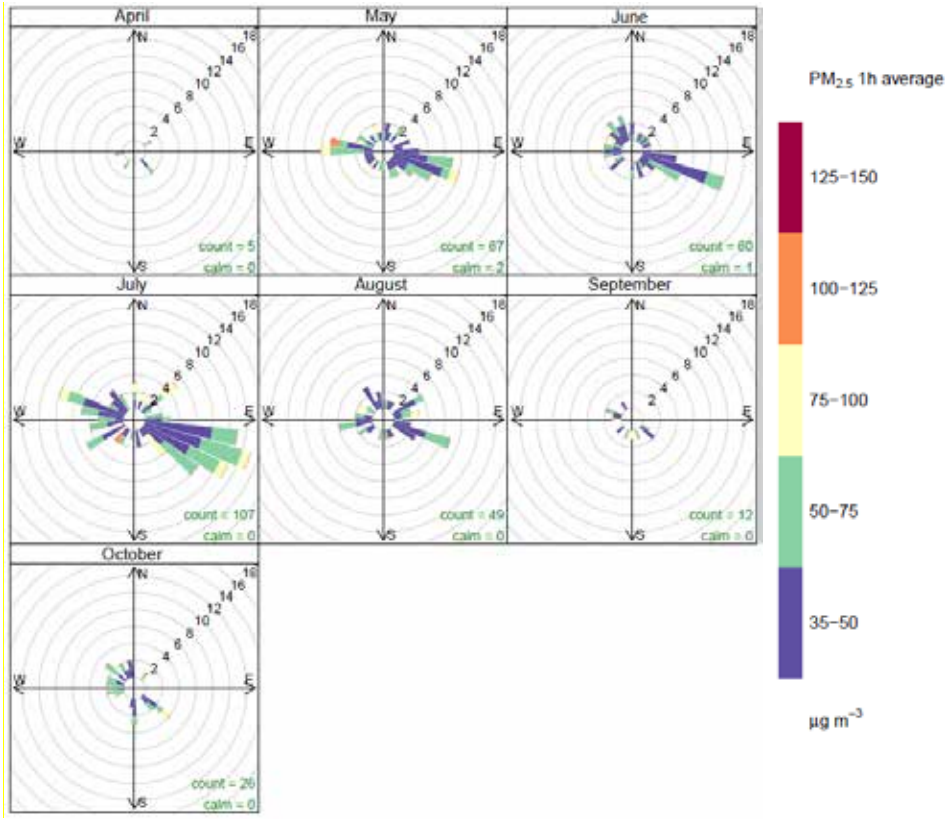


Figure 10d: Muswellbrook Central pollution roses – counts of hourly average $PM_{2.5}$ levels > 35 µg/m^3 by calendar month (1 January 2012 – 31 December 2012)



NOTE: In Figures 10c and 10d, 35 µg/m^3 was chosen as a lower cut-off point to highlight only those hours with relatively elevated hourly $PM_{2.5}$ levels.

The time of day and seasonal aspects of these results, together with Muswellbrook's topography and wintertime conditions, again re-enforce the notion that the source of the particles is likely to be combustion-related; combustion processes are a major source of fine particles as $PM_{2.5}$.

Outcomes – How is air quality in the Upper Hunter being improved?

Particle characterisation studies

To better understand the source of $PM_{2.5}$ particles in the Muswellbrook area, NSW Health and OEH engaged Australian Nuclear Science and Technology Organisation (ANSTO) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to conduct research on the contribution of wood smoke to fine particle concentrations and the fine particle fraction composition in the Upper Hunter. ANSTO and CSIRO began a 12-month program of sampling and analysis in January 2012 to determine the composition of the $PM_{2.5}$ particles. The final report is available at http://www.environment.nsw.gov.au/aqms/uhaqmnfpcs.htm.

Preventing wood smoke

In late August 2011, OEH provided a one-day training workshop in the Upper Hunter for local council staff responsible for managing wood smoke. The workshop was attended by council officers from Singleton and Muswellbrook. The workshop explored the significance of wood smoke in the region and strategies for reduction.

In general, attendees believed attention should mainly focus on other emission sources. However, based on past council case studies and OEH's presentation on educational, policy and regulatory measures for wood smoke, there was broad agreement that there are practical and worthwhile measures councils can take to improve wood smoke management. EPA has provided funds to enable Muswellbrook Council to implement a wood smoke reduction program through education, enforcement and provision of cash incentives for replacement of old heaters.

2.3 Gaseous (NO_2 and SO_2) monitoring data

Data for the gaseous parameters nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) is collected at the Muswellbrook Central and Singleton Central monitoring sites. There were no hours, days or years above the hourly, daily and annual Air NEPM benchmarks at either monitoring site.

SO_2 levels at Muswellbrook were generally higher than those for Singleton during the reporting period (Figure 11).

The higher levels of SO_2 (greater than 2 pphm) experienced by Muswellbrook are associated with winds from a south-easterly direction in summer and autumn (Figures 12 and 13) and for Singleton associated with winds from a north-westerly direction in autumn and winter (Figures 14 and 15).

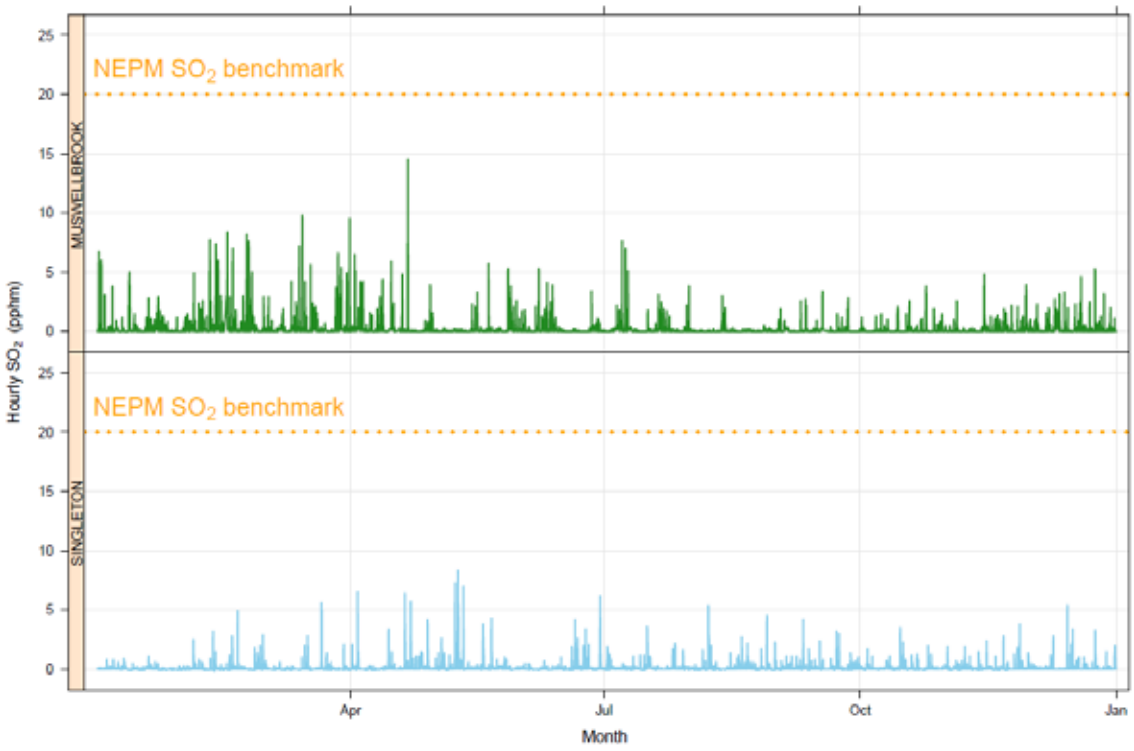
Table 8: Summary NO_2 at Singleton and Muswellbrook (1 January 2012 – 31 December 2012)

Region/Station	Annual average (pphm)	Hourly NO_2 values		Days above standards
		Maximum (pphm)	Date	
Muswellbrook	1.0	4.4	3/9/2012 19:00	0
Singleton	0.9	4.0	17/10/2012 01:00	0

Table 9: Summary SO_2 at Singleton and Muswellbrook (1 January 2012 – 31 December 2012)

Region/Station	Annual average (pphm)	Daily SO_2 average		Hourly SO_2 values		Days above standards
		Maximum (pphm)	Date	Maximum (pphm)	Date	
Muswellbrook	0.2	1.7	21/4/2012	14.5	21/4/2012 13:00	0
Singleton	0.1	1.8	9/5/2012	8.3	9/5/2012 12:00	0

Figure 11: Muswellbrook and Singleton – hourly average SO_2 and NO_2 values (1 January 2012 – 31 December 2012)



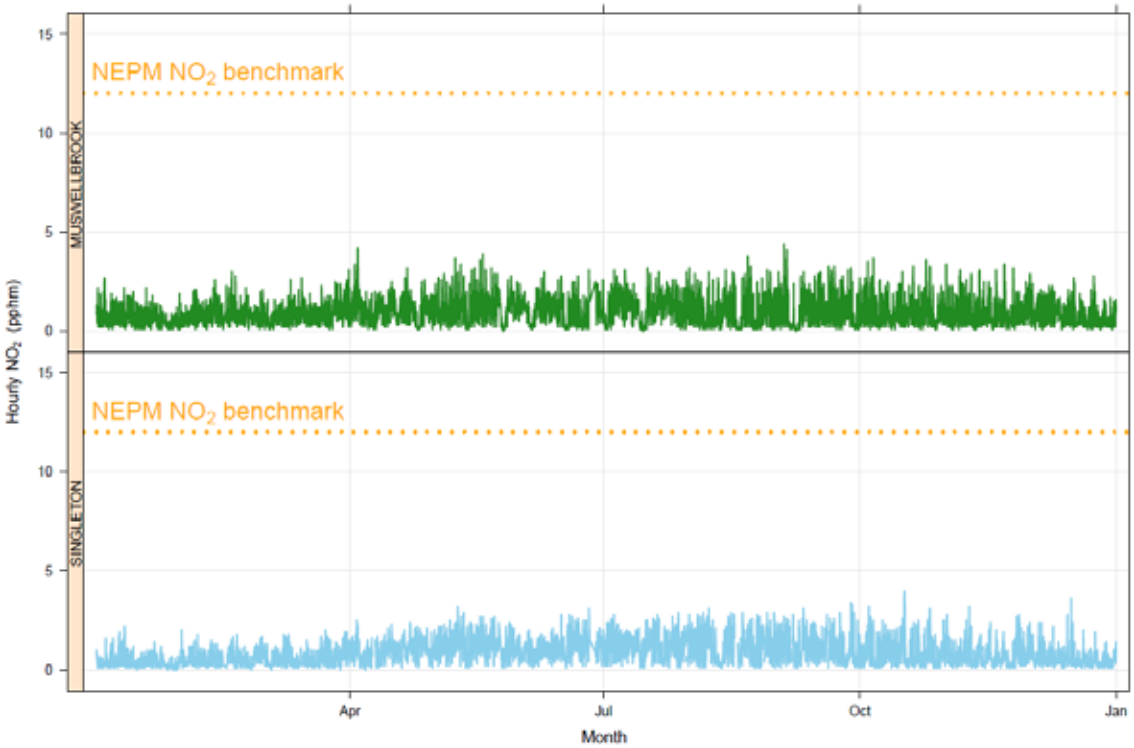


Figure 12: Muswellbrook – seasonal hourly average SO_2 values > 2 pphm (2012)

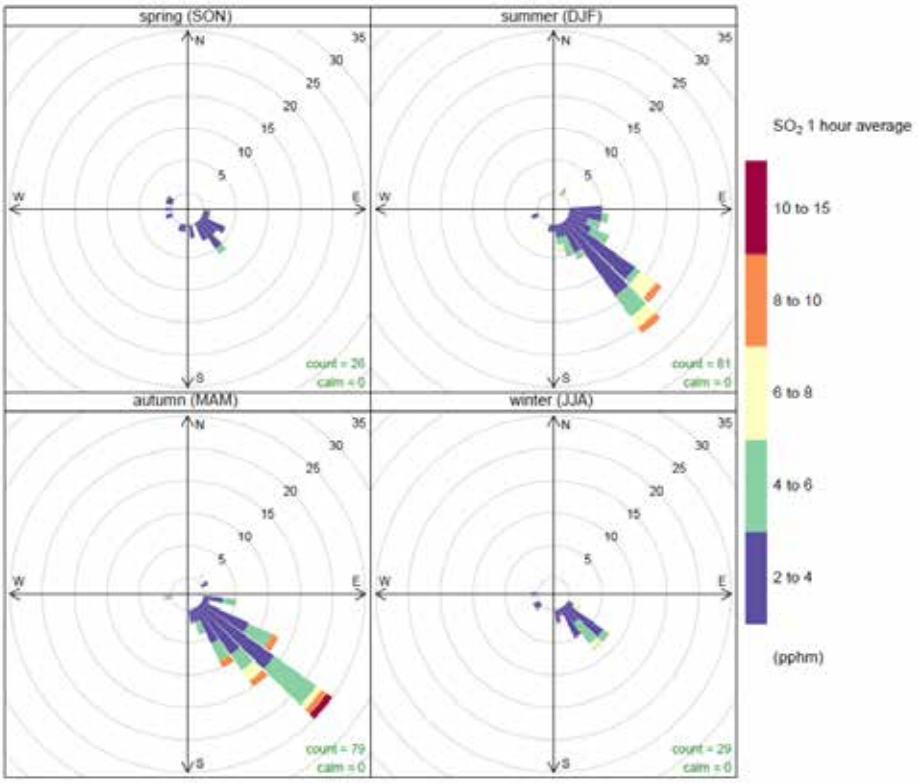


Figure 13: Muswellbrook – hourly average SO_2 values pollution rose for 2012

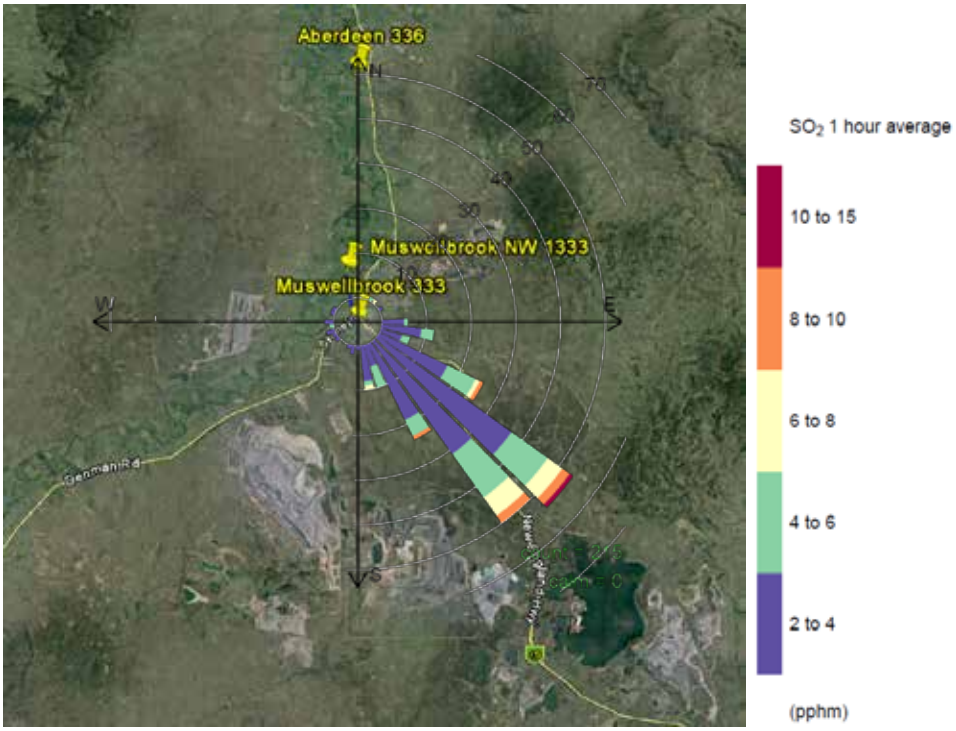


Figure 14: Singleton – seasonal hourly average SO_2 values > 2 pphm (2012)

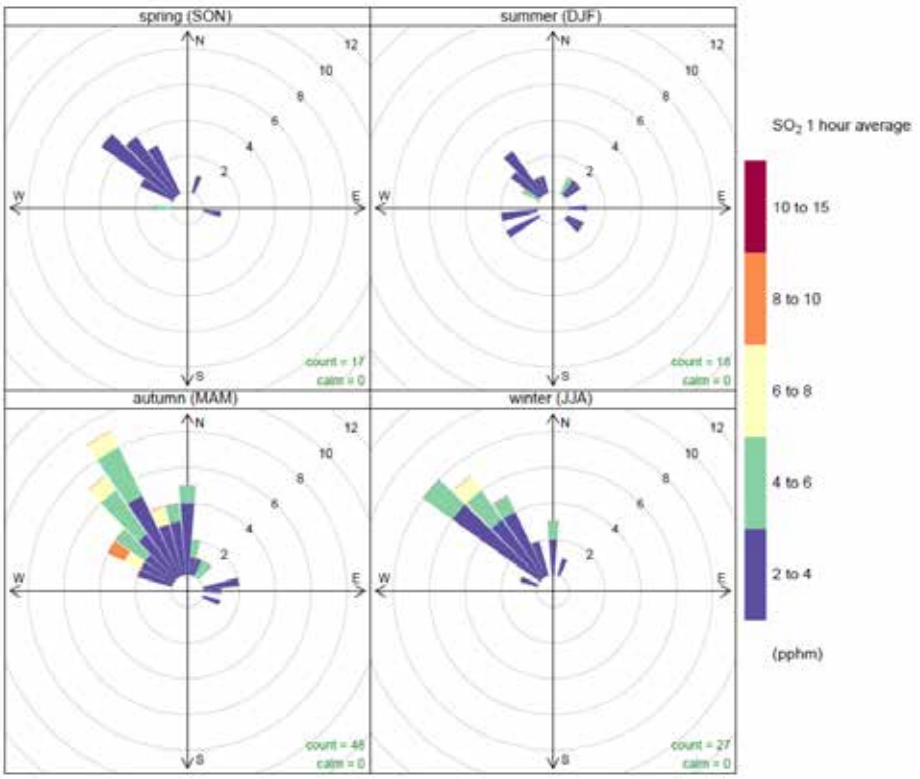
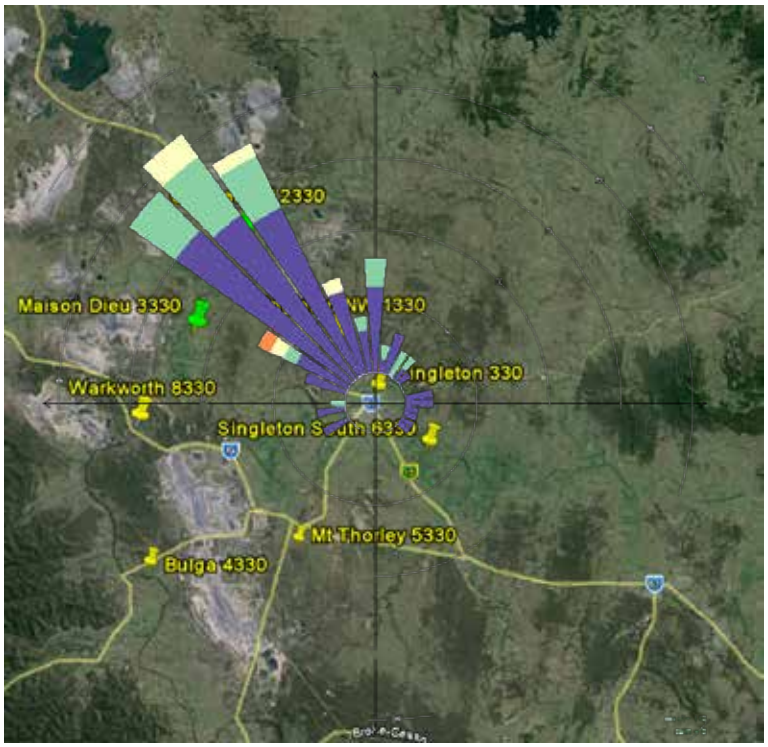


Figure 15: Singleton – hourly average SO_2 values > 2 pphm (2012)



2.4 What do the air quality results tell us?

Two and half years after the first sites at Muswellbrook and Singleton were installed, the network is providing the Upper Hunter community with a more detailed picture of air quality in the region. Now that the network is fully operational, diagnostic sites will yield valuable information about the sources and distribution of particulate matter within the Upper Hunter Valley and analysis of particle data from the smaller population centres will inform local communities and guide any necessary responses.

During 2012, for PM_{10} there were elevated values above the national NEPM standards during particular events associated with extended periods of dry and windy conditions at the two major population centres of Muswellbrook and particularly Singleton. For $PM_{2.5}$, Singleton met the relevant national advisory reporting standard. At Muswellbrook, the network initially identified potential issues with $PM_{2.5}$ during the cooler months; subsequent analyses of annual datasets that cover a complete winter heating season reinforced these findings for $PM_{2.5}$.

To better understand the composition and sources of $PM_{2.5}$ in Muswellbrook and Singleton, a particle characterisation study was undertaken by CSIRO and ANSTO during 2012 in conjunction with OEH and NSW Health. The final report can be found on the OEH website (http://www.environment.nsw.gov.au/aqms/uhaqmnfpcs.htm).

Appendix 1: How are particles measured in the UHAQMN?

Two methods can be used to collect air quality data:

- **Reference methods:** involve batch collection of fine particles on filter paper over 24 hours. Samples are collected and then transported to special laboratory facilities for weighing and reporting of results. This process can take 2–3 weeks.
- **Continuous methodologies:** because of the time lag associated with reference methods, OEH chose recognised techniques to provide the continuous data required for the web-based community reporting and alert systems which it operates.

Two different types of continuous monitoring instruments are used throughout the UHAQMN, one measuring PM_{10} and one $PM_{2.5}$. Both are recognised as equivalent methods to the relevant reference method by the US Environmental Protection Agency and are designated as Federal Equivalent Methods (FEM).

Measurement of PM_{10}

The Tapered Element Oscillating Microbalance (TEOM) instrument was chosen for the continuous measurement of PM_{10}. A TEOM PM_{10} instrument is located in each of the 14 monitoring stations making up the UHAQMN.

These instruments, fitted with a size-selective PM_{10} inlet, draw a constant volume of ambient air through a filter which is mounted on a vibrating hollow glass tube (the tapered element). Particles are collected on the filter, which then increases in weight. This additional weight changes the frequency at which the tapered element vibrates (or oscillates) from one side to the other. The mass of the particles is determined by the change in oscillation frequency. The mass is divided by the volume of air sampled by the instrument over the same time period to produce the mass/unit volume (micrograms/cubic metre: $\mu g/m^3$).

Because the particles can include water (via rain or humidity) as part of their mass, the sensor unit is heated to 50°C to remove water from the particles collected on the filter. The TEOMs operate continuously and the data averaged over one hour are assembled and transmitted to the OEH data centre for further processing and posting on the OEH website (hourly updates).

Measurement of $PM_{2.5}$

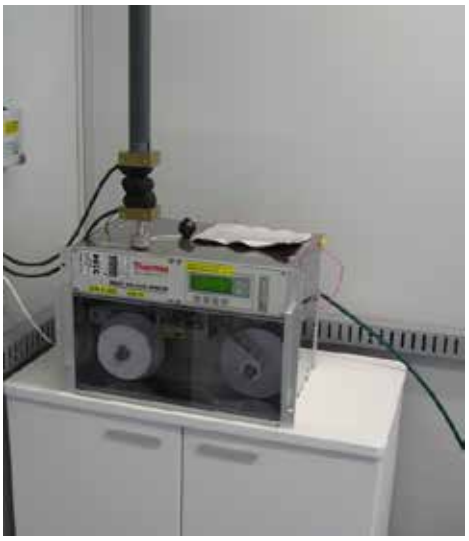
The Beta Attenuation Monitor (BAM) was chosen for the continuous measurement of $PM_{2.5}$. Three BAMs are located in the UHAQMN at Singleton Central, Muswellbrook Central and Camberwell.

These instruments are fitted with size-selective inlets and very sharp cut cyclones (VSCC) to collect the $PM_{2.5}$ sample stream which is then heated (to reduce the effects of humidity) and passed through a filter tape. The amount of heating is determined by the humidity levels of the incoming sample stream.

The particles are deposited onto the glass fibre tape and then the particle mass is irradiated with beta radiation. Fine particle mass is proportional to the attenuation of this radiation through a known sample area to continuously collect and detect the measured mass.

The simultaneous mass measurements of particles on the filter tape and sample volume measurement through a calibrated orifice provide a continuous concentration measurement in micrograms/cubic metre. The hourly averaged $PM_{2.5}$ data are collected and posted on the OEH website (hourly updates).

TEOM instrument – used for PM_{10}



BAM instrument – used for $PM_{2.5}$

Photos: OEH.

Appendix 2: Days when levels were above the benchmarks

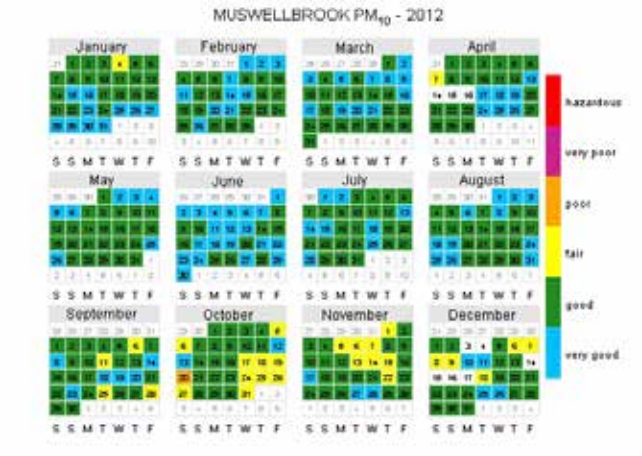
Table 9: Monthly breakdown of the number of days when levels above the PM_{10}, $PM_{2.5}$, NO_2 and SO_2 benchmarks were recorded (2012)

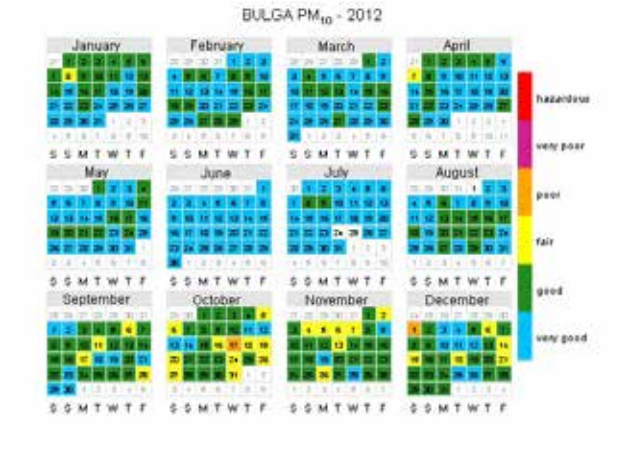
Parameter	Purpose	Station	Month	No. of days exceeding benchmark
PM_{10}	Population centre	Muswellbrook Central	Oct	1
		Singleton Central	Sep	2
			Oct	3
			Nov	1
	Smaller community	Camberwell	Jan	1
			May	1
			Aug	2
			Sep	7
			Oct	9
			Nov	3
		Maison Dieu	Jan	1
			Aug	1
			Sep	6
			Oct	9
			Nov	3
		Bulga	Oct	1
			Dec	1
		Wybong	Oct	1
	Diagnostic	Mount Thorley	May	6
			Aug	4
			Sep	9
			Oct	7
			Nov	2
		Singleton North West	May	6
			Aug	4
			Sep	7
			Oct	9
			Nov	3
		Muswellbrook North West	Nov	1
	Background	Merriwa	Oct	1
		Singleton South	Sep	1
			Oct	1

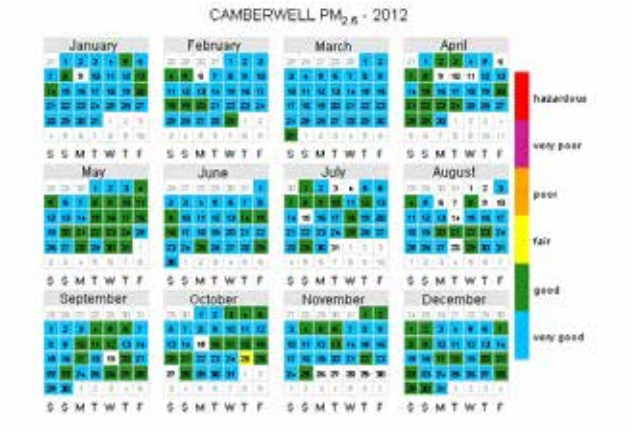
$PM_{2.5}$	Population centre	Muswellbrook Central	Jul	2
			Oct	1
NO_2 and SO_2	Population centre	Muswellbrook Central		Nil
		Singleton Central		Nil

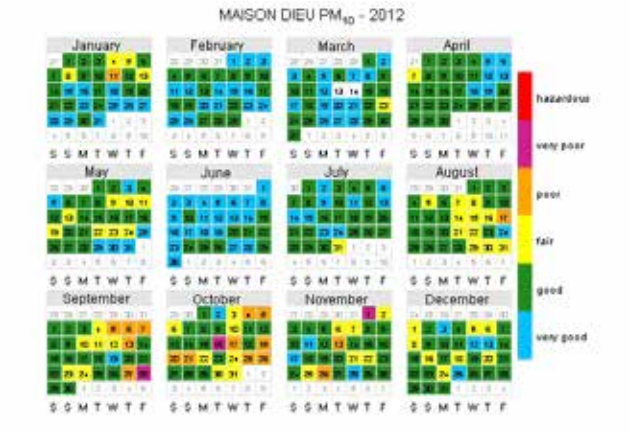
Appendix 3: Daily average PM_{10} data

The following calendar plots show daily average PM_{10} levels categorised against a benchmark of 50 µg/m^3. Days where levels are higher than the benchmark are coloured orange, maroon or red. The categories are those used in the OEH Regional Air Quality Index (RAQI) web pages.

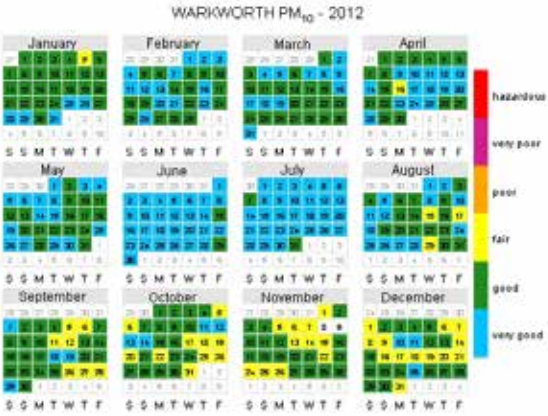


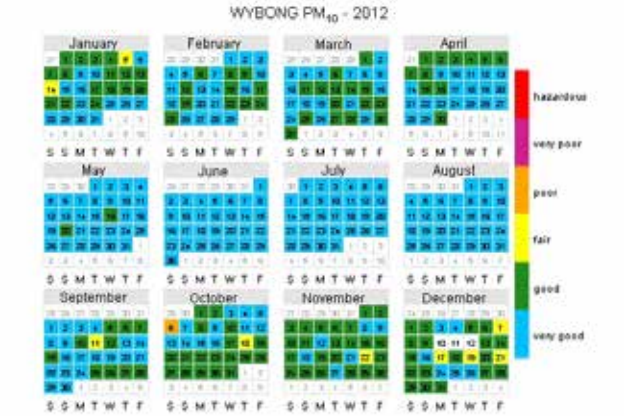


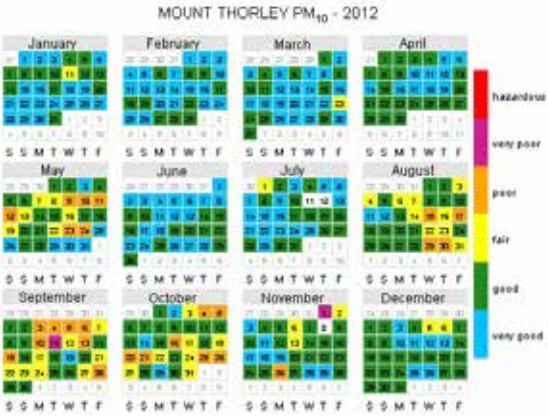




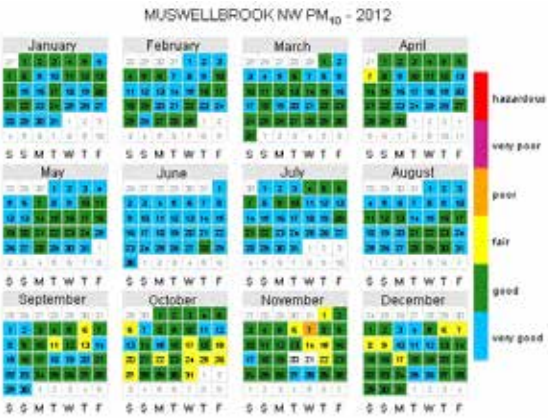

JERRYS PLAINS PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good

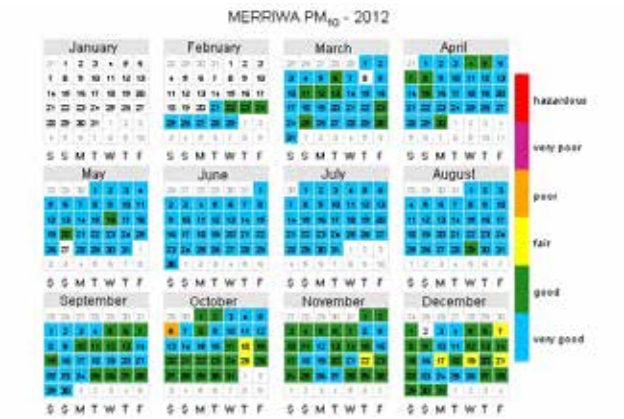

WARKWORTH PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good


WYBONG PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good


MOUNT THORLEY PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good


SINGLETON NW PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good

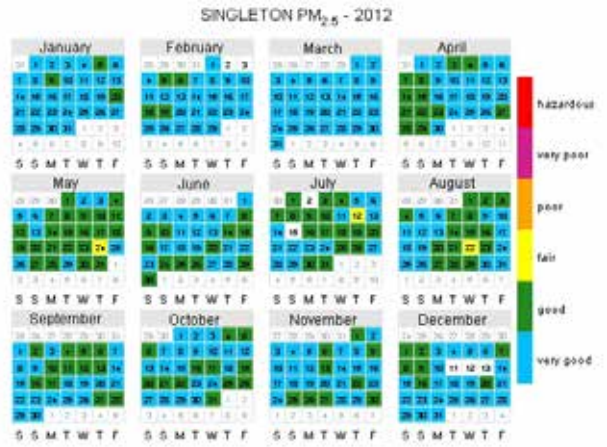

MUSWELLBROOK NW PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good

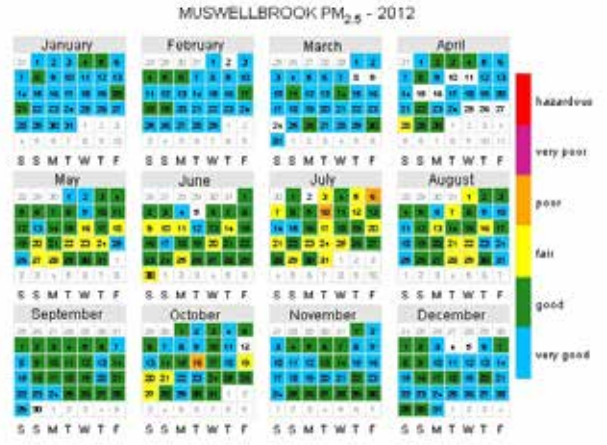

MERRIWA PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good

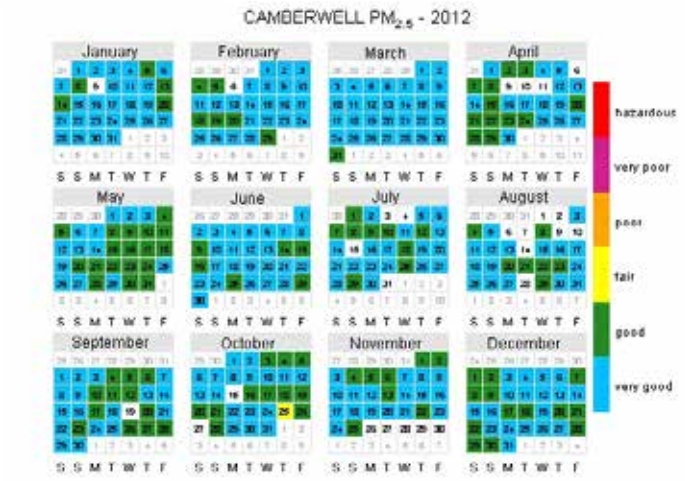

SINGLETON SOUTH PM10 - 2012
January
February
March
April
May
June
July
August
September
October
November
December
hazardous
very poor
poor
fair
good
very good

Appendix 3: Daily average $PM_{2.5}$ data

The following calendar plots show daily average $PM_{2.5}$ levels categorised against a benchmark of 25 µg/m^3. Days where levels are higher than the benchmark are coloured orange, maroon or red. The categories are those used in the OEH Regional Air Quality Index (RAQI) web pages.

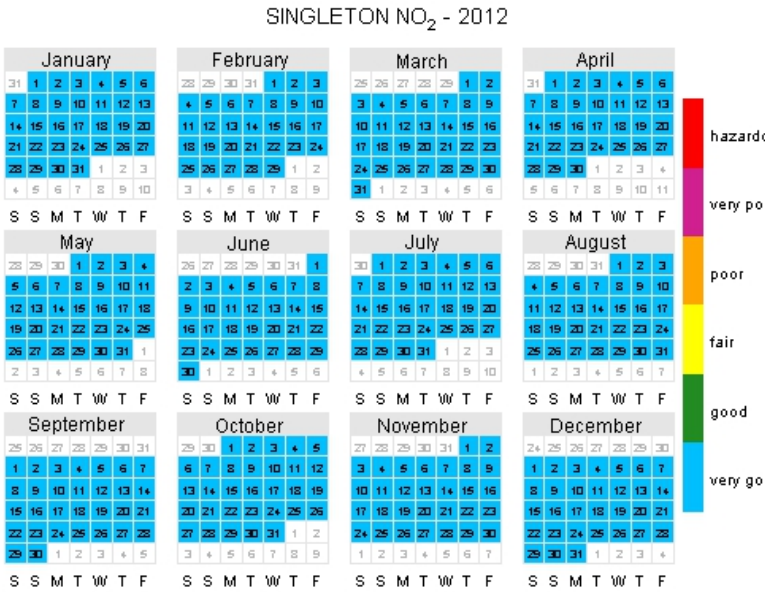


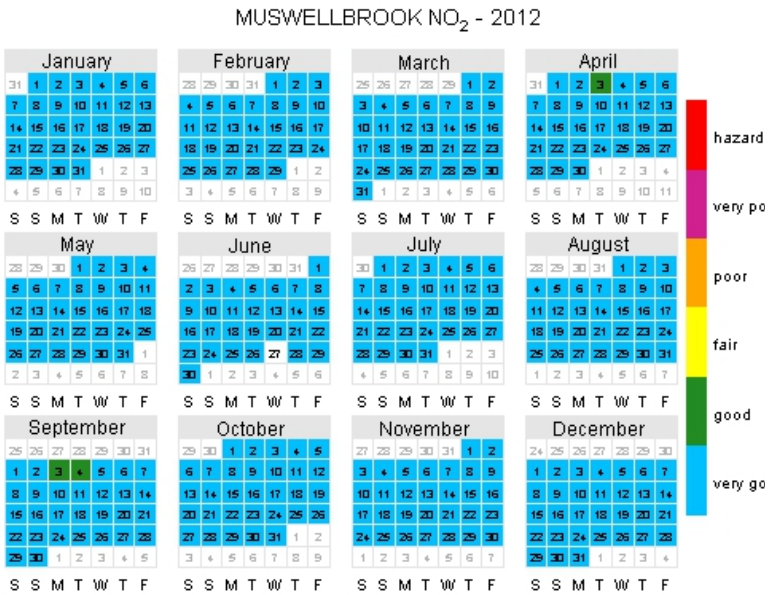




Appendix 4: Daily maximum NO_2 data

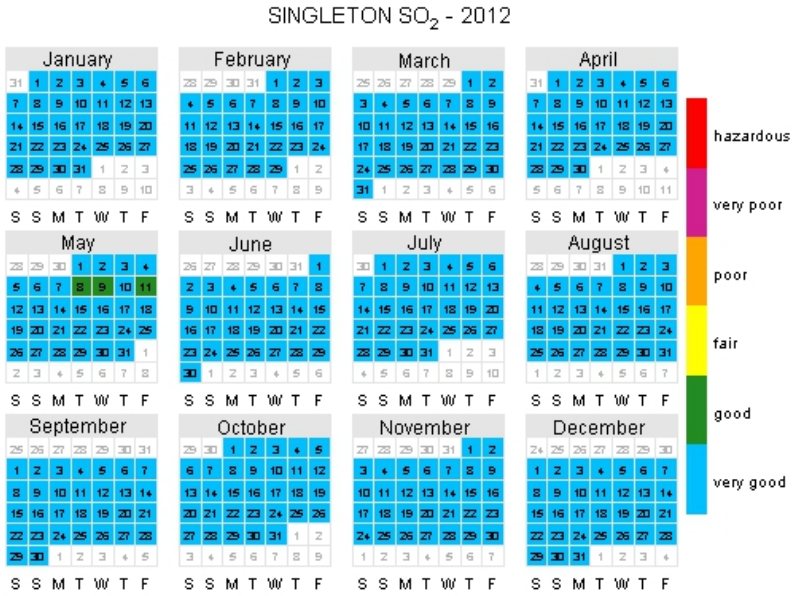
The following calendar plots show daily maximum 1-hour NO_2 levels categorised against a benchmark of 12 parts per hundred million (pphm). Days where levels are higher than the benchmark are coloured orange, maroon or red. The categories are those used in the OEH Regional Air Quality Index (RAQI) web pages.

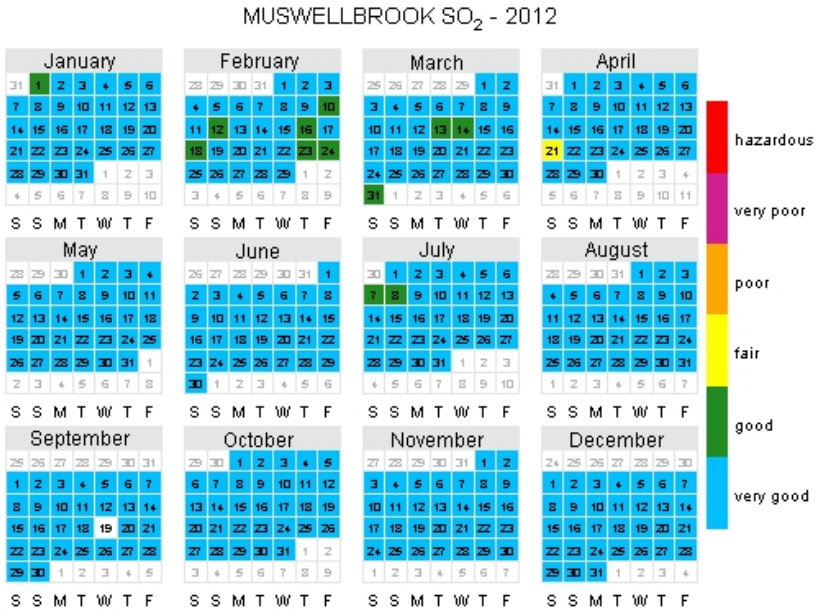




Appendix 5: Daily maximum SO_2 data

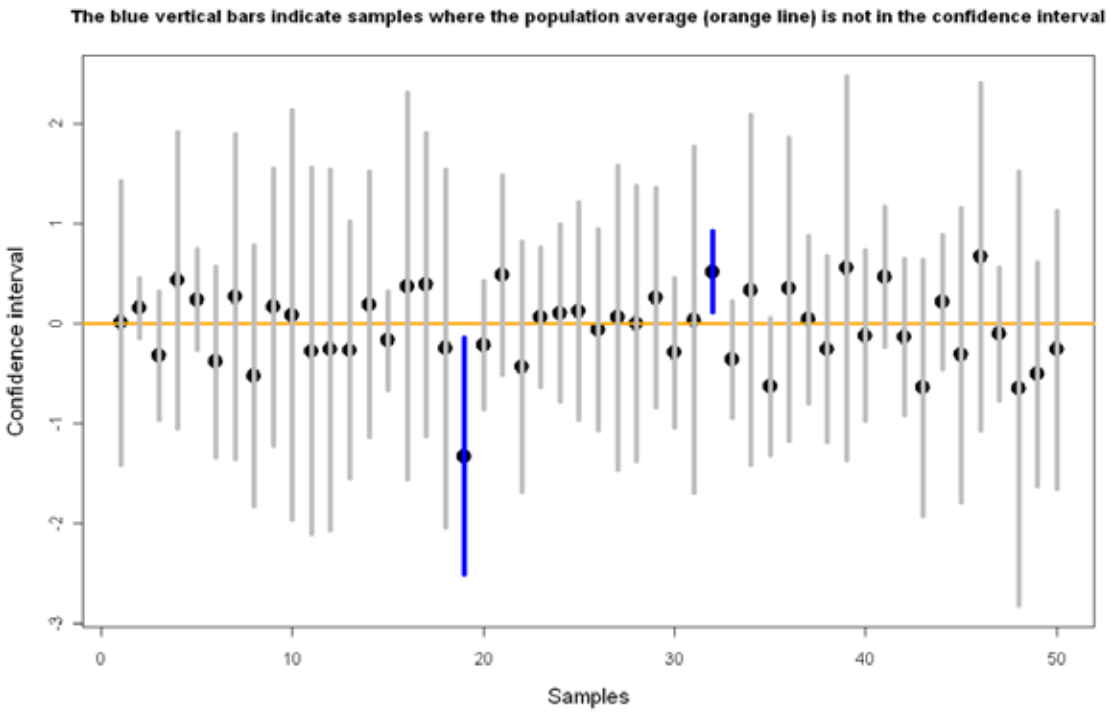
The following calendar plots show daily maximum 1-hour SO_2 levels categorised against a benchmark of 20 parts per hundred million (pphm). Days where levels are higher than the benchmark are coloured orange, maroon or red. The categories are those used in the OEH Regional Air Quality Index (RAQI) web pages.





Glossary

Confidence limit – After the average of a sample of observations has been calculated (e.g. calculating the average PM_{10} value for each day of the week over a year), in analysing these data it is useful to give some indication of how close this sample average is to the population average. One way to do this is to determine a confidence interval, where upper and lower values are defined as confidence limits. Usually, 95% confidence limits are used. Providing 95% confidence limits means that if repeated random samples are taken from a population and the average of each sample calculated, the confidence interval for 95% of samples taken would include the population average. The size of the 95% confidence interval gets smaller with larger sample sizes and also when sample values are closer together. Usually, if confidence intervals for samples do not overlap, the averages for each sample are seen to be different from one another (for example, in the graph below, the averages for blue samples above the orange line are different to those for the blue samples below the orange line).

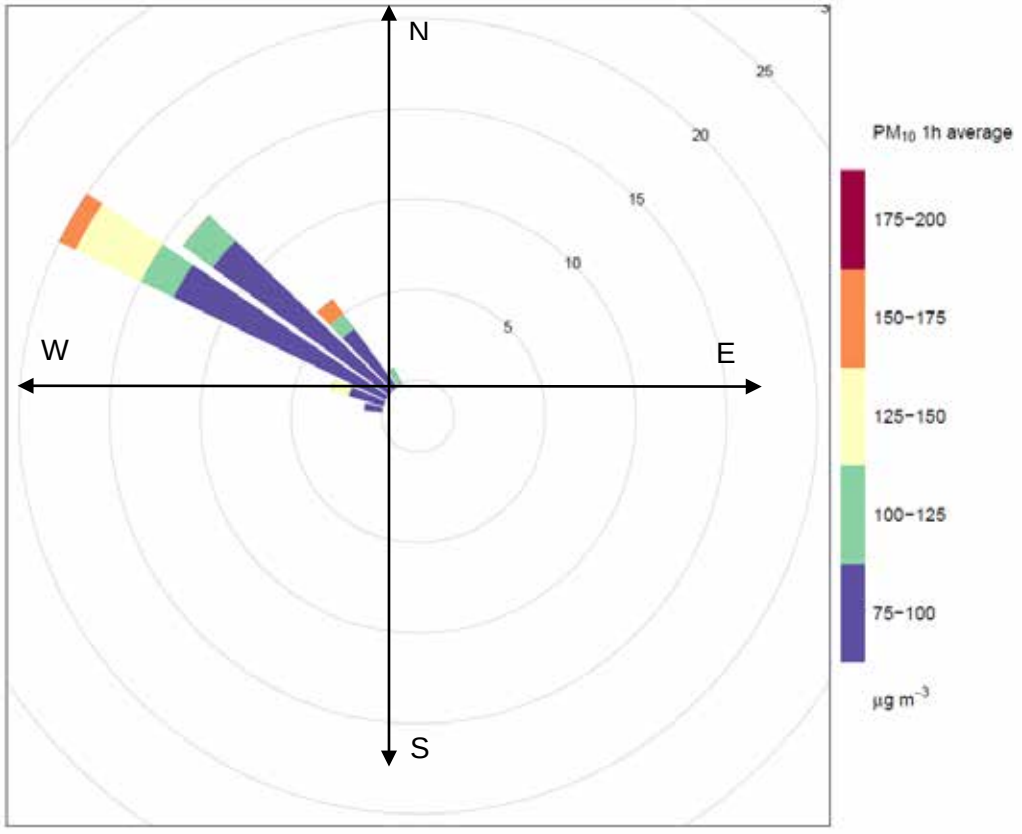


Day-of-week plot – is a way of displaying patterns of pollutant values averaged for each day of the week over a prolonged sampling period e.g. for a month, quarter, season or year.

Diurnal plot – is a way of displaying patterns of pollutant levels throughout hours of the day averaged over a period of time. For example, over a month all pollutant levels with

a time stamp of 1:00 am are averaged, all levels with a timestamp of 2:00 am are averaged, and so on for all hours of the day up to midnight.

Pollution rose – is another way of presenting pollutant data in relation to the wind direction recorded for the same time at a monitoring site. In the image below, wind direction data are counted for each of the pollutant categories. The colour categories represent hourly PM_{10} levels; the angle of the coloured wedges represents the **direction from which the wind is blowing** associated with each of these pollutant categories. The concentric circles show number of hours for each category (the scale for these counts is displayed at a 45° angle in the NE wind direction sector of the plot). In the image below, it can be seen that all hourly pollutant values above 75 µg/m^3 originated from the NW sector.



Number of hours with 1hr PM_{10} concentrations above 75µg m^{-3} by wind direction

Quadrants – in pollution rose image above, refers to directions on a compass divided into four broad regions, namely:

- the NE quadrant refers to directions between 0° (North) and 90° (East)
- the SE quadrant refers to directions between 90° (East) and 180° (South)
- the SW quadrant refers to directions between 180° (South) and 270° (West)
- the NW quadrant refers to directions between 270° (West) and 360° (North).