Air quality summary report

Summarising the air monitoring and conditions during the Hazelwood mine fire, 9 February to 31 March 2014

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On 9 February 2014, embers from a bushfire ignited the open-cut Hazelwood Coal Mine near the town of Morwell, Victoria. The fire, which burned for 45 days, was an unprecedented event due to the large scale of the fire in a brown coal mine, the length of time that the fire burned and its proximity to the town.

The combustion of brown coal can produce varying amounts of pollutants such as breathable airborne particles (PM10 and PM2.5), carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen dioxide (NO2). However, a risk assessment conducted by response agencies at the beginning of the mine fire showed that some of these pollutants were unlikely to come from Hazelwood brown coal. Response efforts therefore focused on airborne particles and carbon monoxide as the pollutants most likely to impact on air quality.

The response to the emergency was a multi-agency effort. Environment Protection Authority Victoria's (EPA) role was to measure, validate and assess the impacts of the smoke and ash on local air, water and soil. This is in line with EPA's responsibilities as the State of Victoria's environmental regulator. EPA administers the *Environment Protection Act* (1970) via legislation called state environment protection policies (SEPPs). SEPPs outline in detail how EPA defines and regulates acceptable standards of pollution.

This report summarises the methods and results of the realtime air quality monitoring done by EPA and other organisations as the fire was burning, and provides an overview of how the fire impacted the quality of the air.

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About this report

This report summarises the air monitoring data collected by EPA during the Hazelwood mine fire. The data was collected from 9 February 2014 until the fire was declared safe on 25 March 2014 and for six days after the fire was declared safe (until 31 March 2014).

While the data has already been made available to the public, this publication brings together EPA's measured air quality data and analysis to provide a general summary of the fire's impact on air quality at the time of the fire.

Monitoring to Australian Standards

During the first weeks of the fire, EPA began monitoring air quality using sophisticated air monitoring instruments placed at strategic locations. The equipment used for this monitoring, such as BAMs (beta attenuation monitors) (see Figure 2), comply with Australian Standards. They provide data that can be directly compared against air quality standards.

Other air quality monitoring

As part of EPA's rapid-response monitoring, mobile monitoring instruments were used to measure very small airborne particles ($PM_{2.5}$). These instruments can be deployed quickly during a pollution event. Data from rapid-response monitoring is considered indicative. In this case it was used to inform some response-related activities, such as the development of air quality protocols. This indicative data was not however, used for all operational decisions taken at the time.

This is because at the time of the fire, EPA believed that further work was needed to understand how the indicative data could be compared to the air quality standards. The data has also been useful in the analysis conducted after the fire was declared safe by providing a better understanding of air quality conditions in the early days of the fire.

Because of the different technology and the indicative status of data from the rapid-response instruments during the fire, EPA later corrected the data to produce estimates that are more comparable with the established methods for measuring $PM_{2.5}$ levels. Information about this process is presented in the EPA publication 1599: *Estimating air quality in the early stages of the 2014 Hazelwood mine fire*.

This summary report also includes carbon monoxide data provided by the Country Fire Authority's (CFA) monitoring instruments. This data has been used to complement EPA's carbon monoxide data.

This publication has been written for a general audience. For further details about any aspect of this report, or to access data, please contact EPA Victoria on 1300 372 842 or contact@epa.vic.gov.au

EPA's role during the fire

Throughout the Hazelwood mine fire, EPA Victoria was the agency responsible for monitoring and assessing the fire's impact on the quality of the air, soil and waterways in the region.

EPA provided data to the Department of Health (now the Department of Health and Human Services), whose role was to assess potential impacts on human health and to inform the community on appropriate actions to minimise health impacts.

Around one-third of EPA's staff was involved in the Hazelwood mine fire response at various stages.

Although the fire was declared safe on 25 March 2014, EPA continues to operate five monitoring stations in the Latrobe Valley. The station at Traralgon is a 'general conditions' monitor which is part of the statewide network of monitors that provide an overall picture of air quality. The other four stations are described as 'local conditions' monitors, which have been set up in response to the mine fire and are currently located at Churchill, Moe, Morwell (South) and Morwell (East).

Hourly air quality updates from these stations are available on the Hazelwood air monitoring page on EPA's website.

What pollutants did we monitor?

Pollutants produced from brown-coal fires can include breathable airborne particles (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3). Information on each of these pollutants is provided below.

Risk assessments led by the Department of Health in the early stages of the fire showed that the pollutants of primary concern were carbon monoxide and breathable airborne particles (in particular $PM_{2.5}$). While the other pollutants were not deemed to be of concern, they were still measured by EPA to allay community concerns. Visibility reduction (a good indicator of smoke intensity) was also measured by EPA.

Airborne particles or particulate pollution is the presence of liquid droplets or solid particles (such as dust and smoke) in the air. Particles come in a wide range of sizes. They are measured in micrometres (µm) – 1 micrometre is 0.001 millimetres (mm). Two categories of particle size were measured by EPA during the Hazelwood mine fire:

- $PM_{2.5}$ are airborne particles with a diameter of less than 2.5 µm. General sources of these particles include all types of combustion processes, including motor vehicles and power plant emissions and, in this case, a coal fire. Very fine particles pose the greatest risk to human health, as their very small size means they can be breathed deep into the lungs.
- PM_{10} are particles less than 10 µm in diameter. Sources of these particles include combustion sources, but also crushing or grinding operations, pollen, road dust and sea salt.

Carbon monoxide (CO) is a colourless and odourless gas that is produced when fuels are burned. The most common source of carbon monoxide in the outdoor environment is car exhaust emissions. As a result, low levels of carbon monoxide are always present in the air in Australian towns and cities.

Sulfur dioxide (SO_2) is a strong-smelling, colourless gas that can irritate the lungs, and can be particularly harmful for people with asthma. In this area, coal-fired power stations are a major source of sulfur dioxide in the air.

Nitrogen dioxide (NO_2) is an invisible gas with a strong, unpleasant odour. It is produced by all types of combustion. The most common source of nitrogen dioxide in the air is car exhaust emissions.

Ozone (O_3) is a colourless gas with a strong, distinctive odour. Although ozone naturally occurs everywhere, especially high up in the atmosphere, where it protects us from some of the sun's harmful UV radiation, a higher-than-normal concentration of ozone found closer to the ground is a main part of air pollution called smog. Ozone forms when other air pollutants combine on warm or hot days.

Visibility reduction measurements are a good indicator of smoke intensity: the greater the smoke intensity, the higher the visibility reduction measurement and the lower the visual range. Visibility is reported as an airborne particle index, which is based on the measurement of the amount of fine particles in the air.

Up-to-date information on the impacts of air pollution on human health can be found on the Department of Health and Human Service's Better Health Channel website.

EPA also tested the air for a wide range of **other pollutants**, including metals, volatile organic compounds, dioxins and polycyclic aromatic hydrocarbons, as some of these pollutants could have potentially been produced by the combustion of brown coal. However, following on from risk assessments conducted in the early stages of the fire, EPA did not expect to find high levels of most of these pollutants in the air. EPA tested for these pollutants using passive air-sampling processes which use different techniques to the automated, realtime air monitoring techniques included in this report. An explanation of the air sampling methods and results will be available in a separate report to be published by EPA later in 2015: *Hazelwood Recovery Program air quality assessment – Morwell and surrounds. February 2014 – May 2015* (Publication 1601).

EPA ensures the accuracy of its air quality data by using best-practice technologies and applying the relevant Australian Standards for sampling and analysis. For the air quality monitoring processes used during the Hazelwood mine fire, EPA had its methods peer reviewed by five leading, independent Australian and international science experts. All reviewers agreed that the processes used by EPA during the fire were appropriate for this type of pollution event.

Testing against air quality standards

Air quality data collected during the Hazelwood mine fire was measured against the Australian *National Environment Protection (Ambient Air Quality) Measure*, commonly known as the Ambient Air NEPM. These national air quality standards have been used across Australia since 2002 and include a set of air quality goals and standards for a range of air pollutants (see Table 1).

The standards set out the acceptable levels of key air pollutants as agreed to by all Australian jurisdictions. Further information about these standards can be found on the Australian Government Department of the Environment's air quality standards webpage.

To find out more about how EPA Victoria fulfils its responsibilities under the standards, see Victoria's Ambient Air NEPM monitoring plan.

For other pollutants not covered in the Ambient Air NEPM, such as visibility-reducing particles (measured as visual distance, and reported as an index), EPA reports against air quality objectives defined in the *State Environmental Protection Policy (Ambient Air Quality)* (Air SEPP AAQ). The Air SEPP AAQ sets air quality objectives and goals for the State of Victoria. It mirrors the requirements in the Ambient Air NEPM. EPA also uses the *State Environmental Protection Policy (Air Quality Management)* (Air SEPP AQM) for some objectives and monitoring. This SEPP provides a framework for managing air emissions in the air environment.

During the Hazelwood mine fire, EPA primarily used the SEPP AAQ and the Ambient Air NEPM to assess the concentration of pollutants in the air. During the fire EPA also followed the Carbon Monoxide Response Protocol and the $PM_{2.5}$ Response Protocols. These interagency agreements are decision-making tools that were developed by the Department of Health in the early stages of the fire to assess the risks to the community.

Table 1: Standards and assessment criteria for key pollutants

Pollutant	Averaging time	Standard	Origin
Particles as $PM_{2.5}$	24 hours	25 $\mu g/m^3$	Ambient Air NEPM*
Particles as $PM_{2.5}$	Annual	8 $\mu g/m^3$	Ambient Air NEPM*
Particles as PM_{10}	24 hours	50 $\mu g/m^3$	Ambient Air NEPM
Carbon monoxide	8 hours	9 ppm	Ambient Air NEPM
Nitrogen dioxide	1 hour	0.12 ppm	Ambient Air NEPM
Nitrogen dioxide	Annual	0.03 ppm	Ambient Air NEPM
Ozone	1 hour	0.10 ppm	Ambient Air NEPM
Ozone	4 hours	0.08 ppm	Ambient Air NEPM
Sulfur dioxide	1 hour	0.20 ppm	Ambient Air NEPM
Sulfur dioxide	24 hours	0.03 ppm	Ambient Air NEPM
Sulfur dioxide	Annual	0.02 ppm	Ambient Air NEPM
Minimum visible distance	1 hour	20 km	Air SEPP AAQ

Notes:

1. Each pollutant has a specific averaging time. Averaging is done over defined time periods (1 hour, 8 hours, 24 hours and annually) to compare against the standards and criteria for health effects. Most air monitoring instruments measure air quality over minutes, and these are then averaged over longer time periods.

2. $\mu g/m^3$ means micrograms per cubic metre; ppm means parts per million.

3. * Under the current Ambient Air NEPM, there is no direct standard for $PM_{2.5}$; however there is an agreed advisory standard of 25 $\mu g/m^3$. The Australian Government is currently leading work to finalise an agreement on a national standard for $PM_{2.5}$.

How did we monitor air quality?

EPA used a number of methods to monitor air quality during the Hazelwood mine fire:

Rapid-response monitors are mobile instruments (such as those used on trucks or cars) that can be set up quickly in response to a pollution event. They provide immediate data about the impacts of a pollution event and give a good overview of air quality. This data can help EPA and other agencies to plan what to do next during a pollution event.

One of the monitoring instruments used is called a DustTrak™. These instruments are currently not accepted under the Australian Standards for assessing air quality against standards. EPA has worked to increase our understanding of the scientific corrections applied to data from rapid response instruments, which is useful to understand for future incidents. This information is available in EPA publication 1599: *Estimating air quality in the early stages of the 2014 Hazelwood mine fire*.

Local condition monitoring stations contain sophisticated monitoring instruments, such as BAMs (beta attenuation monitors). These instruments give more accurate readings of pollution levels than instruments used in rapid-response monitoring. They are approved under the Australian Standards and therefore can be used to assess air quality against Ambient Air NEPM standards.

Figure 1: One of the mobile, rapid-response air monitoring devices used by EPA during the Hazelwood mine fire. The pictured device shows the inlet for a DustTrak™ instrument.

Figure 2: One of the 'local conditions' monitoring stations, which contains a beta attenuation monitor (BAM).

Where was air quality monitored?

During the Hazelwood mine fire, EPA's monitoring focused on measuring $PM_{2.5}$ levels and carbon monoxide, as these pollutants potentially posed the greatest risk to human health.

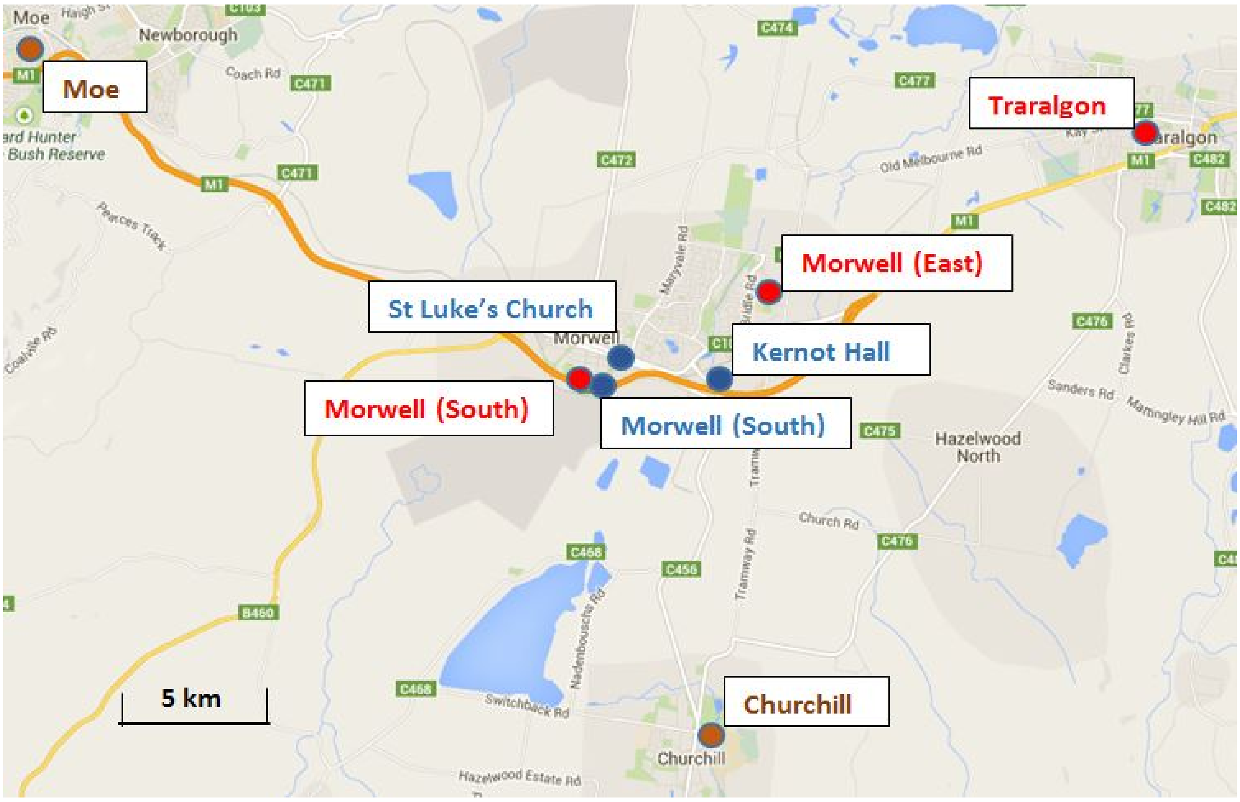
EPA had nine fixed and two mobile air quality monitoring devices operating in and around Morwell and across the Latrobe Valley region. CSIRO also ran two air quality sites in Morwell (east and south) and one in Traralgon.

The locations of the monitoring stations were chosen to best capture the local condition of the air and identify the worst impacts of the smoke.

The Country Fire Authority (CFA) also monitored levels of carbon monoxide in and around Morwell and provided this information to EPA, who assessed this data and provided the assessment of air quality impacts to the Department of Health.

Note: CFA data was collected according to CFA principles and procedures. As the data collected by the CFA was not measured directly by EPA, it has not been validated by EPA for the purposes of this report and is considered to be 'indicative'.

Figures 3 and 4: EPA standard sites (●), EPA indicator sites (●), EPA other sites (●), CFA CO sites (●).



Monitoring equipment by location

EPA's scientists measure air quality using rigorous monitoring systems and best-practice technology.

During the Hazelwood mine fire, EPA monitored air quality using different types of equipment at different locations in and around Morwell (see Table 2):

BAM – a standard beta attenuation monitor automatically measures and records airborne particles. This instrument works by collecting particles on a special filter and measuring their density. From this, the concentration of airborne particles is calculated (see Figure 5).

TEOM – a transverse element oscillating microbalance monitor continually measures the concentration of airborne particles. It does this by collecting and weighing the particles using a very sensitive balance. TEOMs are standard across EPA's network and meet the Australian National Standard (AS 3580.9.8).

DustTrak – a portable, 'rapid-response' instrument which uses an optical sensor. The data produced by the DustTraks helped EPA map particle level variations and exposures.

ADR 1500– Area dust monitors use highly sensitive light-scattering sensors to detect smoke particles. The data from this type of instrument is indicative and the ADR was not subject to the same rigorous data processes (post-monitoring) that the DustTrak underwent. This data therefore has not been included in the report.

Gas analysers – these instruments are used to measure the concentrations of different gases in the air. Each gas is measured by a different digital analyser.

Nephelometer – this instrument measures the amount of particles in the air in a similar way to the ADRs, and calculates a visibility reduction index.

Table 2: Location of air monitoring equipment during the Hazelwood mine fire

Site	Monitoring equipment	What was measured	Monitoring period
Morwell (South) air monitoring station	DustTrak, BAM, gas analyser, nephelometer	$PM_{2.5}$, CO, ozone, NO_2, SO_2, visibility reduction	February 2014 – present
Morwell (East) air monitoring station	BAM, gas analyser, nephelometer	$PM_{2.5}$, CO, SO_2, visibility reduction	February 2014 – present
Traralgon air monitoring station	TEOM, gas analyser, nephelometer	PM_{10}, CO, ozone, NO_2, SO_2, visibility reduction,	1981 – present
Kernot Hall, Morwell	DustTrak	$PM_{2.5}$, PM_{10}	February – March 2014
St Luke's Uniting Church, Morwell	DustTrak	$PM_{2.5}$, PM_{10}	February – March 2014
Churchill	ADR 1500	$PM_{2.5}$	February 2014 – present
Moe	ADR 1500	$PM_{2.5}$	February 2014 – present

Figure 5: A BAM instrument that measures airborne particles ($PM_{2.5}$).

Results of air quality monitoring

Overview

Based on our air monitoring results the pollutants that, to varying degrees, exceeded the relevant Ambient Air NEPM air quality standards at different times during the mine fire were: airborne particles ($PM_{2.5}$ and PM_{10}) and carbon monoxide. Visibility reduction also exceeded the SEPP (ambient air quality) standard at various times during the fire.

As expected by risk assessments from the Department of Health very early in the fire, pollutants that did not exceed the Ambient Air NEPM standards during the fire were: sulfur dioxide; nitrogen dioxide; and ozone.

These monitoring results are presented below.

Averaging data over 24 hours – what can it tell us?

For airborne particles ($PM_{2.5}$ and PM_{10}), data is gathered hourly and the results are presented as an average over a 24-hour period – but we can look at two different types of 24-hour periods.

Daily average is an average of the hourly data collected over 24 hours, from midnight to midnight, on a calendar day. This means the average is updated each day and it provides a record of air quality for a particular date.

Rolling 24-hour average is an average of any 24-hour period, which is calculated at each hour as the day goes on. This means the average value (for the previous 24 hours) is updated each hour. This way of looking at the data gives us more detail about when changes in air quality occurred, and how fast they were occurring.

Airborne particles ($PM_{2.5}$)

Figure 6 shows the $PM_{2.5}$ levels recorded at Morwell (South), which was the location that was most affected by smoke, and at Morwell (East).

The results show that $PM_{2.5}$ levels were well above the air quality standard, particularly during the early stages of the Hazelwood mine fire between 14 February and 3 March. However, as the fire was gradually extinguished, $PM_{2.5}$ levels dropped.

$PM_{2.5}$ was measured by two different instruments at each location: a BAM instrument (solid line) and a DustTrak instrument (dotted line). The DustTrak data should be treated with caution, as it not accepted under Australian Standards and is known to be inaccurate when pollution levels are very high. However, it does provide the best available indication of $PM_{2.5}$ levels in the absence of BAM measurements during the earlier stages of the fire.

EPA has since undertaken further corrections of DustTrak data to produce a more accurate estimate of $PM_{2.5}$ levels for the period before the BAM was installed. These corrections are provided in *Estimating air quality in the early stages of the 2014 Hazelwood mine fire* (publication 1599).

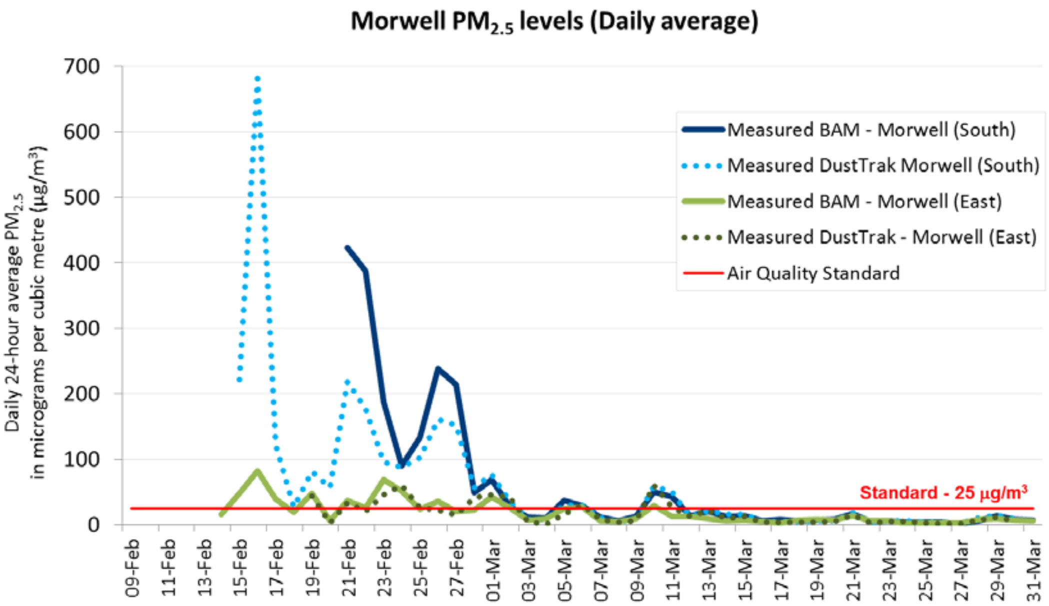


Figure 6: Daily average $PM_{2.5}$ levels measured at Morwell (South) and Morwell (East).

Notes:

1. Dotted lines show the data from DustTrak monitoring, which underwent a correction factor as advised by EPA Tasmania at the time of use.

2. The DustTrak data needs to be treated with caution as it is not Australian Standard instrumentation. The levels are indicative. Solid lines show data recorded from BAM instruments, which are in line with the Australian Standard.
3. Daily average is measured from midnight to midnight, in line with the Ambient Air NEPM standard.

The effect of wind direction on $PM_{2.5}$ levels

Our monitoring results show that wind direction affected the concentration of airborne particles ($PM_{2.5}$) measured at the Morwell (South) and Morwell (East) monitoring stations.

Levels of $PM_{2.5}$ tended to be higher on days when the wind was southwesterly (smoke blowing over Morwell and towards the monitoring stations) and lower on days when it was blowing in other directions. $PM_{2.5}$ levels were also high during a calm wind period that occurred around 9–10 March 2014.

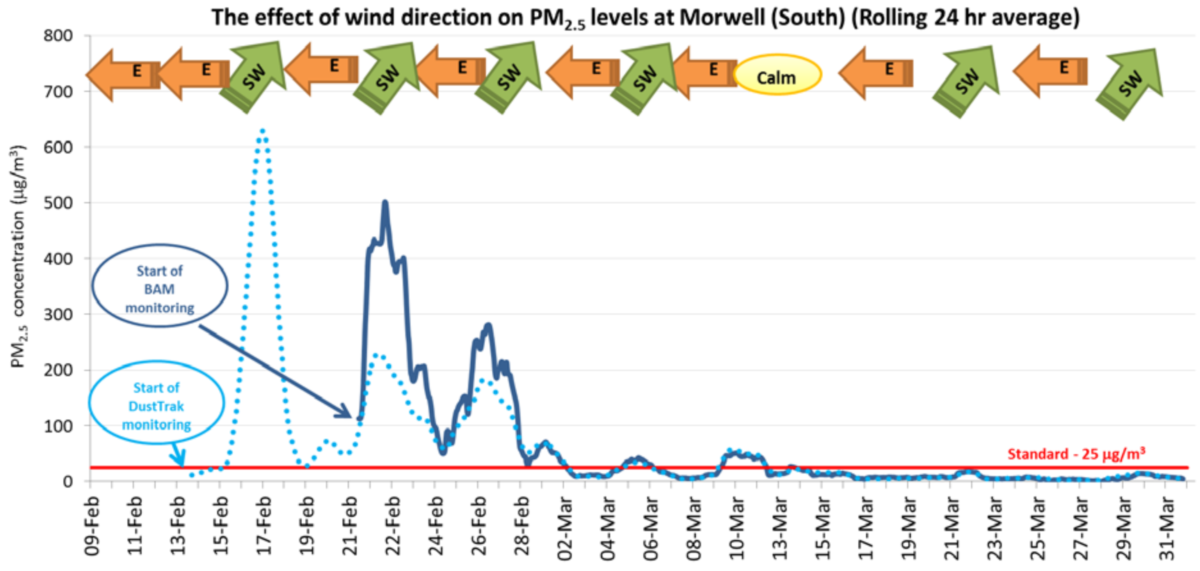


Figure 7: The effect of wind direction on PM2.5 concentrations at the Morwell (South) monitoring station. The 24-hour rolling average is the average of the hourly readings of $PM_{2.5}$ over the previous 24-hour period. It is updated each hour.

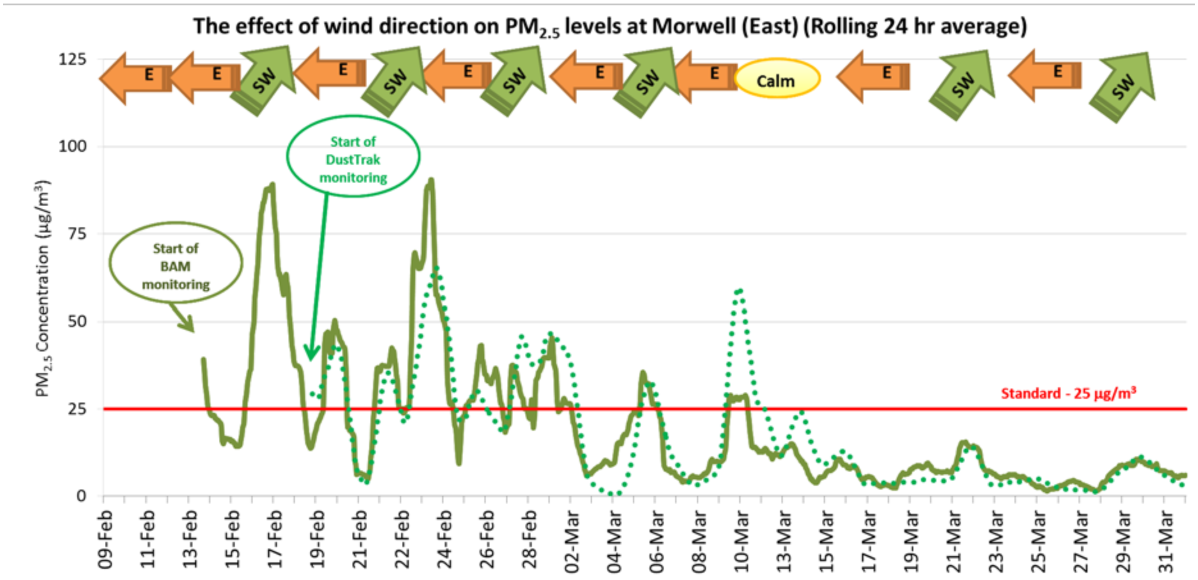


Figure 8: The effect of wind direction on $PM_{2.5}$ concentrations at the Morwell (East) monitoring station. The 24-hour rolling average is the average of the hourly readings of $PM_{2.5}$ over the previous 24-hour period. It is updated each hour.

Airborne particles (PM_{10})

PM_{10} levels exceeded the Ambient Air NEPM standard at Traralgon when the fire first started, and at Morwell (South) at various times between 27 February and 21 March 2014.

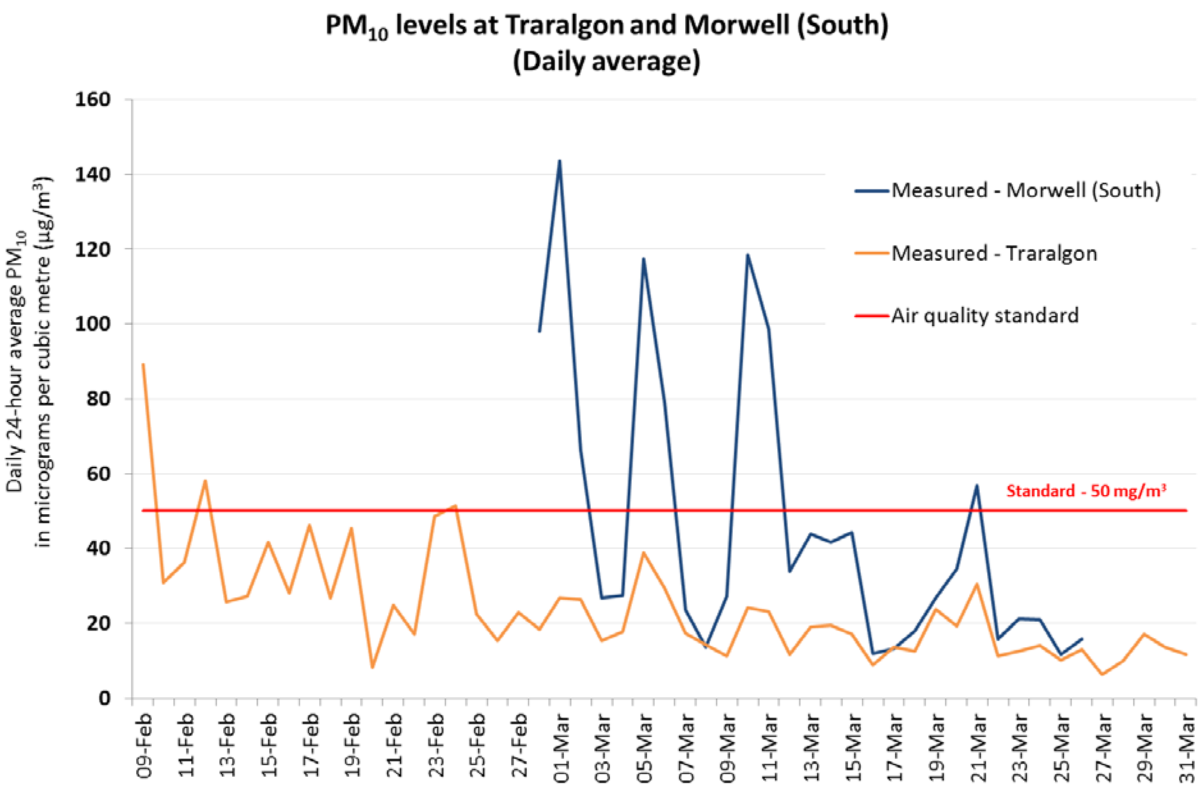


Figure 9: PM_{10} measured by EPA at Morwell (South) and Traralgon. Both locations recorded PM_{10} concentrations above the Ambient Air NEPM standard of 50 micrograms per cubic metre ($\mu g/m^3$) at various times.

Carbon monoxide

EPA recorded carbon monoxide at levels above the Ambient Air NEPM standard at Morwell (South) on three days in February 2014: Friday 21, Saturday 22 and Wednesday 26.

Indicative levels recorded by CFA monitoring instruments also suggest that carbon monoxide levels exceeded the standard at Keegan Street, the bowling club and the police station, which are all located close to the Morwell (South) EPA station. Indicative levels were particularly high at Keegan Street and the bowling club around 15–17 February.

As the mine fire was brought under control, carbon monoxide levels dropped.

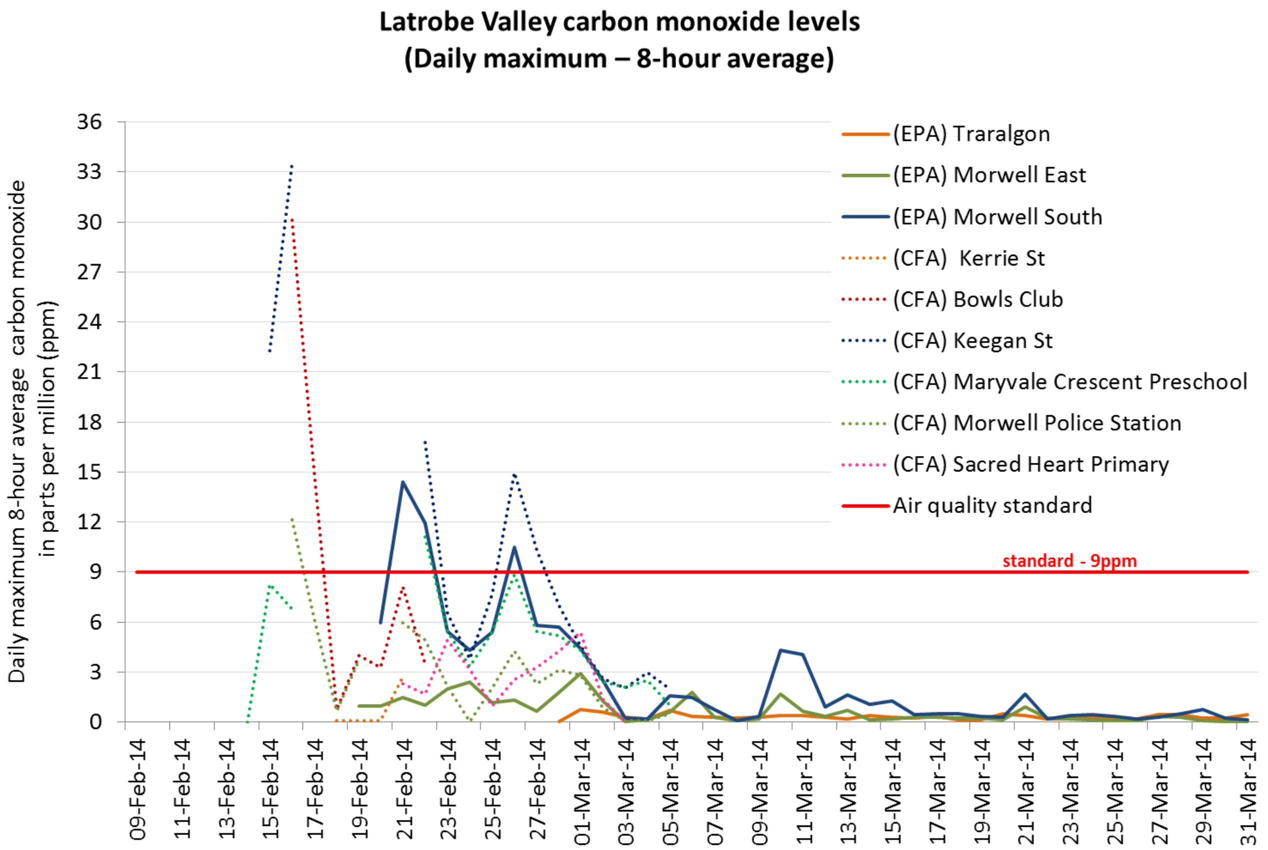


Figure 10: Carbon monoxide levels recorded by EPA at Traralgon, Morwell (South), and Morwell (East), and at other locations recorded by the CFA.

Notes:

1. Data recorded by EPA (solid lines) was measured by Australian Standard instruments that have undergone EPA-supervised calibration.
2. Data recorded by CFA (dotted lines) provided EPA indicative levels.

Visibility (smoke intensity)

Visibility due to smoke intensity was very poor at various times throughout the Hazelwood mine fire, particularly during the first month. Visibility is reported as an airborne particle index, which is based on the measurement of the amount of fine particles in the air.

Throughout the fire, smoke intensity was frequently higher than the air quality objective set in the Air SEPP AAQ (an index value of 2.35, which is equivalent to a visibility reduction of 20 km. Smoke intensity was particularly high at Morwell (South), but decreased as the fire was being brought under control.

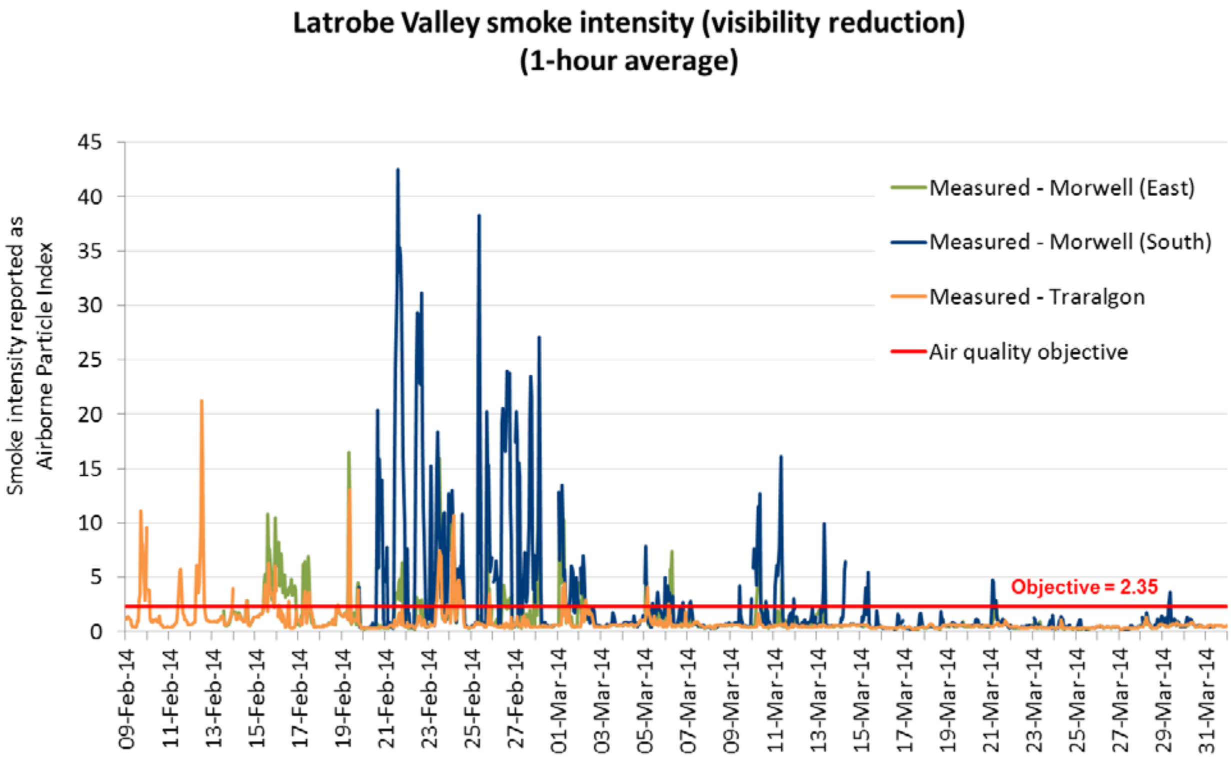


Figure 11: Smoke intensity recorded at Morwell (East), Morwell (South) and Traralgon. Smoke intensity was frequently recorded above the air quality objective set by the Air SEPP AAQ. The highest levels were recorded at Morwell (South).

Sulfur dioxide

Sulfur dioxide was detected at low levels, which were well below the Ambient Air NEPM standard. EPA considers the most likely source of sulfur dioxide was the nearby power station emissions rather than the fire.

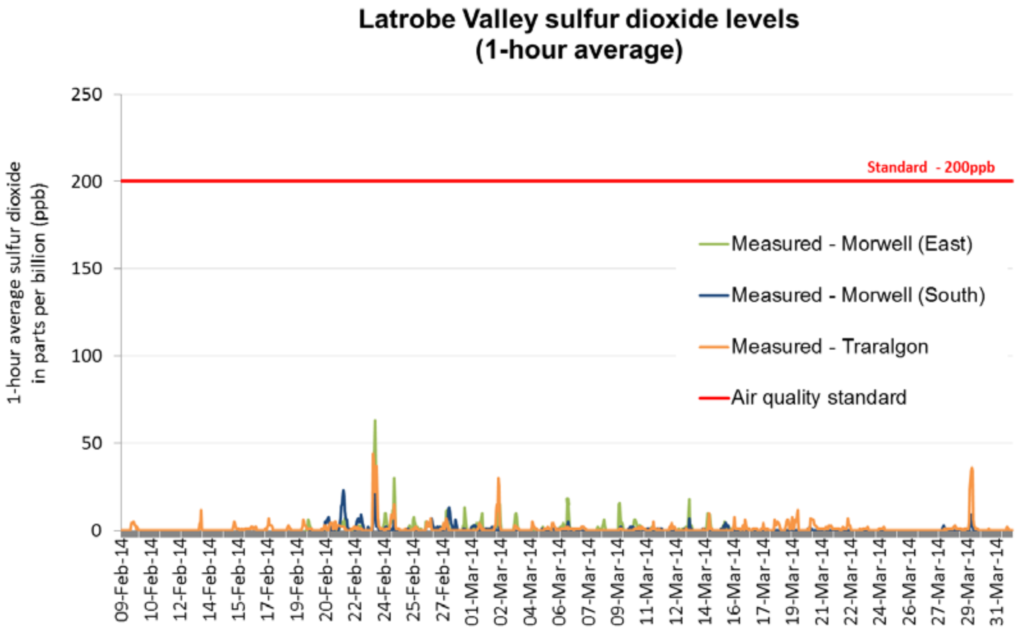


Figure 12: Sulfur dioxide levels recorded at Morwell (South), Morwell (East) and Traralgon. All recorded levels were well below the Ambient Air NEPM standard.

Nitrogen dioxide

Low levels of nitrogen dioxide were detected at Morwell (South) and Traralgon. All recorded levels of nitrogen dioxide were well below the Ambient Air NEPM standard.

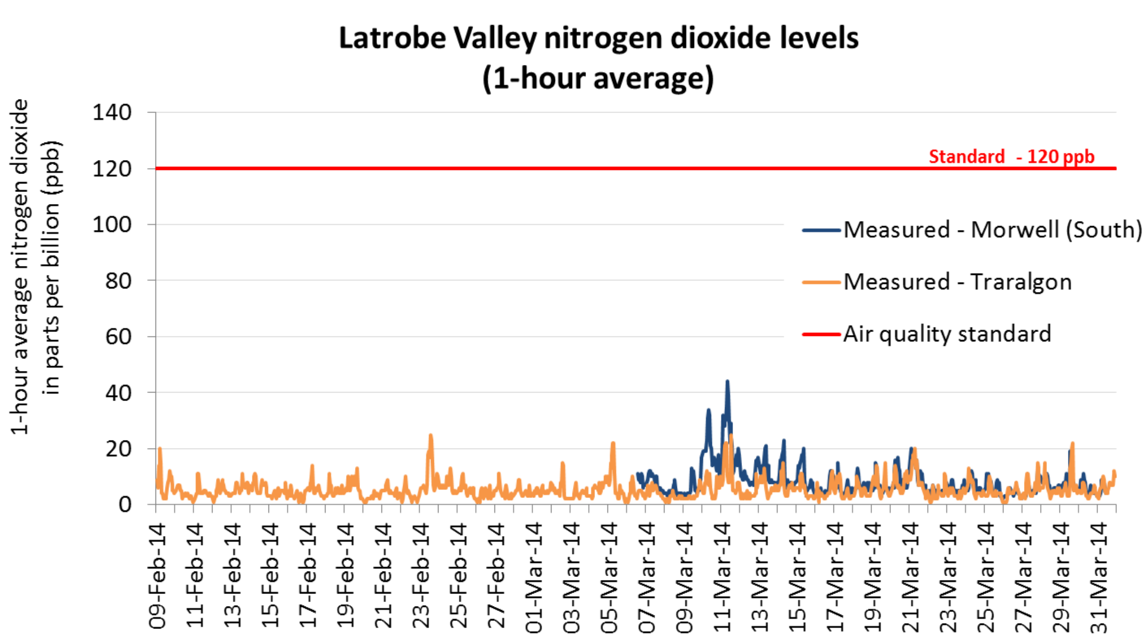


Figure 13: Nitrogen dioxide levels recorded at Traralgon and Morwell (South). All recorded levels were below the Ambient Air NEPM standard.

Ozone

Low levels of ozone were detected at Morwell (South) and Traralgon. All recorded levels of ozone were well below the Ambient Air NEPM standard.

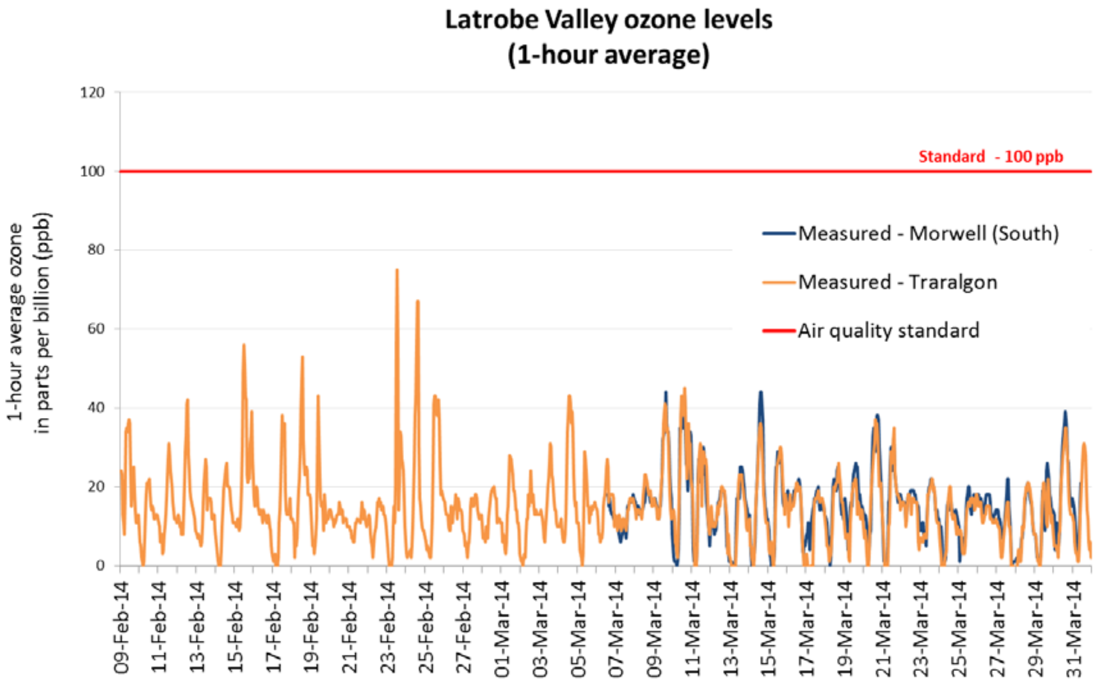


Figure 14: Ozone levels recorded at Traralgon and Morwell (South). All recorded levels were below the Ambient Air NEPM standard.