

# SmokeWatch Adelaide Hills Pilot Study Part 2 2007





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## **SmokeWatch Adelaide Hills Pilot Study Part 2, 2007**

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## TABLE OF CONTENTS

SUMMARY .....	1
ABOUT THE SMOKEWATCH PROGRAM .....	3
WHAT DID THE 2007 TELEPHONE SURVEY TELL US? .....	4
CHANGES IN COMMUNITY ATTITUDES AND BEHAVIOUR.....	6
WHERE DID AIR MONITORING OCCUR? .....	7
WHAT WAS MEASURED DURING THE AIR MONITORING?.....	8
HOW DID THE 2007 MONITORING RESULTS COMPARE TO 2006?.....	9
WHAT IS A WOOD SMOKE SIGNATURE? .....	10
WHAT DOES THIS SIGNATURE TELL US?.....	12
HOW DID WOODSIDE COMPARE TO OTHER LOCATIONS IN ADELAIDE? .....	13
VISUAL AIR QUALITY (VAQ) MEASUREMENTS.....	14
DISCUSSION .....	15
REFERENCES AND FURTHER INFORMATION .....	17
APPENDIX 1        MAP OF AIR MONITORING LOCATION .....	18
APPENDIX 2        GLOSSARY .....	19

### List of figures

Figure 1	A map showing the Woodside monitoring site and contours. ....	7
Figure 2	A typical morning where high levels of fine particles were measured .....	10
Figure 3	Wind blown dust measured at the Woodside project site, 27 August 2007.....	11
Figure 4	An increase of PM <sub>10</sub> particle levels during calm wind conditions at Woodside ..	13
Figure 5	Dust event (PM <sub>10</sub> ) measured at Woodside compared to two other EPA monitoring sites .....	13
Figure 6	Visual air quality as measured by students at Woodside Primary School during the SmokeWatch pilot program .....	14

### List of tables

Table 1	Comparison of AHC community attitudes and behaviours 2006 and 2007. ....	6
Table 2	Woodside monitoring results compared to the NEPM Standards.....	9



## SUMMARY

From late June to the end September 2007, the South Australian Environment Protection Authority (EPA) delivered Part 2 of the SmokeWatch behaviour change pilot program in the Adelaide Hills Council (AHC) area, particularly concentrating strategies in and around the township of Woodside.

To support the behaviour change program, evaluate any discernible change in the air quality, and to determine a smoke 'signature' which may be used in other environments, air quality monitoring was again undertaken in the township of Woodside.

This provided an excellent opportunity to identify different sources of pollution, including assessing the impact of wood smoke in an isolated airshed and measure any improvements in air quality as a result of the behaviour change program spanning 2006 and 2007.

Air quality results for 2007 clearly identified an impact from wood smoke in an area with a small population and were generally consistent with the results found in the 2006 study (EPA 2007). The higher levels of fine particles were identified as the impact of wood heaters during cold and still nights.

While current standards for PM<sub>2.5</sub> were probably not exceeded in this study, the EPA is concerned that the PM<sub>2.5</sub> could be exceeded in extreme conditions at Woodside. These results suggest that areas of the state with higher populations and with high wood heater use are likely to exceed PM<sub>2.5</sub> standards at times. To quantify this risk and assist in the development of management strategies, further investigations are required to determine the PM<sub>2.5</sub> particle levels present in these areas.

At the conclusion of the program, a telephone survey was conducted to evaluate the success of the SmokeWatch program in facilitating behaviour change. In general the survey found that there was a reported increase in the use of efficient wood heater practices among residents in the AHC area since the inception of the SmokeWatch program in 2006. However, despite this there continues to be a perception among residents that wood smoke is not a problem in the AHC area and residents remain generally unconcerned about the negative impact of wood smoke in the area.

Interestingly, increases in the use of efficient wood heater practices were not reflected in the air monitoring results, where wood smoke levels remained generally consistent over the two winters. Possible reasons for this outcome include:

- while residents were reportedly using their wood heaters more efficiently, few were actually going outside to check their chimney for smoke, therefore it is possible that some were not following the correct wood heater procedures and were unaware of this
- residents who changed their behaviour may not have necessarily been in and around the Woodside township where the monitoring site was located therefore these changes were not realised in the monitoring results
- over half of survey respondents indicated that they already knew how to use their wood heaters more efficiently therefore did not make any changes to their behaviour.

While it is difficult to substantiate the above possibilities, it is important that they are noted and taken into consideration when developing and implementing future programs.



## ABOUT THE SMOKEWATCH PROGRAM

The SmokeWatch program was again implemented in partnership with the Adelaide Hills Council (AHC) from June–October 2007. However, in 2007 the SmokeWatch program concentrated behaviour change strategies predominantly in and around the Woodside township. This is in contrast to the 2006 program where emphasis was placed across the AHC area. The aim of the change of focus was to allow the EPA to evaluate if behaviour change strategies were effective in reducing wood smoke pollution in a particular area, ie Woodside.

Consistent with the 2006 program a 'SmokeWatch Challenge' was promoted to residents to encourage the adoption of four key efficient wood heater practices:

- burn only dry and seasoned wood
- keep air vents open for 20 minutes after lighting the fire
- keep the fire live and bright, but let it go out at night
- regularly check to ensure there is no smoke from my chimney 20 minutes after lighting the fire.

In addition, Woodside Primary School was engaged to increase student understanding of wood smoke issues with the aim that these messages would also be filtered through to school families.

In contrast to the 2006 program, an additional emphasis was placed on engaging the community, through visits to businesses in and around the AHC area encouraging support for the program, and a mail-out to all residents in and around the Woodside area.

Air monitoring was again undertaken in the township of Woodside to support the behaviour change program. The EPA used its air monitoring caravan equipped with several instruments to measure the main pollutants emitted from domestic wood heaters, which are (in varying amounts) carbon monoxide, fine particles, volatile organic compounds and nitrogen oxides (NSW EPA 2008).

At the conclusion of the program, a telephone survey was again conducted to evaluate the success of the SmokeWatch program in facilitating behaviour change.

## WHAT DID THE 2007 TELEPHONE SURVEY TELL US?

In October 2007, a telephone survey of 400 wood heater users in the AHC area was undertaken (100 users called were those living in and around Woodside). The survey was undertaken by the research company Square Holes on behalf of the EPA to evaluate the success of the two-year SmokeWatch program in facilitating behaviour change in Woodside and the surrounding Adelaide Hills suburbs.

The main issues explored in the survey were:

- use of wood heating
- awareness and scope of the SmokeWatch program
- attitudes and perceptions regarding the SmokeWatch program
- attitudes and general behaviour towards good wood heating practices.

Results of the October 2007 survey were compared with results from a survey undertaken in January 2007 by McGregorTan which evaluated the 2006 SmokeWatch program. Comparisons between the two surveys are detailed below.

Awareness of the program among wood heater users in the Adelaide Hills was 43% in October, which decreased since the January survey (59%). However, the campaign was significantly better received in Woodside, with 70% of respondents aware of the program in 2007. This is not surprising, given that the 2007 program was purposely focussed in and around Woodside.

Overall, the survey indicated that the SmokeWatch campaign had a notable impact in increasing knowledge about the efficient use of wood heaters, with information received enabling over half (54%) of respondents to follow the correct wood heating procedures. While this was a slight decrease from January (58%), more respondents stated that they already knew the correct procedures in October (37%) compared with January (20%).

However, despite having the knowledge of how to use a wood heater more efficiently, this was not completely reflected in residents' reported behaviours, with one quarter (24%) stating that their behaviour had changed as a result of the SmokeWatch program. Nevertheless, this figure was an increase from January's percentage of 19%. Interestingly, 59% of respondents indicated that they did not change their behaviour, stating that they were already aware of how to use a wood heater efficiently.

Motives cited for following good wood heating practices were mainly to protect the environment (70%) and to reduce emissions (64%), rather than saving money (14%) or increasing efficiency (18%). None of these reasons were notably different from those given in January.

The key campaign messages were generally appreciated by residents, particularly 'burning only dry, seasoned wood' (97%) and 'keeping the air vent open for 20 minutes after starting and reloading the fire' (87%). This appreciation was confirmed with the majority of respondents 'always' complying with the previously mentioned practices, particularly keeping air vents open, where there was a demonstrated 6% increase since January.

However, there was a notable decline in the perceived importance of 'checking for smoke coming from chimneys' [a 10% decrease from January's survey (71%)]. Furthermore, only 22% reported that they actually check for smoke 20 minutes after starting their fire, a 10% decrease since January (33%).

There was strong agreement that the EPA should be involved in initiatives such as the SmokeWatch program (88% agreed or strongly agreed, a 21% increase from January). Similarly, 82% agreed or strongly agreed that the local council should be involved in initiatives such as SmokeWatch, a 12% increase from January.

## CHANGES IN COMMUNITY ATTITUDES AND BEHAVIOUR

As shown in Table 1, there has been a general increase in efficient wood heating practices among residents in the AHC area since the baseline survey undertaken in July 2006 by McGregorTan. In particular there has been a:

- 22% increase in understanding how to use a wood heater efficiently in order to minimise wood heater smoke
- 36% increase in respondents indicating that they leave their air vents open for more than 20 minutes after starting a fire.

The only significant negative trend has been the 25% decrease since July 2006 of those checking for smoke coming from chimneys 20 minutes after starting a fire.

Furthermore, there continues to be a perception that wood smoke is not a problem in the Adelaide Hills, and there seems to be little concern for the negative impact wood smoke pollution can have on individuals. As can be seen in the table below, despite very slight percentage increases, both of these figures remain low.

**Table 1 Comparison of AHC community attitudes and behaviours 2006 and 2007 (highlighted cells show significant change in attitude or practice).**

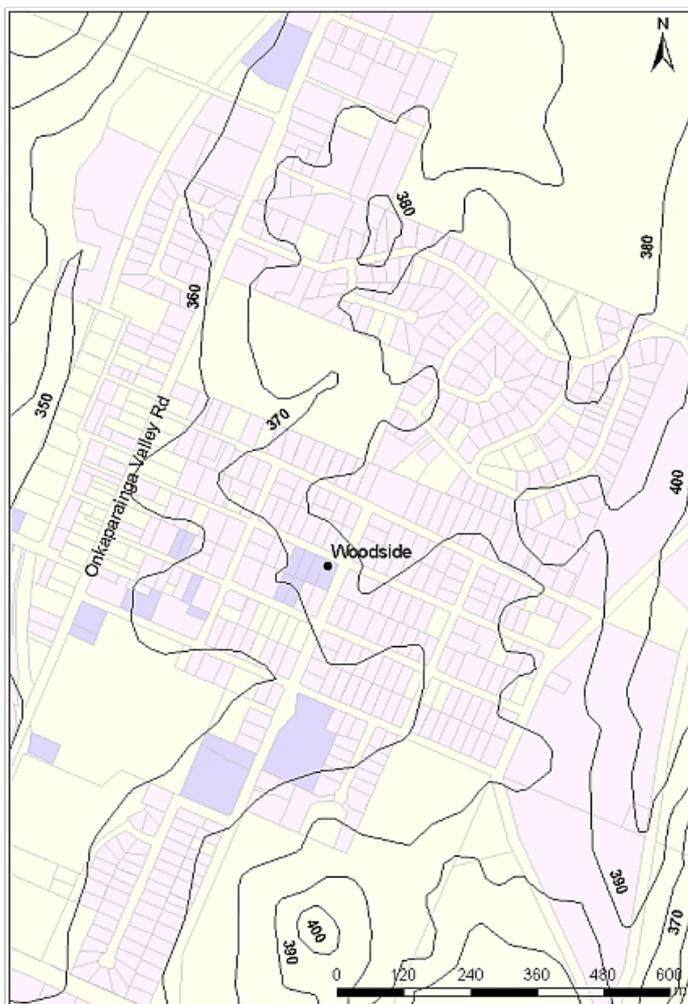
	October 2007	January 2007	July 2006
Good understanding of efficient use of wood heater	92%	94%	70%
Believe wood smoke is a problem in Adelaide Hills	28%	25%	22%
Believe wood smoke negatively impacts me in winter	16%	18%	15%
Burn only dry seasoned wood	92%	94%	87%
Keep air vent open for 20 minutes after starting and reloading	75%	69%	39%
Keep fire alive and bright but let it go out at night	58%	59%	No data available
Check no smoke coming from chimney 20 minutes after starting	22%	32%	47%

## WHERE DID AIR MONITORING OCCUR?

The site selected for monitoring was in the township of Woodside, at the Woodside Primary School. This site offered several unique conditions for the study that served to limit the number of potential pollution sources, including:

- the township's location in the Adelaide Hills made it unlikely that pollution would be transported from other sources/regions
- Woodside was considered to be large enough to discriminate wood smoke events from local sources, a fact confirmed with discussions with school staff
- the school site was well placed for monitoring, being located centrally in the township and in an open area that minimised contributions from local sources, so that broad air quality could be assessed.

Figure 1 below shows the contours of the land elevation surrounding the site. Appendix 1 shows where Woodside is located in respect to Adelaide, Central Business District.



**Figure 1** A map showing the Woodside monitoring site and contours.

## WHAT WAS MEASURED DURING THE AIR MONITORING?

Wood smoke is a very complex mixture of solids, liquids and gases including carbon compounds, many of which are toxic or irritating. However, emissions from each wood heater can be radically different depending on, for example, the type of fuel burnt, design of the heater and if the heater has just been lit or has been burning well for some time.

The study included monitoring of carbon monoxide, which is a gas released when a fuel such as wood is not burnt completely, ie carbon monoxide is a product of incomplete combustion. Concentrations of carbon monoxide in the air provided a way to assess how well people in Woodside were operating their wood heaters. Other gaseous pollutants measured include nitrogen oxides, formaldehyde, benzene and sulfur dioxide, all of which can be released in varying amounts from burning fuels, including wood.

Wood smoke also consists of very small particles which generally range from 0.6 to 1  $\mu\text{m}$  (micrometres<sup>1</sup>), or millionths of a metre, in diameter (Environment Australia 2002). To assist in determining whether particles were in fact from wood smoke and not other sources, the EPA measured particles smaller than 10  $\mu\text{m}$  in diameter ( $\text{PM}_{10}$ ) and particles smaller than 2.5  $\mu\text{m}$  in diameter ( $\text{PM}_{2.5}$ ) (also called 'fine particles'<sup>2</sup>). Therefore, if there are many of these very small particles in a town such as Woodside, it is likely they have come from smoke.

The size of particles, the number of particles and the way individual particles reflect light can be very different according to where they have come from, ie their 'source'. For example, some particles may be coloured, very dark, white, or shiny, and some may be bigger than others. There are many different sources that can increase the concentrations of particles in the air. Motor cars and trucks, industrial factories, natural dust storms and wood heaters are all sources and may all add to pollution in the air we breathe. If we know how much each source contributes to pollution, it helps us to understand how best to improve air quality.

Given the complexity of particles the EPA used three types of instruments to gain and understanding of how much smoke was present during the study period. An instrument called a TEOM (see Appendix 2), weighs the  $\text{PM}_{10}$  it samples from the air. Another instrument, called a nephelometer, measures the haziness of the atmosphere caused by fine particles, ie it measures how these particles affect our ability to see long distances. Very hazy air means that there is a high concentration of fine  $\text{PM}_{2.5}$  particles, which have probably come from wood smoke.

In this 2007 study, EPA also used a new instrument called an APS (Aerodynamic Particle Sizer), that measure the proportions of different sized particles in the air, which helps us to understand how much smoke is present and how many other particles, such as ordinary dust might have affected the air quality.

Air quality is affected by weather, or meteorology. Cold, still weather (called 'inversions') act like a lid on a saucepan, trapping smoke and allowing it to build up. To understand when this occurred, or when windy conditions might bring dust into Woodside from other areas, the EPA measured wind speed and direction, air temperature and pressure while the air pollutants were being monitored. This has helped the EPA to know when smoke was the most likely cause of high particle concentrations.

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<sup>1</sup> Micrometres are sometimes also called 'microns'.

<sup>2</sup>  $\text{PM}_{2.5}$  particles may be 16 times smaller than the smallest human hair, which is about 40 micrometres across (CR Robbins).

## HOW DID THE 2007 MONITORING RESULTS COMPARE TO 2006?

The 2007 monitoring results were comparable to those of 2006. There was a dust event occurring in August 2007, similar to one which occurred in August 2006. Hydrocarbon levels were almost identical for the two study years, except for formaldehyde where the maximum value had decreased to approximately 50% of the 2006 measured value. All of the gas pollutants that were monitored were at very low concentrations, often so low that the very sensitive instruments were barely able to detect them. Even so, concentrations of several gaseous pollutants were lower in 2007 than in 2006. The reason for this was not identified; however it is most likely due to variation in the weather from year to year.

Not surprisingly the levels of wood smoke remained more or less the same. Wood smoke had its greatest effect on air quality in the evenings when wind speeds were low (less than 1 metre per second, or 3.6 kilometres per hour).

The air quality at Woodside during the study was again found to be generally good compared to current national environment protection standards for air quality. The study did not detect any events above these standards. However, this report notes that a high proportion of PM<sub>2.5</sub> was found in particles monitored during still nights. This raises concerns about exposure of populations to fine particles, which are discussed in later sections.

Table 2 shows the maximum levels in 2007 and 2006 study years and the relevant standards or Investigation Limits.

**Table 2 Woodside monitoring results compared to the NEPM Standards**

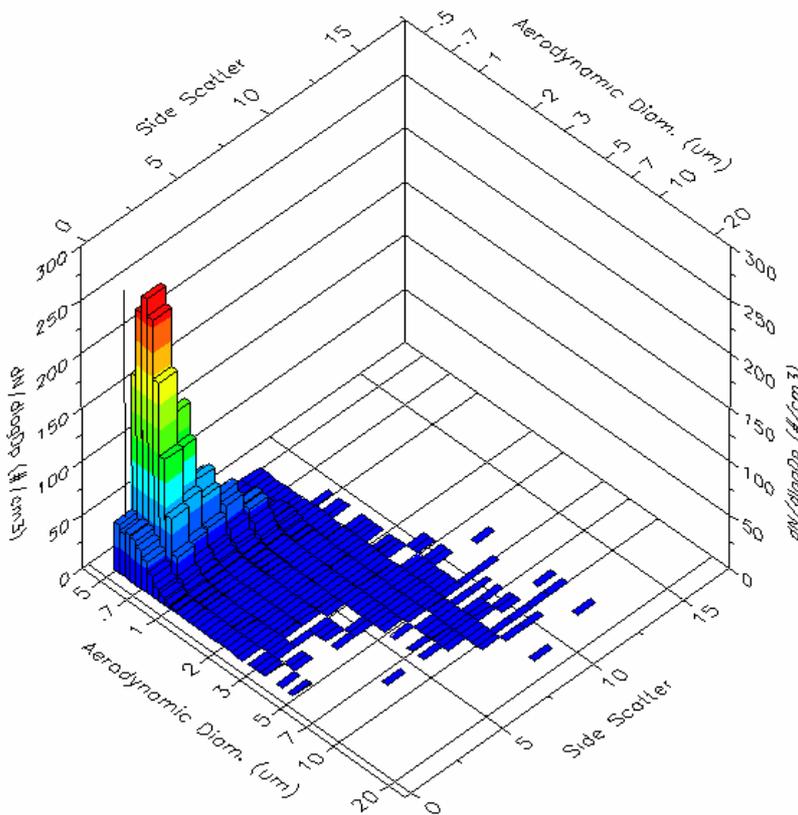
Pollutant	Maximum 2007 Average	Maximum 2006 Average	NEPM (National Standards) (EPHC 2007)
			Standard/Investigation Limit
PM <sub>10</sub> (µg/m <sup>3</sup> )	30.1	29.6	50 µg/m <sup>3</sup> (24 hour average)
CO (ppm)	1.4	1.7	9 ppm (8 hour rolling average)
NO <sub>2</sub> (ppm)	0.018	0.023	0.12 ppm (1 hour average)
SO <sub>2</sub> (ppm)	0.008	0.007	0.20 ppm (1 hour average)
Benzene <sup>3</sup> (ppm)	0.002	0.002	0.003 ppm (annual average–Investigation Limit)
Formaldehyde (ppm)	0.011	0.025	0.04 ppm (24 hour average–Investigation Limit)

<sup>3</sup> Benzene has an annual averaged Air Toxics NEPM Investigation Level. As there was insufficient data for an annual average, the mean value during the monitoring was used for comparison.

## WHAT IS A WOOD SMOKE SIGNATURE?

As mentioned previously, EPA's newly acquired monitoring instrument, the APS, has enabled a more accurate measurement for determining the source of particles measured in the air, therefore allowing for a wood smoke 'signature' to be developed.

To illustrate this, Figure 2 details a typical morning where there was a very light wind enabling smoke to 'hang' in the area. There are a large number of fine particles that have very low reflectiveness. This has been found to be the wood smoke 'signature'. The major wood smoke source observed in Woodside during the study was from domestic wood heaters.



**Figure 2** A typical morning where high levels of fine particles were measured

By comparison, Figure 3 shows a dust event that occurred during the study period, when strong winds quickly dispersed the wood smoke.

This event allowed the EPA to highlight the different sources of dust in the air during that time. Figure 3 shows that there were still small particles in the air, however there were also many more large particles present which were due to the strong winds transporting top soil from farming land on the Yorke and Eyre Peninsulas. The APS, with assistance from other measurements allowed the determination of likely sources of particles like wood smoke or wind blown dust.

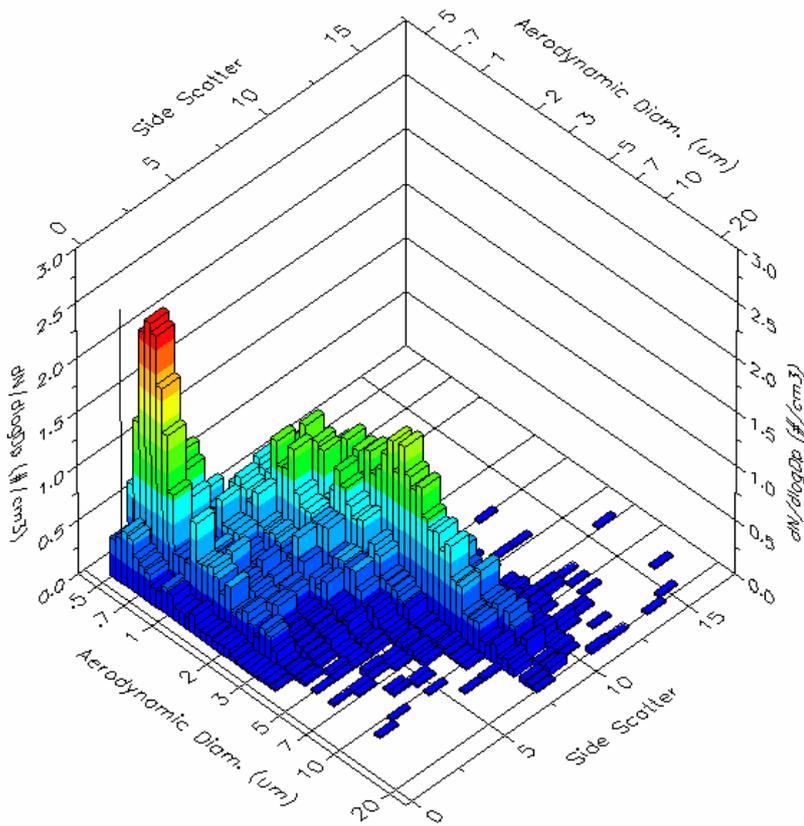


Figure 3 Wind blown dust measured at the Woodside project site, 27 August 2007

## WHAT DOES THIS SIGNATURE TELL US?

The types of monitoring used during the second stage of the SmokeWatch pilot study provided more information regarding the distribution of particle size in the air. This signature provides a method for determining information as to the source of particles. The particle signature confirmed, via measurement for the first time, that still evenings and early mornings have significant particle contributions from wood smoke.

As the particle sizing instrument does not measure the mass of particles present, no assessment of the levels of particles as per the health standards can be confirmed. However, the sizing distribution provides strong evidence that fine particles dominated the measurement value. During times when wood smoke was present (confirmed by the particle signature) the major proportion of particle levels measured by standard equipment would be due to the PM<sub>2.5</sub> size range.

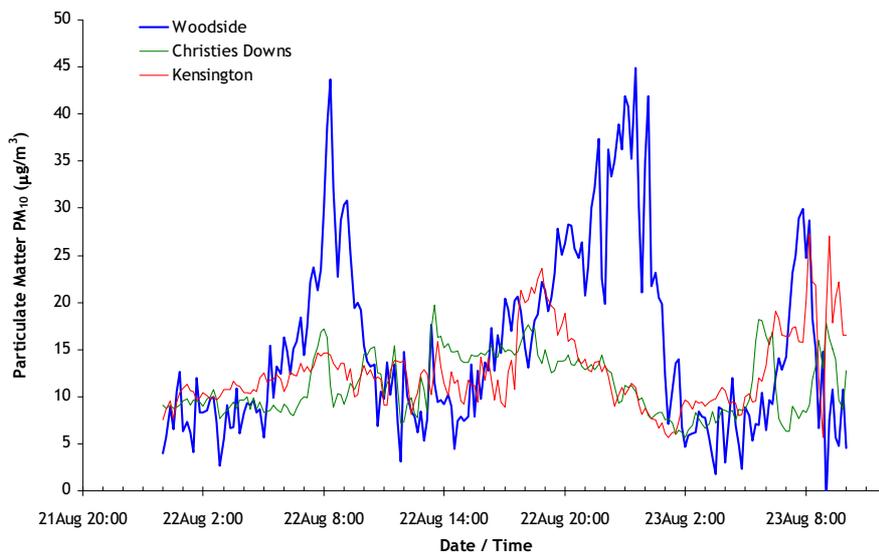
With the information from the particle signature and particle levels it can be assumed that during some evenings where winds speeds are low there is an opportunity for the levels of PM<sub>2.5</sub> to exceed the national standard. This would be expected to occur in a study area where the population is only slightly greater than that at Woodside.

A comparison of data for PM<sub>10</sub> and fine particles showed that 21% of one-hour averages had a significant contribution from wood smoke. On 18 of the 79 days of the study period the particle levels were dominated by PM<sub>2.5</sub>. This indicated that these events were short lived and occurred only under specific conditions. Of note is that this did occur in an environment where there are relatively few sources. If this finding is extended to a larger township in the Adelaide Hills region it is most likely that the levels of wood smoke would exceed the PM<sub>2.5</sub> standard.

The EPA needs to undertake further work to confirm these results in a study area where there is a larger population. However this finding does raise concerns that the levels of the finer PM<sub>2.5</sub> particles most likely pose an increased risk for populations exposed to the wood smoke, where smoke from wood heaters can build up on winter nights.

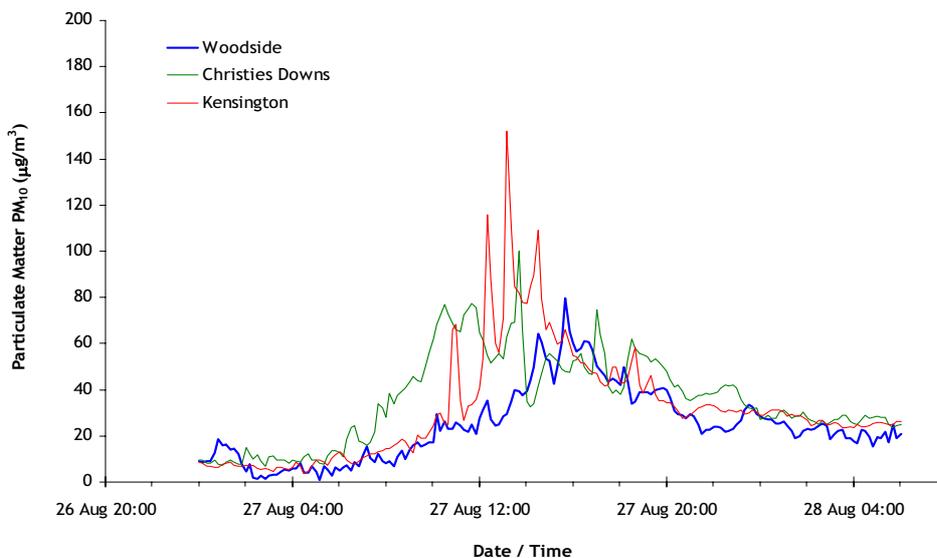
## HOW DID WOODSIDE COMPARE TO OTHER LOCATIONS IN ADELAIDE?

Particle levels in Woodside were found to be lower than most of the metropolitan monitoring sites again in 2007. The maximum level of particles measured were approximately 30% lower than those measured at Christies Downs or Kensington residential monitoring sites. The most notable exception to this observation was during calm wind conditions where the wood smoke can 'pool'. Figure 4 shows this effect where smoke increases before being dispersed by an increase in wind speed.



**Figure 4** An increase of  $PM_{10}$  particle levels during calm wind conditions at Woodside

The dust event measured during August 2007 (Figure 5) was very similar to that experienced in 2006. The dust levels that reached Woodside were lower than those measured at other sites in metropolitan suburbs of Adelaide. This highlights limited transport effects of pollutants into Woodside.



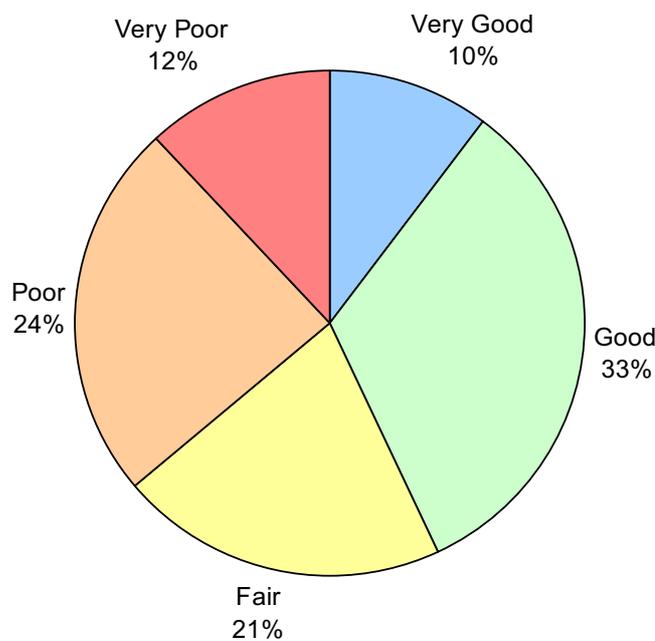
**Figure 5** Dust event ( $PM_{10}$ ) measured at Woodside compared to two other EPA monitoring sites

## VISUAL AIR QUALITY (VAQ) MEASUREMENTS

The Woodside Primary School provided information regarding the visual air quality (VAQ) as part of their involvement in the pilot study and the AirWatch school program<sup>4</sup>.

VAQ is a measure of visibility. How clearly an object is seen in the distance depends on the quality of air in between.

The school conducted visual air quality observations each weekday for 12 weeks providing information to assist the EPA monitoring results. Students rated the VAQ on a scale from very good to very poor in five increments. The possible ratings were 'very good', 'good', 'fair', 'poor', and 'very poor'. The information was collated and is shown in the pie chart below. The observations were typically taken at or around 9 am which would be expected to be close to the time when smoke or fogs would be just starting to lift or be blown away. The results were generally found to match well with measured elevated levels of particles at the time of VAQ measurements. On occasion poor air quality was found not to coincide with elevated measurements of particles. This may be due to fog/smoke mixes limiting visual distance or smoke not present at the monitoring site but being between the monitoring site and the object of interest.



**Figure 6** Visual air quality as measured by students at Woodside Primary School during the SmokeWatch pilot program

<sup>4</sup> The AirWatch school program seeks to engage school communities in local air quality issues and work towards increased understanding of, and willingness to adopt practices that support clean air.

## DISCUSSION

In general there has been an increase in the use of efficient wood heater practices among residents in the AHC area since the inception of the SmokeWatch program, despite a drop in the awareness of the program in October 2007 (most likely due to the types of communication strategies used to promote the message).

Of concern, however, is the significant decrease in the practice of checking the flue or chimney 20 minutes after starting a fire. This practice is critical in identifying whether a chimney is emitting excessive smoke, and hence if a wood heater is being used efficiently. It is difficult to explain the continual decrease of this practice over the duration of the three surveys. However, the perceived inconvenience of going outside, especially during winter, to check the chimney may to some extent explain why this practice resulted in a generally overall lower percentage.

Despite the general increase in efficient wood heater practices among wood heater users, and the perceived importance of adhering to these practices particularly to protect the environment and reduce emissions, residents still remain generally indifferent to the negative impact of wood smoke in the AHC area. Only 28% of respondents believe that wood smoke is a problem and only 16% believe wood smoke negatively impacts on them in winter. These figures have not changed by any major significance since July 2006.

These findings suggest that while residents responded well to messages of how to use their wood heaters more efficiently, this was not the case with regard to recognition of there being a wood smoke problem in the Adelaide Hills. A possible reason for this may be linked to the monitoring results where it was found that wood smoke was only detected during cold and still nights and not during the day when people would be more likely to notice the smoke.

However, interestingly, increases in the use of efficient wood heater practices were not reflected in the air monitoring results, where wood smoke levels remained generally consistent over the two winters. Possible reasons for this inconsistency include:

- while residents were reportedly using their wood heaters more efficiently, few were actually going outside to check their chimney for smoke, therefore it is possible that some were not following the correct wood heater procedures and were unaware of this
- residents who changed their behaviour may not have necessarily been in and around the Woodside township where the monitoring site was located therefore these changes were not picked up in the monitoring results
- over half of surveyed respondents indicated that they already knew how to use their wood heaters more efficiently therefore did not make any changes to their behaviour.

While it is difficult to substantiate the above possibilities, it is important that they are noted and taken into consideration when developing and implementing future programs.

Monitoring data showed that the effects of wood smoke in Woodside were consistent with the levels measured in 2006. As mentioned above, wood smoke in Woodside remains a night time issue, with smoke being transported away from the area or diluted during the morning.

Fine particles were found to dominate the size distribution of airborne particles, which provides conclusive evidence that the particles are from wood smoke. This would mean a major proportion of particle mass concentrations measured were made up of  $PM_{2.5}$  particles.

While current standards for  $PM_{2.5}$  were probably not exceeded in this study, the EPA is concerned that the  $PM_{2.5}$  standard could be exceeded in extreme conditions at Woodside. Further, these results suggest that larger towns with populations slightly greater than the Woodside study area are likely to exceed the  $PM_{2.5}$  standard at times.

Even though standards have not been exceeded, EPA recognises that current health research indicates significant risks for populations exposed to fine particles even at concentrations below the standards, so good risk management practice would include efforts to reduce wood smoke as much as possible.

This indicates that there are potential risks to populations from PM<sub>2.5</sub> particle levels in areas of the state where a high proportion of houses have wood heaters and topography where wood smoke can collect and build up. To quantify this risk the EPA will need to carry out further studies, particularly in the Adelaide Hills and Mount Gambier regions, to inform development of appropriate management strategies.

The EPA would like to acknowledge the staff and students of Woodside Primary School, Adelaide Hills Council and the residents of Woodside for their assistance in a successful pilot program.

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## APPENDIX 1 MAP OF AIR MONITORING LOCATION



## APPENDIX 2 GLOSSARY

### Glossary

NEPM	National Environment Protection Measure and is a national legislated policy that sets limits for the highest permissible pollution levels for a limited range of pollutants
NOX	Total nitrogen oxides
NO <sub>2</sub>	Nitrogen dioxide
NO	Nitric oxide
CO	Carbon monoxide
PM <sub>10</sub>	Particle matter of a size less than 10 millionths of a metre (µm) diameter
PM <sub>2.5</sub>	Particle matter of a size less than 2.5 millionths of a metre (µm) diameter
Fine particles	Particles measured via a nephelometer. A close approximation to PM <sub>2.5</sub> particles

### Instruments and Methods

Monitoring undertaken met relevant Australian Standards.

- TEOM 1400a Tapered Element Oscillating Microbalance  
As specified in AS 3580.9.8–2001
- ML9830 Carbon monoxide Direct Reading Method  
As specified in AS 3580.7.1–1992
- ML9841B Nitrogen Dioxide Chemiluminescence Method  
As specified in AS 3580.5.1–1993
- Radiance Research Nephelometer  
As specified in AS 2724.4–1987
- AR500 (DOAS) Differential optical absorption spectroscopy (DOAS) method

Further information can be found at <[www.opsis.se](http://www.opsis.se)>.