Environment Protection Authority

SmokeWatch Mount Gambier

2009–2011

EPA
South Australia

SmokeWatch Mount Gambier 2009–11

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Summary

SmokeWatch Mount Gambier was established as a collaborative three-year partnership between the Environment Protection Authority (EPA), Department of Health, City of Mount Gambier, Firewood Association of Australia and Australian Home Heating Association. Since its launch in 2009, SmokeWatch also gained the support of several local schools, businesses and community organisations.

Release of this final report marks completion of the SmokeWatch Mount Gambier project, the core of which was an integrated approach to community education, engagement, and health and air science. It incorporated air quality monitoring, education activities and community surveys to characterise wood smoke pollution in Mount Gambier and understand attitudes within the community to air quality.

The project partners recognise that making substantial changes to community behaviour is generally a long-term process. The project has been successful in initiating strong positive responses from newspapers, radio and television stations in Mount Gambier, which have given substantial support in broadcasting the important messages of the project.

Active participation by the Mount Gambier community indicates a will, and an increasing understanding of the need, to improve air quality—and recognition that individuals can take action that collectively contributes to improvements in the environment for all. Partner organisations wish to acknowledge the important voluntary contributions by the media, local health services and the wider Mount Gambier community, during the whole project.

Community surveys were used during the project to elicit perceptions and attitudes towards smoke and air quality, possible impacts of poor air quality, strategies used to reduce exposure and actions people might take to continue to improve air quality. A major survey was undertaken in 2010 of specific groups within the City, including children, older people, and people with existing illnesses (Galicki 2010). Subsequent smaller scale community surveys built on this work in 2011.

Survey results were not statistically significant, but provided some valuable information about awareness of air quality in Mount Gambier (as monitored by the EPA) and of the SmokeWatch project. For example:

- The rate of wood heater use in Mount Gambier remains at around 30% of households, consistent with levels found in the 2010 survey and surveys undertaken prior to the project.
- Residents ranked highly the importance of clean and healthy air.
- Residents also indicated they could best be supported to continue to improve air quality through education and continued encouragement of efficient wood heating practices.
- Stakeholders were willing to continue to promote the key messages of the project, especially where there is common benefit between the project and stakeholders.

Air quality monitoring commenced earlier in 2011 than in previous years, with the aim of capturing any impacts of activities such as forestry or agricultural burning; and the project was also prolonged into the spring and early summer months of 2011, to garner some information on particle patterns under warmer conditions.

The air monitoring component of SmokeWatch Mount Gambier confirmed that multiple exceedences of the national standards for fine particles (PM_{10} and $PM_{2.5}$) typify conditions during the cooler months of the year. These standards are set out for in the *National Environment Protection (Ambient Air Quality) Measure 1998 (as amended 2004)* [the Air NEPM].

While the number and severity of exceedences varied from year to year, it is clear that Mount Gambier consistently experienced poor winter air quality in the form of high daily average concentrations of fine particles ($PM_{2.5}$ particles or particles with diameter less than 2.5 micrometres or µm) during the project; with a typical pattern of persistent elevated concentrations being recorded overnight.

The variability observed between years and seasons is a characteristic of ambient air quality data, as it is driven by both sources of emissions and by weather and climactic conditions. Three years of measurements is not sufficient to calculate reliable trends; however, particle measurements in this project were comparable with those of short studies conducted previously in Mount Gambier (with different instrumentation), suggesting that winter air quality remains consistent over the long term.

Measurements using a suite of techniques showed that the $PM_{2.5}$ particles were primarily due to smoke—most likely wood smoke—from a range of local sources, which build up during cold, still weather conditions, known as *temperature inversions*.

The effect of an inversion is like putting a lid on a saucepan. It traps any emissions beneath it, so that they build up to concentrations that may cause health problems for people. In contrast, windy and rainy conditions will clear the emissions away and clean the air.

A large proportion of the fine particles consistently emanated from residential areas of the city, supporting the conclusion that domestic sources were major contributors to poor air quality in Mount Gambier.

This report also looks at 'PM_{coarse}' particles, which are within the 'breathable' PM_{10} size range, but are larger in size than $PM_{2.5}$—so they do not include smoke. Episodes of higher concentrations of PM_{coarse} were at times recorded from sources adjacent to the monitoring sites, possibly reflecting contributions from industrial, developmental and agricultural activities in the region. A full understanding of sources of coarse particles in Mount Gambier is likely to require monitoring throughout all seasons of the year, to capture those periods when dry, dusty conditions prevail, and activities such as harvesting are underway.

Conclusions and recommendation

Overall, winter patterns of fine particle pollution are entirely consistent with the dominance of wood smoke during cold winter nights. As the project progressed, monitoring results increasingly strengthened the evidence that wood smoke is a major winter pollutant in Mount Gambier, with the clear message that programs to reduce smoke will achieve the most effective improvements in air quality. This, combined with feedback from the community, provides a case for continuing to promote key wood heating efficiency messages in Mount Gambier beyond the conclusion of this project, and further investigation into the relative contributions of the different sources contributing to poor winter air quality in the city.

It is proposed that any future programs be driven locally, with EPA continuing scientific support for the key messages that promote better operation of wood heaters in Mount Gambier.

1 Introduction

SmokeWatch Mount Gambier commenced in March 2009 in response to historical evidence pointing to the influence of wood smoke on air quality in the city. Progressive improvements in industrial emissions from wood fuelled plants in the city were achieved by effective cooperation between industry and the Environment Protection Authority (and its predecessors) over the last few decades. With improvements in those sources, it has become increasingly apparent that other activities, particularly domestic wood burning, were also likely to be significant contributors to fine particle levels.

SmokeWatch Mount Gambier was established as a collaborative partnership between the Environment Protection Authority (EPA), City of Mount Gambier, Australian Home Heating Association and Firewood Association of Australia, with the Department of Health and Ageing and the local health service formally joining later in the project. The project focused on a suite of key objectives:

- Raising community awareness of the environmental and health effects of inefficient wood heating.
- Building community understanding of the importance of following efficient wood heating practices to minimise pollution, maximise home comfort, promote energy efficiency and reduce the health effects of wood smoke pollution.
- Advising wood heater users of the correct practices for efficient wood heater use.
- Developing and implementing creative solutions to enable wood heater users to easily and conveniently follow the key practices to efficient wood heater use.
- Engaging schools, businesses, organisations and key community groups in promoting clean air messages.
- Raising awareness among the community of the role of the EPA and the City of Mount Gambier in managing wood smoke pollution.
- Defining the sources of wood smoke pollution and their contributions through monitoring.
- Measuring the effectiveness of actions to reduce wood smoke through air quality monitoring.

Health research in Australia and overseas over many years has shown that fine particles as PM_{10} and $PM_{2.5}$ are associated with cardio-respiratory effects in humans. Recent work has confirmed effects of average daily particle levels on cardio-respiratory hospital admissions in metropolitan Adelaide (Hansen *et al* 2011). Fine particles in the form of wood smoke have been of concern in Mount Gambier for some years, as wood is widely used for both industrial and domestic heating in the city.

Programs similar to SmokeWatch have been operated by the EPA in various parts of South Australia for many years, to develop and implement regional strategies to reduce wood smoke pollution caused by the inefficient use of domestic wood heaters. SmokeWatch has traditionally focused exclusively on education programs, encouraging engagement with the community and other relevant stakeholders towards building awareness and understanding of local air quality, while promoting broad ownership of wood smoke pollution.

The three-year SmokeWatch Mount Gambier project was the first major SmokeWatch project to integrate traditional education and awareness activities with active air and health science components. While achieving understanding of air pollution and its sources in the city was an important component, the primary focus of the project was to provide and reinforce a positive message: that everyone in the community can participate in improving air quality by operating their wood heaters more efficiently.

The City of Mount Gambier nestles in a valley in the south east of South Australia. It is surrounded by commercial forestry activities and a range of other agricultural, horticultural and vinicultural industries. Within the city, several industries are dependent on the forests, including panelboard manufacture, fuelled by wood waste products. These are licensed under the *Environment Protection Act 1993*. The range of industries is quite diverse, as shown on the map in Figure 1.

Wood is also a readily available fuel used for domestic heating in the city and surrounding areas, and about one-third of residents use wood heaters. Both the community activities and the air monitoring program evolved through the three years, as knowledge of air quality in the city and the opinions of its community were better understood.

Phase 1 – 2009

The first year of SmokeWatch Mount Gambier focused on alerting the community of the project, the issue of wood smoke and its potential health effects, backed up by presentations to community groups and publication of monitoring information. Broadly, results of monitoring were referenced against National Environment Protection Standards for particles, shown in Table 1 (EPHC 2004). A great deal of health research over the last decade or two shows that there is no threshold for effects of PM_{10} and of $PM_{2.5}$ particles on human health. On that basis it is argued that *any* significant reductions of fine particle pollution would provide benefits for communities, a view reflected in current moves to introduce a national *exposure reduction goal* in Australia. Appendix 2 provides more information on fine particles.

Table 1 Ambient standards and goals for particles

Pollutant	Averaging period	Maximum concentration	10 year goal: maximum allowable exceedences
PM_{10} (full standard)	1 day	50 $\mu g/m^3$	5 days a year
$PM_{2.5}$ (advisory reporting standards)	1 day	25 $\mu g/m^3$	–
	1 year	8 $\mu g/m^3$	

Source: National Environment Protection (Ambient Air Quality) Measure 1998 (as amended 2004)

The air monitoring station at Gordon Education Centre initially comprised instruments to measure PM_{10} particles directly; It also included an instrument for determining particle size distributions; however, direct reading instruments for $PM_{2.5}$ were unavailable to EPA at the time, so techniques were deployed that provided indirect measurements of $PM_{2.5,}$ which were nevertheless shown to be well-correlated to ambient $PM_{2.5}$ concentrations. The capabilities of the monitoring component were enhanced in 2010. Appendices 2 and 3 have further information on particle sizes and measurement methods used during the project.

From its early conception, involvement of local media was always seen as central to the project. *The Border Watch* provided space to publish weekly graphical summaries of daily average PM_{10} concentrations to provide the community with up-to-date information, and continued to provide this valuable service throughout the three years of the project.

Interviews with EPA staff and other key players by radio and television stations provided further opportunities to disseminate information about the project and offer simple ways in which people could improve emissions from their heaters. From the beginning, SmokeWatch Mount Gambier also had the active support of several local schools, businesses and community organisations in promoting key wood heater effectiveness messages.

Phase 2 – 2010

The second year of the project saw the Department of Health join as a formal partner, reinforcing the important messages regarding the potential effects of wood smoke on human health and the simple actions that people could take to reduce smoke from their heaters.

Results from the first winter had provided an improved picture of air quality in Mount Gambier, especially those from domestic sources, but further clarification was needed about relative contributions of domestic, industrial and transport emissions in Mount Gambier. The EPA responded by acquiring and deploying additional instrumentation in 2010, providing a capability for direct measurement of $PM_{2.5}$ at the original Gordon Education Centre station. It also established

a new station at the Mount Gambier Showgrounds. These enhancements were aimed at improving understanding of patterns of particle pollution and transport around the city.

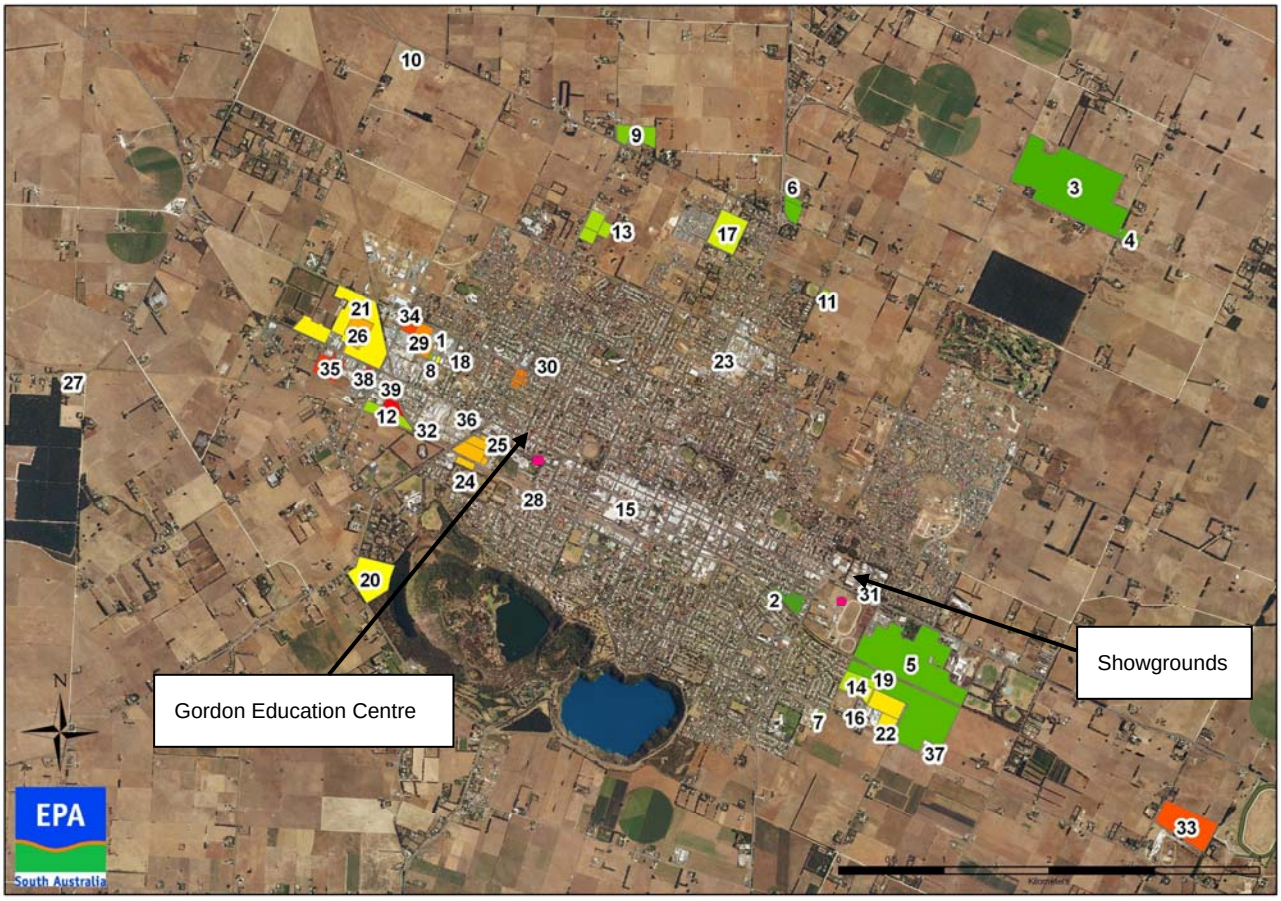


Figure 1 Monitoring stations and EPA licensed activities in Mount Gambier

Map key

1	MTU Detroit Diesel Australia Pty Ltd	21	Carter Holt Harvey Wood Products (Sth Region) P/L
2	Carter Holt Harvey Wood Products Australia Pty Ltd	22	Whiteheads Timber Sales Pty Ltd
3	Van Schaik Organic Soils & Bark Suppliers Pty Ltd	23	SE Battery Service Pty Ltd
4	GJ & TL Douglass Pty Ltd	24	Hanson Construction Materials Pty Ltd
5	Carter Holt Harvey Wood Products Australia Pty Ltd	25	Carter Holt Harvey Wood Products Australia Pty Ltd
6	South Pacific Seeds Pty Limited	26	Carter Holt Harvey Wood Products Australia Pty Ltd
7	Quickmix Concrete	27	Osmose (Aust) Pty Ltd
8	South East Handymix	28	Holcim (Australia) Pty Ltd
9	Kraft Foods Limited	29	AA Scott Pty Ltd
10	Mount Gambier Pistol Club Inc	30	K & S Freighters Pty Ltd
11	Mount Gambier Gun Club Incorporated	31	Powdercoating & Electroplating Professionals
12	Gambier Earth Movers Pty Ltd	32	Southern Blasters
13	NF McDonnell & Sons	33	Lowndes Abrasive Blasting
14	City of Mount Gambier	34	Scotts Agencies Pty Ltd
15	Gribbles Pathology (Vic) Pty Ltd	35	Landmark Operations Ltd
16	Green Triangle Recyclers Pty Ltd	36	De Bruin Engineering Pty Ltd
17	SA Pathology t/a Institute of Medical & Veterinary Science	37	Bin It
18	Fairsea International (SA)	38	Hexcon Pty Ltd
19	Transpacific Cleanaway Pty Ltd	39	Metalcycle
20	Mount Gambier Cemetery Trust		

The Border Watch again published weekly summaries, but this time they included both $PM_{2.5}$ and PM_{10}—identified as 'Smoke' and 'Other Particles' respectively—as illustrated by Figure 2. The distinction was based on real information from EPA's particle size distribution analyser, which showed that during episodes of poor air in winter 2009, virtually all of the $PM_{2.5}$ particles fell within the narrow size range of smoke particles (around 0.9 µm).

The EPA also redesigned the graphics to present information in terms of descriptions of air quality, rather than scientific units. Five descriptors ranging from 'very good' to 'very poor' were based on comparisons with the national air quality standards. The aim was to provide Mount Gambier residents with current and readily comprehensible information to assess the impacts of wood smoke on air quality. The graphs were also posted on the EPA website.

SmokeWatch Mount Gambier 2010 included a community survey undertaken in concert with the Department of Health, aimed at evaluating wood smoke impacts on vulnerable people and to gauge attitudes to wood heaters. The results, discussed in more detail below, suggested a likely focus for any future education and awareness programs.

The EPA published interim reports on these first two phases of the project on its website (EPA 2009, EPA 2011).

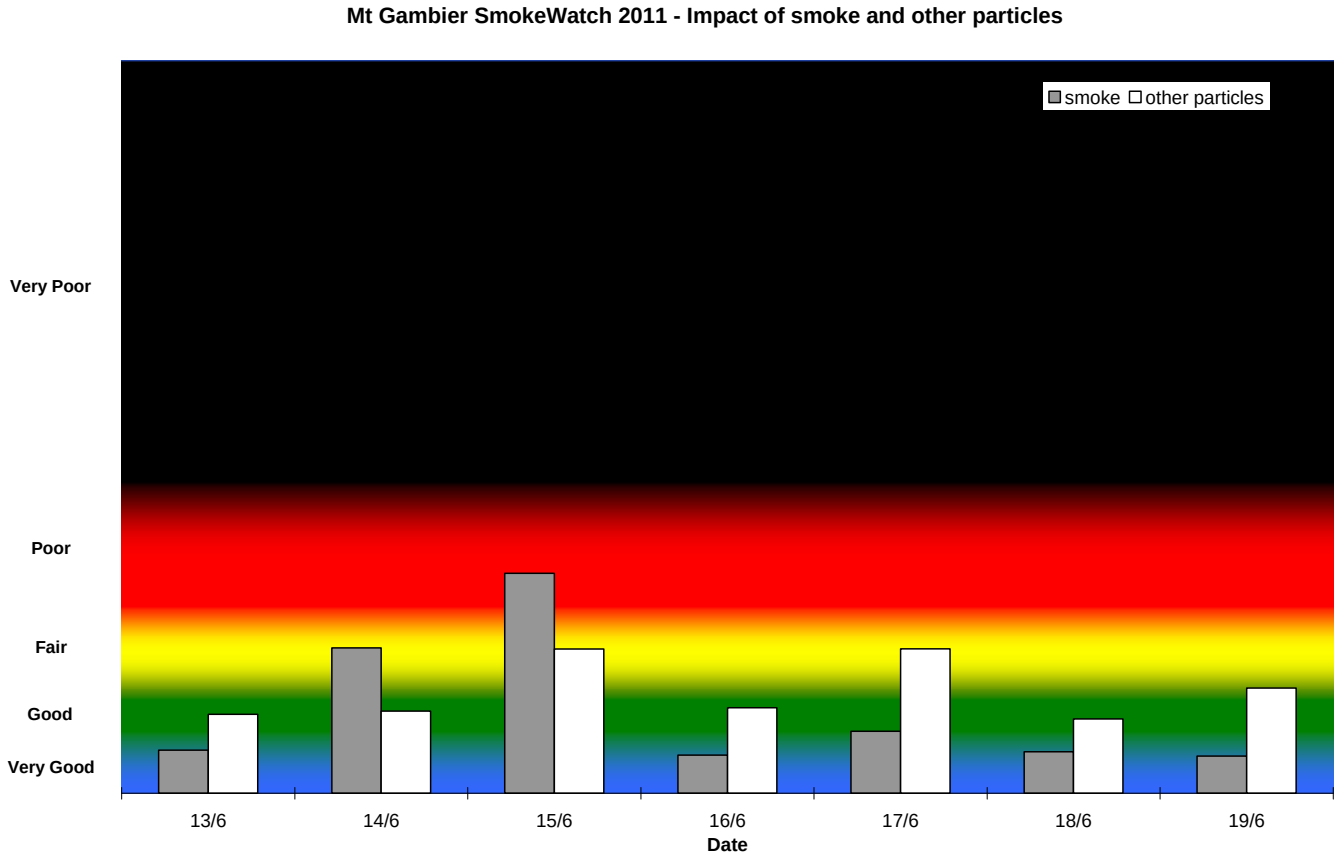


Figure 2 An example of the weekly air quality summaries published in *The Border Watch*

Phase 3 – 2011

The final phase saw air quality monitoring recommence earlier in 2011, aiming to capture data from any planned burning activities in the area during autumn. EPA also extended the monitoring into the warmer weather during spring.

The focus for engagement also broadened from susceptible groups to encompass the wider Mount Gambier community. Small-scale community surveys again provided information on perceptions and attitudes towards smoke and air quality; possible impacts of air quality; strategies used to reduce exposure; and actions people might take to continue to improve air quality. On the basis of previous surveys, capacity building was identified as a further goal for community engagement.

Throughout the life of the project, an initial suite of tools was progressively developed and refined to promote awareness of and actions to reduce wood smoke, including:

- Information displays at the Mount Gambier Library, Regional Community Health Centre, and City of Mount Gambier Council Chambers to raise awareness of the project and efficient wood heating practices, specific to the Mount Gambier community.
- Community information sessions at the Mount Gambier Library, providing an opportunity for residents to ask questions and share knowledge about wood heating efficiency and air quality in Mount Gambier.
- Surveys with the wider Mount Gambier community to gain an understanding and awareness of air quality in Mount Gambier, sources of poor air quality, and the capacity residents have to improve air quality through more efficient wood heater use. Results from surveys undertaken early in the project were actively utilised in designing later promotions.
- Wood moisture meters were made available on loan through the Mount Gambier Library to allow householders to test their firewood.
- Involvement of schools including providing education materials and the loan of simple air quality monitoring equipment for educational purposes.
- A self-assessment tool promoting good habits and practices for operating wood heaters throughout winter.
- Collaboration with local firewood suppliers, wood heater retailers, chimney sweeps, the local Metropolitan Fire Service, and real estate agents, in promoting effective use of wood and clean operation of heaters.
- Dissemination of a range of communication materials to wood heater users (including website information).
- Real-time monitoring of particles and weather conditions, using several different methods to aid understanding of types and patterns of particle pollution in the city.
- Weekly summary graphs of particle monitoring data published in *The Border Watch*, and the EPA website with progressive improvements in graphics presentations to sharpen the focus on quality of the air (Figure 2). Many thanks to *The Border Watch* for providing the space for the graphs as a public service.
- Regular interviews of EPA staff on local radio and television stations, again generously made available in the community interest.

From its inception, SmokeWatch has always presented clear and succinct messages that promote the idea that householders can actively reduce wood smoke from their wood heaters by adopting some very simple measures:

- observing how their wood heaters are operating
- using only dry wood (preferably seasoned for 12 months)
- ensuring a good, bright and hot fire.

Not only can these improve air quality, but will also reduce wastage of fuel.

The results of community surveys and community engagement indicated reasonable awareness of air quality in Mount Gambier and of the SmokeWatch Mount Gambier Project, but continuing education and encouragement of efficient wood heating practices will be required to effect comprehensive behaviour change and sustained improvements in air quality. To that end, it is proposed that further SmokeWatch-type programs be established and managed at the local level, with support from EPA and other relevant agencies.

In general, winter patterns of fine particle pollution during the three-year project indicated a higher contribution from domestic sources than in the warmer spring weather, consistent with a combination of higher use of domestic heaters and typical winter weather in Mount Gambier. Contributions to coarse particle levels in Mount Gambier's air were not so well described; and in reality further monitoring throughout all seasons of the year would be needed to clarify sources, patterns and impacts of these particles.

Air monitoring during the winter seasons of the three years of the project has enhanced our understanding of sources and their air quality impacts in Mount Gambier. However, because of the variability of air quality over days, seasons, or between years, three years is insufficient to show whether in fine particle pollution levels are improving, deteriorating, or staying essentially the same in Mount Gambier. Continuous monitoring for 5 to 10 years is normally needed to clarify air quality trends.

2 Community surveys

Community surveys have formed an important component of Mount Gambier SmokeWatch throughout the project, throwing light on perceptions and attitudes within the city, towards:

- relationships between air quality and wood smoke
- awareness of the SmokeWatch project itself
- possible impacts of wood smoke
- strategies to reduce exposure
- actions that people might take to improve air quality.

A survey in 2010 focused on susceptible groups, which included children, older people and people with existing illnesses (Galicki 2010). This was a relatively small-scale survey and the results were not statistically significant. However, the data did provide some practical information.

Subsequent surveys aimed to capture perceptions from the wider Mount Gambier community, and the following summary consolidates results from the whole program.

A total of 87 respondents completed a 14-item survey. In essence the survey concluded that:

- Awareness of the SmokeWatch project and air quality monitoring had increased.
- Wood heater use remains constant and continued encouragement of efficient wood heating practices would help address the issue.
- Clean and healthy air is important, and there are still concerns about Mount Gambier's air quality and potential negative impacts.

A more detailed analysis of responses follows (see also Figure 3).

Awareness

Over half of respondents to the survey were aware of the SmokeWatch project or air quality monitoring by the EPA in Mount Gambier. Those aware of air quality monitoring in Mount Gambier increased from 32% in a similar survey in 2010 to 39% in 2011. Publications through local media proved the most effective method of raising awareness, followed by word of mouth, and through efforts of the City of Mount Gambier Council.

Wood heater use

Wood heater use in Mount Gambier remains similar to previous surveys; that is, around 32%. The most common form of heating among respondents is gas (37%), followed by electricity (26%). Most respondents used more than one home heating method.

Impact

More than a quarter of respondents reported being negatively impacted by wood smoke during winter with the most common impact being breathing difficulties and asthma. Other impacts included general health, smell, and affecting washing on the line. Of those who were impacted by wood smoke, 12% did not take action to reduce exposure. One third of the remaining 88% stayed indoors or did not go outside at night, others used their wood heaters correctly, or closed windows and doors.

Perceptions

The importance of clean and healthy air was provided as a scale from 1 – not important, to 5 – very important. The number of respondents per scale division increase with importance. A total of 80% of respondents identified clean and healthy air as very important. Health, children and family, and the environment were among reasons provided for the importance of clean and healthy air. Respondents' opinion of air quality in Mount Gambier was fairly evenly distributed between five categories: positive, fair, could improve, very bad/concerned, and other.

Solutions

Encouraging efficient wood heating practices was identified as a solution by one third of respondents and education by 20% of respondents. When asked how wood heater users could be supported to reduce wood smoke, 18% suggested providing cash rebates or incentives. Encouraging alternative heating and installing more efficient heaters, and retrofitting were also mentioned. Regulation, industry, and encouraging alternatives were suggested by 36% of respondents as requiring attention to improve air quality.

It is noted that financial tools are not a new idea, as rebates have been used in wood heater replacement programs in other states (NHT 2005).

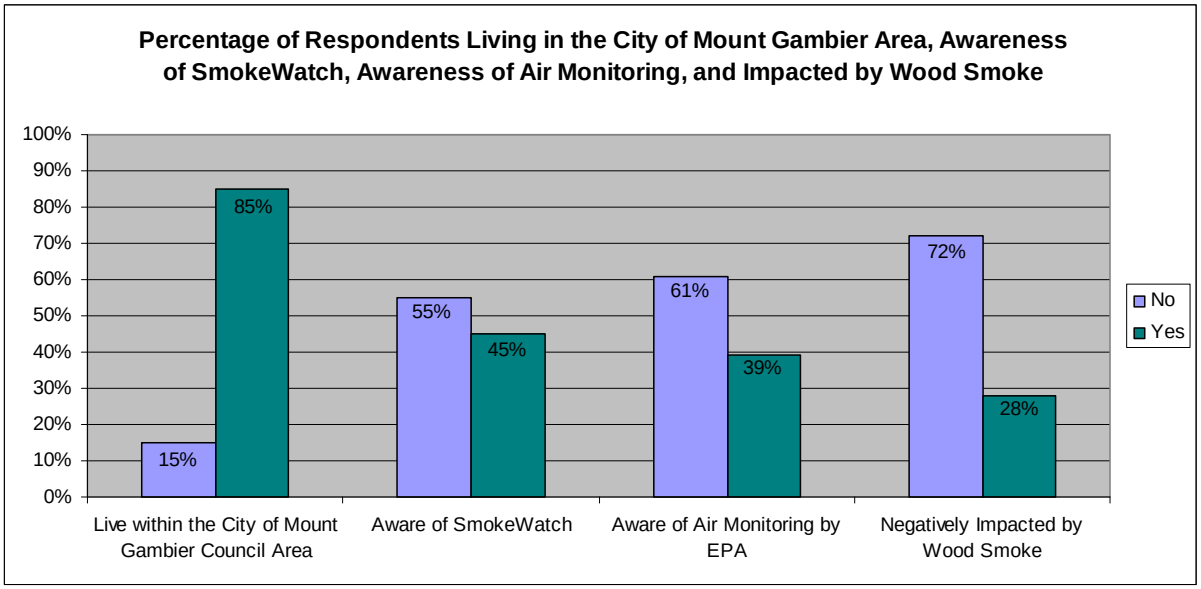


Figure 3 Results of community survey

(See also Appendix 3 for more detailed graphics reproduced from the 2010 report)

3 Air quality

Monitoring over the three winters of the campaign gave quite consistent results, showing that $PM_{2.5}$ particles generally came from residential areas, with larger particles arising from residential and other areas of the town. Particles within the $PM_{2.5}$ range—virtually all of which were very small (PM_1)—predominated during cold nights, consistent with smoke from domestic solid fuel heating.

Figure 4 presents data showing typical patterns of exceedences of the national air quality standards recorded at Gordon Education Centre. Figure 5 illustrates the different patterns of the $PM_{2.5}$ and PM_{10} (which includes PM_{coarse}) with direction in 2009, showing that during that year, $PM_{2.5}$ observations were strongly matched with direction within the north to east sector. In contrast, the PM_{10} plot shows a strong bias towards the west.

The dominance of domestic sources is further illustrated by patterns of air quality throughout the day, as shown in Figure 6. The graph for $PM_{2.5}$ shows a clear diurnal pattern, increasing in the evening, early morning and overnight, and a marked dip in the middle of the day. In contrast, the graph for PM_{coarse} remains flatter throughout the day and night, rising to a 'hill' in the afternoon.

As mentioned earlier, in 2011, monitoring continued well into spring, to provide some insight into conditions during warmer weather, when a reduced use of wood heaters was expected. Comparing Figure 7 with Figure 4 illustrates a decrease in concentrations of fine particles ($PM_{2.5}$) and a marginal decrease in PM_{coarse} from the direction of residential area in spring, which supports this view. No exceedences of the NEPM standards were recorded; but some increases in both PM_{10} and $PM_{2.5}$ concentrations were observed when the wind was from the direction of industrial areas.

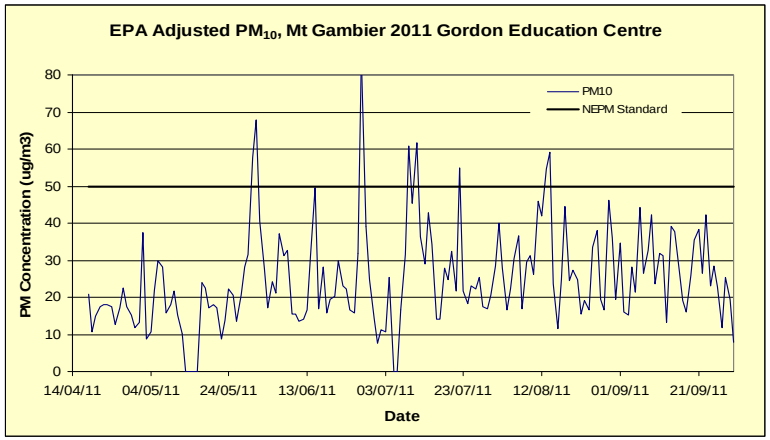
A clear conclusion from these results is that domestic smoke represents a significant contribution to particle pollution in winter. Conversely, other sources appear to make up larger proportions of particle loadings in warmer weather, especially those particles within the PM_{coarse} range; perhaps not surprising, given that:

- people are less likely to use wood heaters
- dryer conditions increase the potential for dust-raising
- other activities such as agriculture may contribute to greater dust loadings.

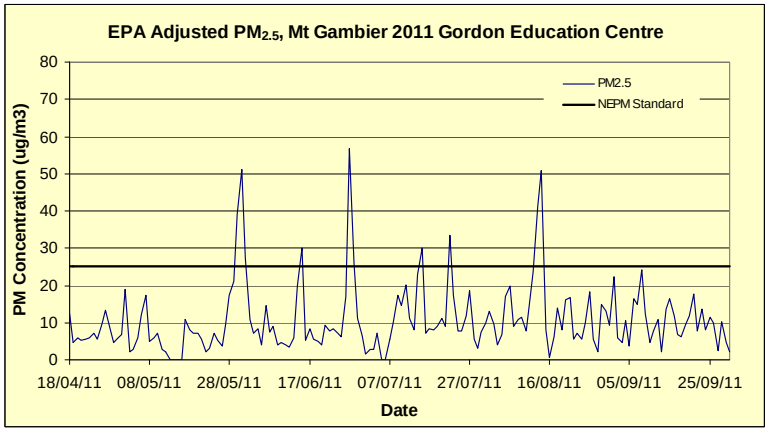
Contributors to $PM_{2.5}$ loadings in Mount Gambier include smoke from solid fuel fires, industry, and to a lesser extent exhaust from motor vehicles. Comparisons of particle concentrations, particle size, time of day, and wind direction, indicated that the proportion of fine particles coming from primarily residential areas decreased in the warmer months. This was matched by a corresponding increase in contributions from the more industrial areas. Traffic is considered a relatively minor contributor, as peak concentrations of $PM_{2.5}$ do not match expected traffic patterns.

Patterns of PM_{coarse} concentrations (eg directions and time of day) indicate that industry emissions contribute strongly to this category of particles.

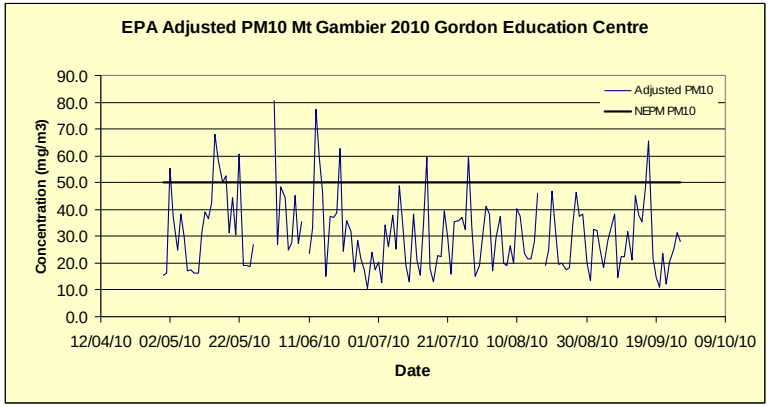
Three years is generally insufficient to show whether long-term air quality in an urban area is improving, deteriorating, or staying essentially the same, because of typically high variability between days, seasons and years. However, winter patterns of daily PM_{10} found in this project were broadly consistent with previous more limited campaigns in Mount Gambier.



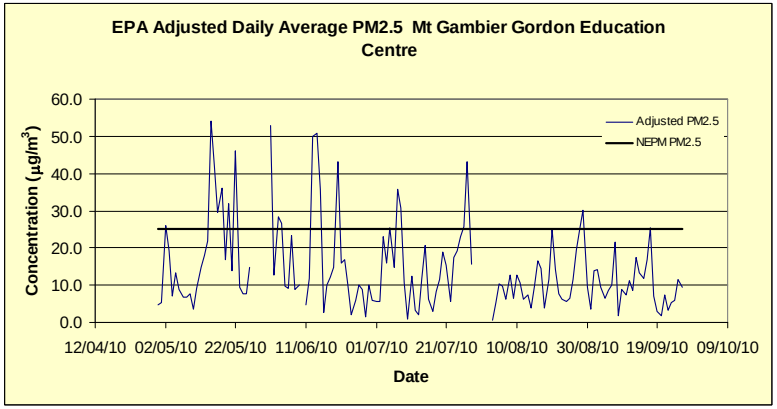
4a: PM_{10} 2011



4b: $PM_{2.5}$ 2011

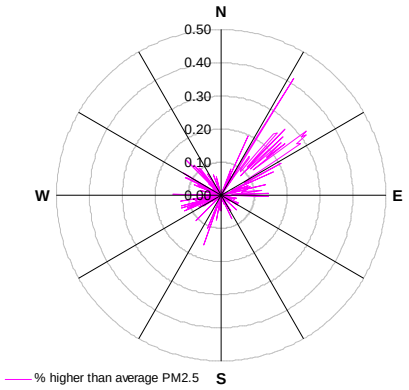


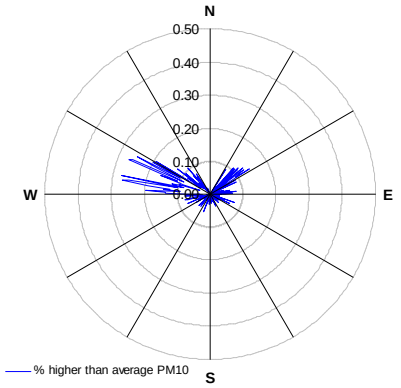
4c: PM_{10} 2010



4d: $PM_{2.5}$ 2010

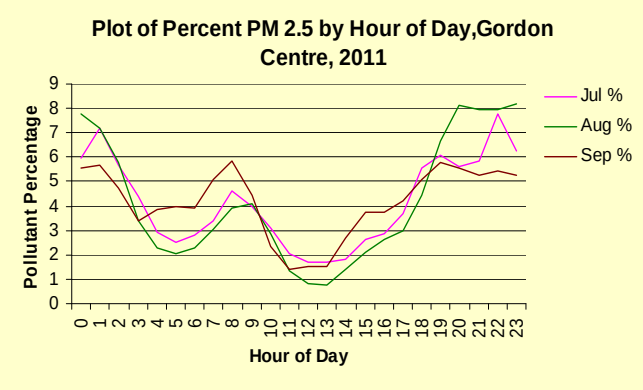
Figure 4 Winter patterns of PM_{10} and $PM_{2.5}$ in Mount Gambier for 2010 and 2011

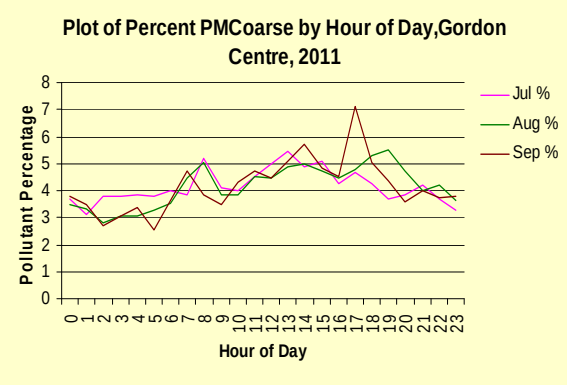




5a: $PM_{2.5}$ winter 2009 **5b: PM_{10} winter 2009**

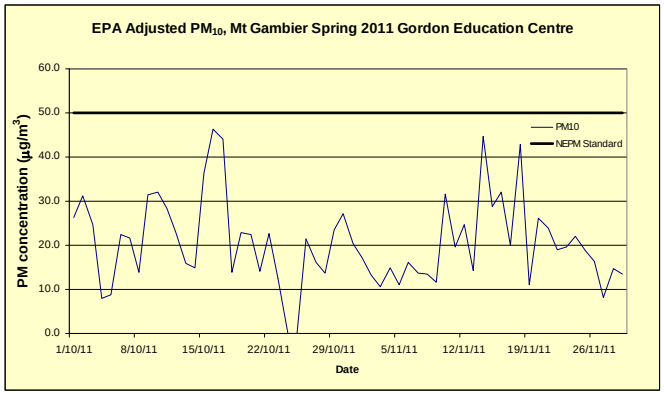
Figure 5 **Plots of higher-than-average readings of fine particles, illustrating the different patterns for PM_{10} and $PM_{2.5}$ with direction from the monitoring station (1 May to 06 September 2009)**



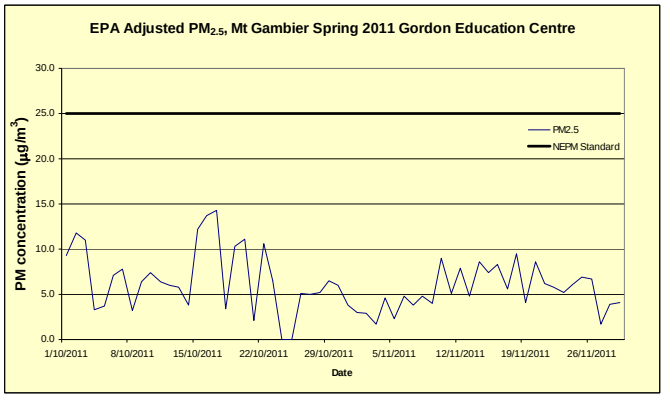


6a: $PM_{2.5}$ winter 2011 **6b: PM_{coarse} winter 2011**

Figure 6 **Graphs of frequency of fine particle observations for each hour of the day in winter 2011, indicating different daily patterns for $PM_{2.5}$ and PM_{coarse}**



7a



7b

Figure 7 Spring data for (a) PM_{10} and (b) $PM_{2.5}$ in 2011

Impacts of smoke from episodes of planned burning also showed up on occasions during the project. When compared with information on prescribed burns provided by Forestry SA and on house fires provided by the Metropolitan Fire Service (MFS), air quality data showed that, where wind directions were favourable, EPA monitors recorded short-term increases in fine particle concentrations, so these events probably do generally influence air quality to a relatively minor extent.

Figure 8 illustrates the impacts of planned fires on 13 April 2011 (see Table 2 for details), which did show up in monitoring records at both Gordon Education Centre and the Showgrounds. The graphs show that all instruments responded with relatively short peaks from around 7 am to midday, corresponding to the time of controlled burning.

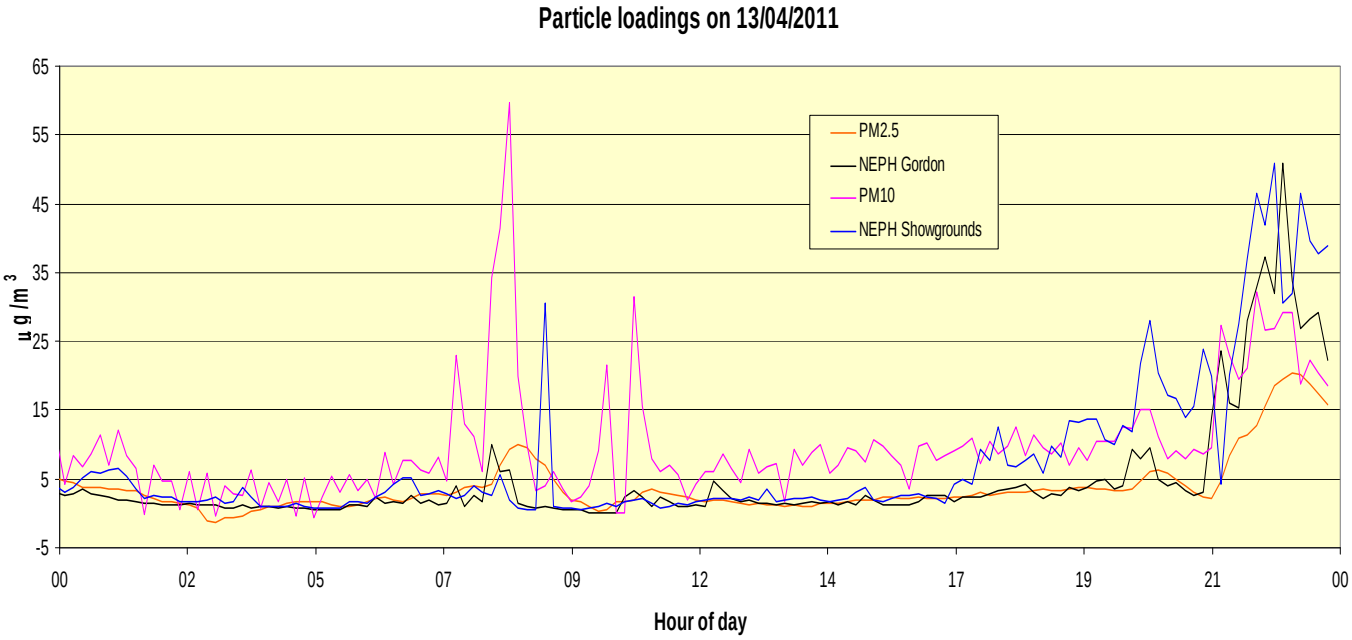


Figure 8 **Fine particle records for 13 April 2011 in Mount Gambier, illustrating responses to planned burning events on that day**

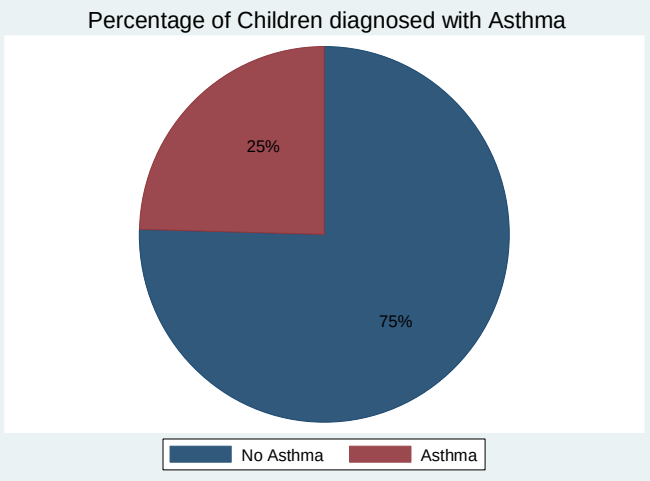
Table 2 Prescribed burning and house fires during 2011

Date	Time	Location	Type of fire	Scale	Comments	Wind direction sector (degrees)	Distance and direction from station
MFS callouts							
22 July 2011	13:47	Wehl St North	House fire	Structure fire, extinguished by MFS	Shed and contents	NE–ENE (50–70)	1.2km NE
24 July 2011	19:15	Varley St	Rubbish	Backyard burn	Garden waste, rubbish	NNE–ENE (20–80)	1.5km NE
27 August 2011	18:10	Macdonald Pl	Rubbish	Backyard burn, extinguished by MFS	Garden waste, rubbish	NW–NNW (300–340)	1.9km NW
21 September 2011	12:20	Commercial St West	Rubbish	Backyard burn, extinguished by MFS	Garden waste, rubbish	WNW (280–290)	2.8km WNW
FSA prescribed burns							
13 April 2011		O'Connors	FSA	4 heaps	CFS map 11 ref 725 255	WNW-NW (270–315)	14 km NNW GEC 16.5km NW SG
13 April 2011		Springs Road	FSA	9 heaps	CFS map 5 ref 685 175	WNW-NW (270–315)	12km WNW GEC 15km WNW SG
14 April 2011		Kangaroo Flat	FSA	16 heaps	CFS map 11 ref 701 251	NW-SSW (320–150)	15km NW GEC 18km NW SG

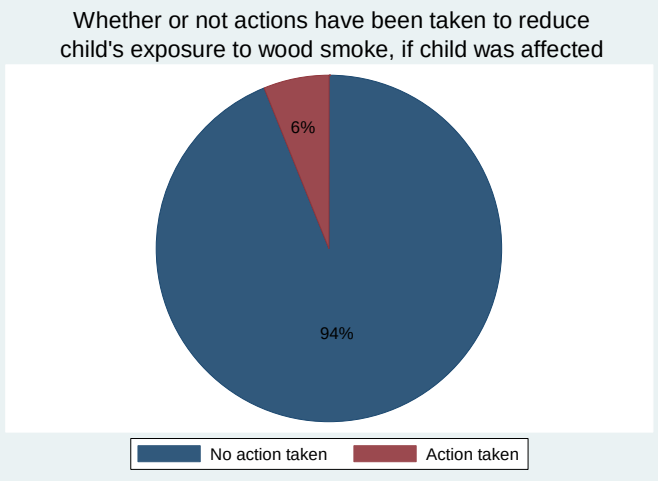
GEC = Gordon Education Centre, SG = Showgrounds

Appendix 1 Detailed survey data

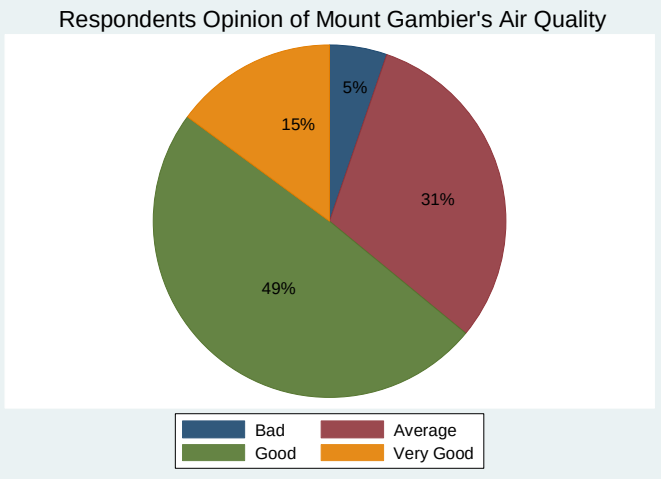
Extracted from Galicki (2010)



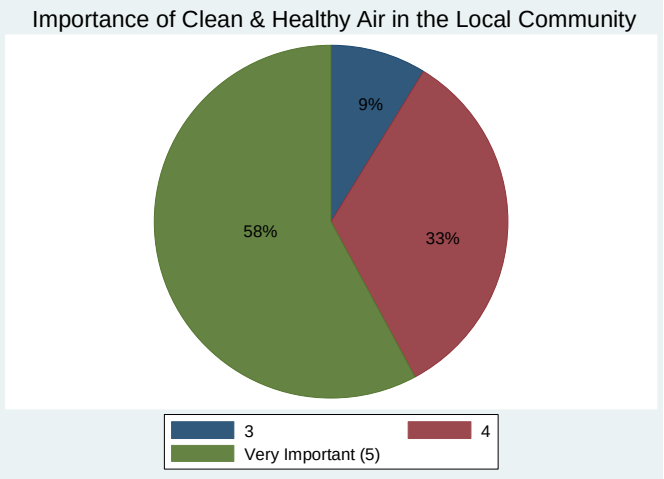
A1–1 Percentage of parents with children diagnose with asthma



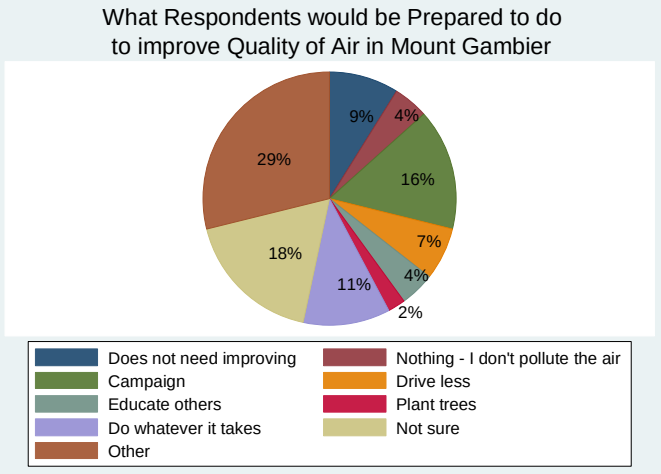
A1–2 Actions to reduce smoke exposure for affected children



A1–3 Opinion of Mount Gambier's air quality



A1–4 Importance of clean and healthy air



A1–5 Preparedness to take action

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Appendix 2 Further information on fine particles

Particles come in all shapes and sizes, and it is important to note whether they can be breathed into our noses and mouths, and beyond that, whether they can enter our lungs. Every particle of smoke or dust has a different shape; they can be long and thin or spherical, or some other shape. It is how they behave in the air we breathe that is most important; and how each particle behaves in the air depends on its combination of its size, shape and density (weight divided by volume).

So how do we deal with all these different combinations?

In practice, we simply treat all particles as if they behave like tiny spherical droplets of water, like those that we find in fog; and we think of particles as having *equivalent diameters* to droplets of water. This allows instrument manufacturers to design sampling intakes that can separate out the particles that can enter our lungs from those that cannot. We measure the *equivalent diameters* in millionths of a metre (micrometres, written as μm) and we know that particles of equivalent diameters of around 10 μm and smaller can enter our lungs when a person breathes in. Larger droplets either do not get in at all, or are trapped in our noses or throats.

For simplicity, we use '*particle size*' in this report to mean '*equivalent diameter*'.

Particles can be made of small pieces of sand or rock, or can be very complex mixtures of chemicals. Particles that we can breathe in are grouped into two size categories or 'fractions':

- Firstly, according to whether they can enter our lungs or not; that is, sizes of 10 μm and smaller, which we can breathe into our throats and upper lung passages.

  These are called PM_{10} and they can come from many industrial sources and roadways; and some of the dusts in a dust storm will be PM_{10}.

- Secondly how far they can penetrate into our lungs. We know that we can breathe particles of 2.5 μm or smaller right down into the deepest parts of our lungs.

  They are called $PM_{2.5}$, and they come from burning fuels such as petrol, diesel or wood are often very complex mixtures of solids, liquids and different chemicals, containing high proportions of water and organic compounds (carbon compounds) from unburnt fuel, some of which are reactive, toxic or may cause cancer.

  $PM_{2.5}$ particles also make our atmosphere hazy, because they scatter light very effectively, just like fog. Fog itself is made up of tiny particles of water suspended in the air, is of the same size as $PM_{2.5}$, and prevents us from seeing distant objects.

Both of these types of particles have recognised health effects, so each has a national air quality standard. An important point to note for this report is that particles measured as PM_{10} may also contain $PM_{2.5}$ particles.

Particles that are larger than 10 μm are called total suspended particulates (TSP),and they include larger dusts from soil, and nuisance dusts, which can be irritating and make window sills and doorsteps dirty, but are otherwise of much less health concern than PM_{10} and $PM_{2.5}$.

They often come from industrial processes like grinding and milling of minerals, or things like animal feed and fertilisers; or from earthmoving and building, and especially dust storms.

Particles are of interest given their health effects on the human population. Assessment of monitoring data from 2001 and the SmokeWatch project has indicated that particles are a significant issue and need further action to manage them effectively in this airshed.

Particles are not always entirely made up of inorganic compounds such as minerals from soil but can have organic chemicals or reactive materials attached or can emanate from man-made sources such as industry, vehicles and wood fires.

Dusts from soils and minerals are largely inorganic (they may contain little or no carbon). They generally have low volatility; which means that there are no liquids that can evaporate from them.

There are many different ways of measuring fine particles and discussing their concentrations and health effects.

The most common way in which we talk about concentrations is as micrograms per cubic metre of air, written as '$\mu g/m^3$'. A microgram is a millionth of a gram, so we are dealing with only very tiny amounts of materials. This is often called the 'mass concentration' of fine particles.

Appendix 3 provides information on the specific instruments used in this study but, in principle, instruments that measure mass concentrations pump the air through intakes or sampling heads specially designed to only allow PM_{10} or $PM_{2.5}$, into the instrument. They then "weigh" the fine particles as they collect on a filter, using highly sensitive detectors. The TEOM is one such instrument.

Other methods count particles as they pass through an intense beam of light, giving a 'number concentration', or the number of particles per cubic metre. In this study, a sophisticated particle counter was used to help identify the different types of particles in Mount Gambier's air, backing up the information from the other instruments.

Still others, called 'nephelometers', measure the way in which these tiny particles scatter light from an intense lamp within the instrument; in effect, they measure the haziness of the atmosphere. In this study the information from nephelometers was shown to be highly consistent with data from the TEOMs, especially for $PM_{2.5}$.

Appendix 3 Air monitoring stations

As noted previously, SmokeWatch Mount Gambier initially incorporated a limited monitoring component during the winter of 2009. Capabilities were enhanced in 2010, and again in 2011, with the acquisition of additional instrumentation, to facilitate understanding of fine particle patterns in Mount Gambier's air and improve the identification of various sources within the city.

Monitoring also commenced earlier in autumn, to capture any impacts of planned forestry and agricultural burning in the region around Mount Gambier.

In 2011, the monitoring component was extended to the end of November at the Gordon Education Centre, to provide some preliminary indication of fine particle emissions in warmer weather, as the use of solid fuel domestic fires decreases, and other activities, such as agriculture, become more important contributors to particle pollution.

Instruments used in the project were—

- TEOM 1400A tapered element oscillating microbalance (AS 3580.9.8–2001)

  These provided the primary direct continuous measurements of mass concentration (micrograms per cubic metre, written as $\mu g/m^3$) for the project. They can be set up to measure PM_{10} or $PM_{2.5}$ particles. Data were adjusted in accordance with the standard method outlined in Technical Paper No 10, developed under the Air NEPM.

- TSI APS 3221 aerodynamic particle sizer

  This type of instrument uses a light beam to literally count and record the relative numbers of particles in up to 31 different classes of particle sizes in the range 0.5 to 20 micrometres. In this project, a knowledge of particle sizes allowed EPA to understand the likely sources of particles; for example, whether they were smoke particles, or larger particles from other activities.

- Nephelometer radiance research (AS 2724.4–1987)

  Nephelometers also use an intense light beam to record the amount of light scattered by fine particles. In effect, they measure the haziness or reduction in visibility of the atmosphere caused by particles (see Appendix 2). In general, this type of reading, called B_{scat}, follows mass concentrations of fine particles in the air very closely, especially for particles in the $PM_{2.5}$ fraction. In this project, nephelometer readings were used to provide supplementary information on patterns of fine particle patterns and movements in the city.

- Vaisala meteorology equipment (AS 2923–1987)

  These instruments provide continuous information on wind speed and direction and other weather indicators. Weather information is essential to understanding where air pollution may be coming from and how it moves around the city.

Two air quality monitoring stations and one weather station were established for SmokeWatch Mount Gambier:

1 Gordon Education Centre, Browns Road, Mount Gambier:
   - two TEOM instruments, set up to measure PM_{10} and $PM_{2.5}$ particles, respectively
   - a TSI optical particle sizing instrument
   - a nephelometer.

2 Mount Gambier Showgrounds, Pick Avenue, Mount Gambier:
   - one nephelometer.

3 Green Triangle Forest Products Mount Gambier:
   - wind speed and direction are also measured continuously by the EPA.

References

EPA 2010, *SmokeWatch Mount Gambier 2009 Winter Campaign Report*, Environment Protection Authority, Adelaide, viewed 13 December 2012, <www.epa.sa.gov.au/xstd_files/Air/Report/mt_gambier_2009.pdf>.

EPA 2010, *SmokeWatch Mount Gambier 2010 Campaign Report,* Environment Protection Authority, Adelaide, viewed 13 December 2012, <www.epa.sa.gov.au/xstd_files/Air/Report/smokewatch_2010.pdf>.

EPHC 2004, *National Environment Protection (Ambient Air Quality) Measure 1998, as amended 2004*, Environment Protection and Heritage Council, Canberra, viewed 13 December 2012, <www.ephc.gov.au/taxonomy/term/23>.

Galicki, Claudia 2010, *Perception and attitudes of wood smoke exposure on the health and well-being of children in the City of Mount Gambier*, supervised by Assoc Prof John Edwards (Flinders University), Dr Monika Nitschke (Department of Health), Ms Polly Weckert (Environment Protection Authority), Flinders University, Adelaide.

Hansen A, Peng Bi**,** Nitschke M, Pisaniello D, Ryan P, Sullivan T, A Barnett 2011, 'Particulate air pollution and cardiorespiratory hospital admissions in a temperate Australian city: A case-crossover analysis', *Sciences of The Total Environment*, **416**:48–52, viewed 13 December 2012, <www.sciencedirect.com/science/article/pii/S004896971101028X>.

NEPC 2001, *National Environment Protection (Ambient Air Quality) Measure, Technical Paper No. 10, collecting and reporting of TEOM PM_{10} data*, prepared by the Peer Review Committee, National Environment Protection Council, Adelaide, viewed 13 December 2012, <www.scew.gov.au/archive/air/pubs/aaq-nepm/aaqprc_tp__10_collection_and_reporting_200105_final.pdf>.

NHT 2005, *Woodheaters in Launceston – Impacts on Air Quality,* A study funded by the Natural Heritage Trust and undertaken by CSIRO Atmospheric Research, Aspendale, Victoria, viewed 13 December 2012, <www.environment.gov.au/atmosphere/airquality/publications/pubs/launceston-woodheaters.pdf>