

# A CASE-STUDY OF SMOKE CONCENTRATIONS FROM A SINGLE RESIDENTIAL WOODHEATER IN HOBART, TASMANIA, AS MEASURED ON AN ADJACENT PROPERTY.

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## Abstract

Population exposure to woodsmoke is a significant air quality issue in many jurisdictions, including Tasmania. Ambient air stations are sited to be (hopefully) representative of exposure in the vicinity. In recent years mobile and/or dense network measurements have shown significant local PM<sub>2.5</sub> inhomogeneity can exist on the sub-city and even sub-suburban scales, probably due to high woodheater densities or topographical and microclimatic circumstances. The prevalence of such hot-spots is of importance to fully understand and interpret data leading to dose-response health studies.

EPA Tasmania receives complaints from householders regarding woodsmoke issuing from neighbouring properties. These complaints are referred to local government (councils) as the regulatory authority under Tasmanian legislation. However, the EPA also provides support to councils to assist in resolving these complaints. This can include, in some circumstances, targeted air monitoring programs to measure the severity and frequency of smoke impacts.

In winter 2016 the EPA, in conjunction with Glenorchy City Council, conducted a monitoring program in the north of Hobart in response to such a complaint. A small monitoring station, reporting PM<sub>2.5</sub> and meteorological data in real-time, was deployed at the rear of the affected residence, some 15 metres from the reported problem flue. Car-based 'Travel BLANKET' smoke measurement surveys were also conducted in the surrounding streets. Elevated episodic PM<sub>2.5</sub> levels were seen on many nights, of duration typically one hour, with peak levels of several hundred micrograms per cubic metre. On-site observations, both visual and photographic, identified the source as the previously identified flue. The elevated episodes appeared to be related to a re-loading of the woodheater prior to the operator retiring for the night.

The local council were able to act on the information provided by the EPA data record, and issued an Environmental Protection Notice preventing use of the woodheater.

*Keywords: Woodsmoke; residential areas; PM<sub>2.5</sub> measurement; regulation.*

## 1. Introduction

Smoke from residential woodheaters is the significant contribution to poor ambient winter-time air quality in Tasmania. Even in towns and communities where ambient PM<sub>2.5</sub> levels may not regularly be elevated, smoke from a single heater can locally degrade air quality. In Tasmania local government ('the council') is the regulatory authority for domestic woodheaters. The Tasmanian Distributed Atmospheric Emission Regulations (known as the DAE regulations) provides the legislative framework for councils.

At times EPA Tasmania directly receives complaints from members of the public concerning smoke emissions from a neighbouring property. These are in general referred to the appropriate council. In some circumstances the EPA maintains an interest in the complaint and, in such cases, will often provide some support for council as they deal with the matter.

### 1.1 Claremont smoke complaint

In late winter 2014 EPA Tasmania and the Glenorchy City Council were both contacted by a

resident of Claremont, in the northern suburbs of Hobart, concerning smoke coming from a woodheater on neighbouring property. Council and EPA officers independently made site visits. It was not possible to confirm the presence of high smoke coming from the identified property.

The EPA received a further communication from the complainant in winter 2015. The complainant was referred to the council. A 'Travel BLANKET' (car-based smoke measurement system) survey in May 2015 did include the complainant's street. Measured smoke levels were very low.

In winter 2016 the complainant contacted Glenorchy council once more. Discussions between council and the EPA led to the EPA deploying a small, relocatable air station at the complainants' property in July 2016. Episodically high to very high PM<sub>2.5</sub> levels (over 200 µg/m<sup>3</sup>) were recorded, often at around 10 to 11 pm at night. Further Travel BLANKET surveys and visual observations confirmed the smoke origin was the woodheater as originally identified by the complainant.

This paper describes the deployment and the data obtained from the fixed-station deployment and the Travel BLANKET surveys. These data are also discussed in the context of localised, very elevated population exposure that very likely occurs when a specific woodheater emits excessive smoke levels in a suburban setting.

## 2. Station deployment and data

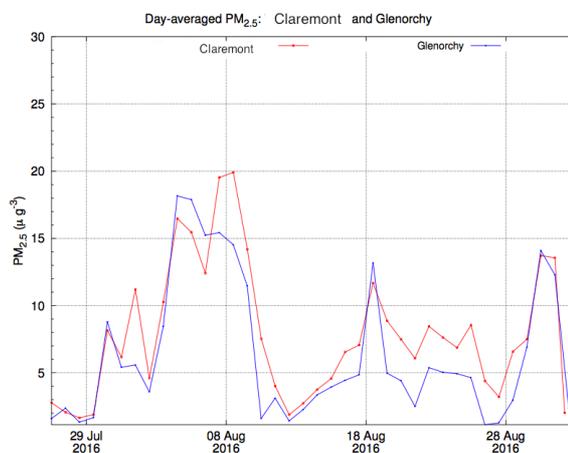
The babyBLANKET station was installed at the rear of the complainant's Claremont residence, effectively outside a bedroom window, and approximately 15-metres from the flue on the neighbouring property. Due to the slope in ground level the top of the (previously-extended) flue was only slightly above the station (Figure 1). The station was in operation from the 25<sup>th</sup> of July to the 2<sup>nd</sup> of September 2016. PM<sub>2.5</sub> and meteorological data were reported to the EPA headquarters in real-time every 5-minutes via a 3G modem. Additionally, PM<sub>2.5</sub> data were logged at a 6-second intervals on a single-board computer at the station, and were manually downloaded at regular intervals.

Overall, day-averaged PM<sub>2.5</sub> levels recorded at the Claremont residence were not dissimilar to levels measured at the Glenorchy air station (Figure 2), with no exceedences of the Australian 24-hour PM<sub>2.5</sub> National Environmental Protection Standard (NEPM) of 25 µg/m<sup>3</sup> during the deployment interval. However it was clear that there were intervals of significantly elevated PM<sub>2.5</sub> concentrations at Claremont when the hour-averaged times series

from these stations were compared, as shown in Figure 3.



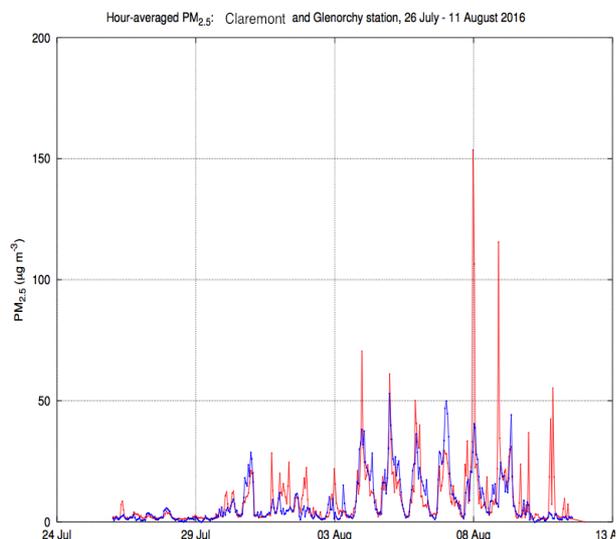
*Illustration 1: View of the chimney flue on the neighbouring property, as seen from the location of the deployed air station. The flue is approximately 15 metres distance from the camera.*



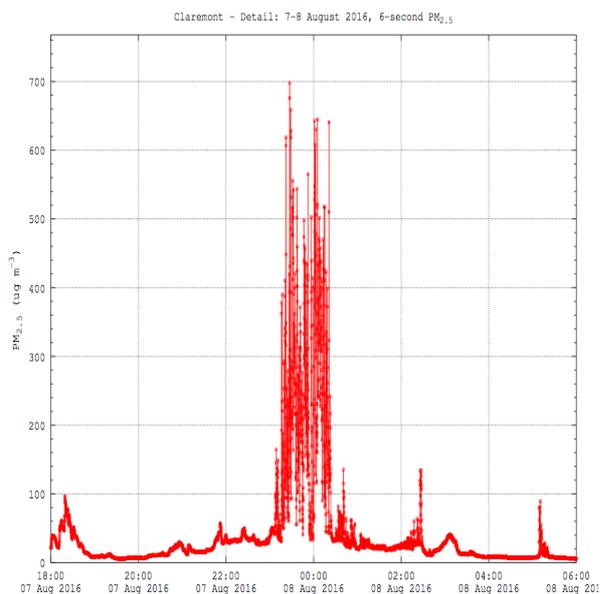
*Illustration 2: Claremont and Glenorchy day-averaged PM<sub>2.5</sub> concentrations during the deployment interval of 25 July to 2<sup>nd</sup> September 2016. Day-averaged concentrations are similar.*

Inspection of the 6-second PM<sub>2.5</sub> time-series data recorded at Claremont revealed the nature of the elevated concentrations: These were characterised by very high (often over 500 µg/m<sup>3</sup>), very short-term episodic increases in PM<sub>2.5</sub>. An example is shown in

Figure 4, from the night of the 7th-8th of August 2016. Soon after 23:00-h on the 7th of August the 6-second  $PM_{2.5}$  shows an interval of very high and variable concentrations. This mostly ceases by around 00:30-h on the 8th of August. The high and rapidly varying signal is suggestive of a nearby localised smoke source.

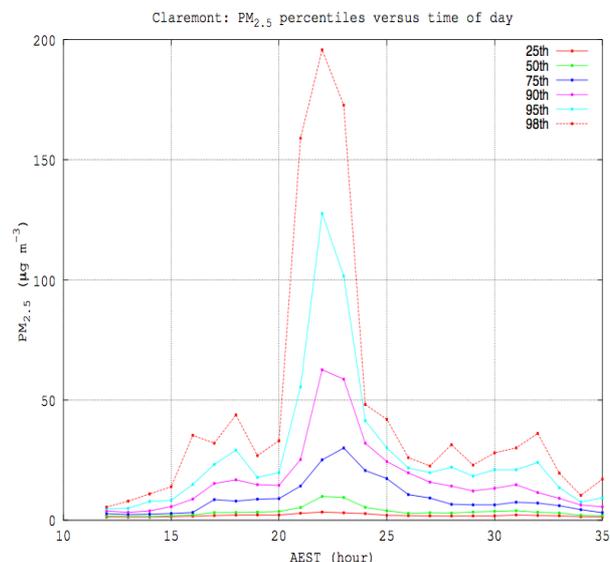


*Illustration 3: Example of hour-averaged  $PM_{2.5}$  time-series from Claremont (red) and Glenorchy (blue) air stations.*



*Illustration 4: Example of 6-second data from Claremont station, showing an interval of very elevated and highly variable  $PM_{2.5}$  concentrations for the night of the 7th-8th August, 2016.*

The daily-profile of the variation in hour-averaged  $PM_{2.5}$  percentile levels shows that the highest concentrations most frequently occurred in the night hours (Figure 5), typically between 9 and 11 pm.



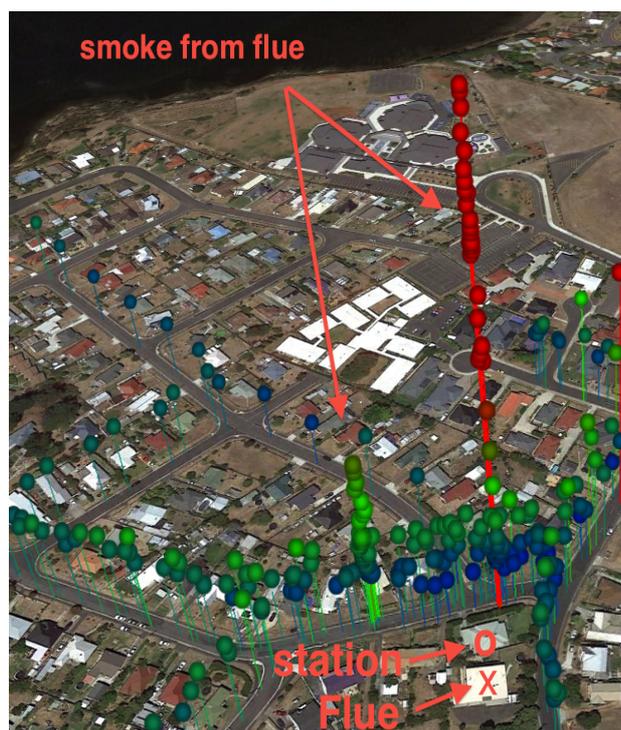
*Illustration 5: Day-profile of hour-averaged  $PM_{2.5}$  percentiles.*

### 3. Travel BLANKET surveys

Three Travel BLANKET surveys were conducted as part of the monitoring program. These were on the 5<sup>th</sup>, 25<sup>th</sup> and 31<sup>st</sup> of August 2016. The surveys encompassed the general Claremont area but with specific attention to the locality of the specific area. The times of elevated  $PM_{2.5}$  seen in the babyBLANKET record were of value in helping plan the surveys. On all three nights significant visible smoke was seen, at times, to be coming from the chimney on the property adjacent to the station. On the first two nights Travel BLANKET was able to sample the plume. On the third night the wind moved the plume to where it could not be reached by car.

A Google Earth view of the 5<sup>th</sup> of August 2016 survey is shown in Figure 6. Each spherical symbol represents the location of a measurement of  $PM_{2.5}$ .  $PM_{2.5}$  levels are represented by symbol colour (dark blue  $\sim 10$  to  $20\ \mu g\ m^{-3}$ ; green  $\sim 50\ \mu g\ m^{-3}$ ; red  $100\ \mu g\ m^{-3}$  and above) and also by height above local ground level. The location of the flue and the monitoring station are also shown. The peak  $PM_{2.5}$  signal, that was identified as originating from the identified flue, measured on this night with Travel BLANKET was just over  $200\ \mu g\ m^{-3}$ . This was taken approximately 35 metres from the flue, in the street in front of the residence with the station. As noted,

the station at the residence was approximately 15 metres from the flue.

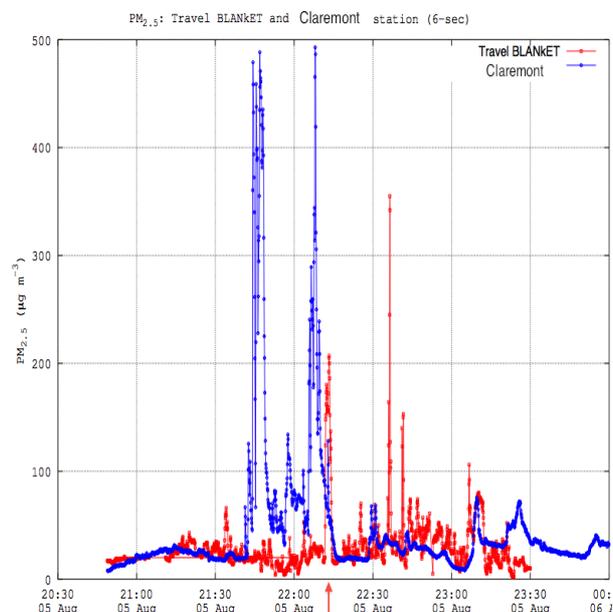


*Illustration 6: Google Earth view of the Travel BLANKET measurements at Claremont, 7th-8th August 2016.  $PM_{2.5}$  levels are represented by symbol colour (dark blue  $\sim 10$  to  $20 \mu\text{g}/\text{m}^3$ ; green  $\sim 50 \mu\text{g}/\text{m}^3$ ; red  $100 \mu\text{g}/\text{m}^3$  and above) and also by height above local ground level. The location of the flue and the monitoring station are also shown.*

On the 5<sup>th</sup> of August, shortly before the plume was measured by Travel BLANKET in the street outside the Claremont residence, the station at the rear of the residence also recorded highly elevated  $PM_{2.5}$  concentrations. Figure 8 plots the time-series of Travel BLANKET and the station for the evening of the 5<sup>th</sup> of August. Travel BLANKET, 35-metres from the flue, recorded a peak (instantaneous)  $PM_{2.5}$  level near  $200 \mu\text{g}/\text{m}^3$ . The babyBLANKET station was 15-metres from the flue, and recorded a number of points over  $200 \mu\text{g}/\text{m}^3$ , with peak  $PM_{2.5}$  concentrations near  $600 \mu\text{g}/\text{m}^3$ . As noted, visual observations on the night confirmed the flue from the residence adjoining the complainant's house as the origin of the smoke.

On each of the three survey nights, the visible smoke plume appeared after the lights were turned off in the house with the flue. It is conjectured that the increased emissions and more visible plume arose after the woodheater was reloaded with fuel,

and the air vent turned down prematurely, as the occupants retired for the evening.



*Illustration 7: Time series of  $PM_{2.5}$  on the evening of the 5th of August recorded by Travel BLANKET (red) and babyBLANKET (blue). The red upward pointing arrow denotes the time Travel BLANKET was measuring the plume from the identified flue. The babyBLANKET station, at the rear of the residence, was approximately 15 metres from the flue. Travel BLANKET was approximately 35 metres from the flue.*

#### 4. Discussion

The babyBLANKET station and Travel BLANKET survey data, together with some photographs (not shown here) and visual records were provided with a written analysis to the Glenorchy Council and the Environmental Health Section of the Tasmanian Department of Health and Human Services (DHHS). The complainant also supplied information that they had undergone several major medical procedures, and were continuing to have further treatment. The DHHS concluded that the episodically high  $PM_{2.5}$  levels recorded at the residence would potentially be of concern to people with certain medical conditions.

The council considered all these factors, and met several times with the owner and the occupier of the residence identified as the source of the smoke. The council noted this house was also equipped with a reverse-cycle air conditioner. Consequently

the council issued an Environmental Protection Notice stating that due to the impact on the neighbouring occupier the woodheater could not be used.

The smoke plume seen to be the cause of the locally elevated PM<sub>2.5</sub> concentrations was probably not the most prominent or persistent of the many plumes that have been noted by officers of EPA Tasmania in the course of winter-time smoke surveys and other work. In this case however the local topography and probably micro-climatic conditions meant the plume often impacted on the affected residence. The affected resident was also determined to bring the circumstances to the attention of both council and the EPA.

It is acknowledged that the first investigations by the EPA of the original complaint, being an initial drive-by in 2014 and a Travel BLANKET survey in mid 2015, did not reveal the severity of the situation. It was only after the deployment of the babyBLANKET station to the complainants' residence in late July 2016 that the scale of the impact became clear. This is a lesson that the author is intending to keep in mind for the future.

In a wider context, the data reported here may give some guidance as to the localised impacts of smoke plumes from other individual woodheaters. It is sobering to note that even though a survey instrument such as Travel BLANKET often measures the elevated PM<sub>2.5</sub> concentrations from a single plume, the levels recorded along the street

may be significantly less than experienced closer to the chimney. In many instances the chimney-to-neighbouring-house distance is less than the chimney-to-street distance.

In many instances, air monitoring stations are sensibly and deliberately sited away from local sources in an attempt to measure representative ambient conditions. There is clearly a case for also conducting 'peak site' monitoring to assist in gauging the range of pollutant exposures in the community. Extrapolating from the work presented here, it is likely that 'peak sites' in winter-time Tasmania include residential backyards.

## Acknowledgments

We acknowledge the interest, support and efforts of the Environmental Health Officers of the Glenorchy City Council in this work.

## References

- J. Innis, A. Cunningham, B. Hyde, and E. Cox, 2015, '*babyBLANKET: A low-cost, highly-portable, real-time, smoke-monitoring station based on the Dylos DC-1700 laser particle counter*'. CASANZ Proceedings 2015 Melbourne conference, ISBN 9780987455321.