OVERVIEW OF AIR MONITORING - BURN BRIGHTER, WINTER 2012
AIR SECTION, EPA DIVISION

Summary
The main findings from the analysis of air quality data from the South/East Launceston and West Hobart Burn Brighter 2012 program are as follows:

Launceston study area air monitoring
- Effective car–based monitoring can be conducted even in a high-density inner urban residential area
- Direct measurement of individual smoke plumes in an inner urban area is possible, at least under some circumstances.
- In some cases the presence of an excessively smoky chimney was first identified from repeated high PM$_{2.5}$ measurements in a given location.
- Using car–based surveys (to measure the spatial pattern of smoke distributions) and fixed station data (for the seasonal variation and nightly-context) is a very powerful combination for studies of wood-heater smoke concentrations in an urban environment.
- There is an indication from the data that smoke levels along the ‘High St ridge’ in the study area may not in general be as high as in the valleys to the east and west.
- There is no evidence from the analysis conducted here that air quality in the South Launceston area in winter 2012 had either changed from 2011, once meteorological influences were accounted for, or changed (i.e. improved) during the 2012 winter as judged from a comparison with Ti Tree Bend data.
- There is evidence from visual surveys that many residences in the study area identified as having excessively smoky chimneys modified their woodheater use after receiving Burn Brighter material.
- Improvement in local emission levels in the study area may not have been directly reflected in measured concentrations at the South Launceston station as the 2012 winter data suggest that not all of the smoke measured at South Launceston is from local sources.

*Date: Version 0.0, 19 November 2012.*
**West Hobart study area air monitoring**

- As also demonstrated in the Launceston work, the West Hobart monitoring shows that car–based smoke measurement surveys of high–density urban areas can provide valuable data, and can measure spatially–localised elevated PM$_{2.5}$ concentrations from specific plumes.
- The eastern, lower–elevation, part of the West Hobart study area generally experienced higher smoke levels than the western (Mt Stuart) part.
- Localised ‘hot–spots’ of elevated PM$_{2.5}$ concentrations were seen on several surveys in particular locations, such as near the intersection of Lower Jordan Hill Rd and Newdegate St, and near the intersection of Lower Jordan Hill Rd and Mellifont St. These hot–spots appear to arise from specific plumes from chimneys identified by visual inspection as emitting excessive smoke.
- As for Launceston, there is evidence from visual surveys that many individual residences in the West Hobart study area, identified in the 2012 season as having chimneys emitting excessive smoke, did respond to the *Burn Brighter* material and subsequently improved woodheater–operation practices.
- There is no evidence from the analysis conducted here to indicate that measured smoke concentrations at West Hobart decreased in the 2012 season as a result of the *Burn Brighter* program. Any decrease in local emissions that may have occurred may have been masked by the contribution of non–locally produced smoke to the West Hobart PM$_{2.5}$ concentrations.
1. The *Burn Brighter 2012* monitoring program

1.1. Overview of the *Burn Brighter 2012* program

*Burn Brighter 2012* was the first phase of the EPAs Domestic Smoke Management Program. The aim of the program is to provide information on and encourage improvement in woodheater operation, with consequent reduction in smoke emissions and hence improved health outcomes for Tasmanian communities. It has been estimated\(^1\) that 10% of the most poorly performing woodheaters in Launceston produce 30% of the smoke emissions, and that most poorly performing woodheaters were doing this in consequence of poor operation. The *Burn Brighter* program aimed to identify these high-emission woodheaters and, by education and raised awareness, improve performance and reduce smoke emissions.

In 2012, the first year of the program, two study areas were selected, as noted above, one in South/East Launceston, and one in West Hobart. All households in the study areas received information sheets in early winter 2012 introducing the program and providing advice on woodheater operation and air quality issues.

During the winter of 2012 both Travel BLANKET smoke measurement surveys and visual searches for chimneys considered to be producing excessive smoke were carried out in the study areas. Residences identified as having excessively smoky chimneys were contacted by letter containing

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\(^1\)J. Todd, personal communication
further advice concerning woodheater operation. If a given residence continued to exhibit excessive smoke production further letters were sent. In most cases residences that received the first letter were not subsequently seen to be continuing to produce excessive smoke.

Further details of the program itself will be presented elsewhere. This current report summarises the scientific results of the air monitoring carried out in support of the program. It is intended that a more complete scientific discussion will also be made available at a later date.

1.2. General. The air monitoring carried out in support of the *Burn Brighter 2012* program consisted of both fixed–site monitoring and car–based mobile surveys. The fixed–sites used ‘BLANkET’ stations of the standard network design\(^2\). The car–based monitoring was carried out using ‘Travel BLANkET’ equipment.

1.3. South and East Launceston. The South/East Launceston study area was on the High Street Ridge from Elizabeth St in the north to Lawrence Vale Road in the south. Lawrence Vale Road was an obvious southern boundary as the ridge dips slightly in this area, but apart from this the borders of the study area were selected somewhat arbitrarily. A 2011 EPA–sponsored telephone survey of domestic woodheater use estimated that about 15% of households in this area were likely to use woodheaters as the primary heating method. Launceston City Council data indicated that 624 residential properties were in the study area. Hence approximately 90 households in the study area were likely to use woodheaters as their primary heat source.

1.4. West Hobart. The West Hobart study area was bounded by Elizabeth St to the east, Elphinstone Road and Mount Stuart Road to the north, the south through Clift St, Hillside Crescent, and Summerhill Road to Mellifont St, then via Arthur St back to Elizabeth St. Hobart City Council data indicated that 559 residential properties were in the study area. The recent EPA–sponsored woodheater telephone survey identified 15% of residence in West Hobart as using woodheaters as their primary heating means. This would correspond to approximately 85 households in the study area. The temporary West Hobart air station was installed on a residential property in Lower Jordan Hill Road on the 28th of June 2012.

1.5. Comparison of air quality between the West Hobart and South/East Launceston areas. Figure 1 shows calendar–day–averaged PM\(_{2.5}\) measured at the South Launceston (red squares) and West Hobart (blue circles) stations. Monitoring at West Hobart commenced in late June 2012. For the data after this time, it is clear that South Launceston often experienced higher peak day–averaged PM\(_{2.5}\) (smoke) concentrations. For reference, the Air NEPM day–averaged advisory reporting standard for PM\(_{2.5}\)

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is 25 µg m$^{-3}$. There were 12 days in the interval shown where the South Launceston day–averaged PM$_{2.5}$ value was above $325$ µg m$^{-3}$. In contrast, the peak day–averaged value at West Hobart was 25 µg m$^{-3}$ (which is not above the Air NEPM standard) on the calendar day of the 30th of June.

![Comparison of South Launceston and West Hobart day–averaged PM$_{2.5}$ data. The averaging interval used was the calendar day.](image)

**Figure 1.** Comparison of South Launceston (red squares) and West Hobart (blue circles) day–averaged PM$_{2.5}$ data. The averaging interval used was the calendar day.

$^3$The BLANkET data presented here are ‘indicative quality’, and cannot be used to formally determine if an exceedence of the Air NEPM standards have occurred. However they provide a good indication as to whether or not, had a reference instrument been sampling at that location at that time, whether an exceedence would have been recorded.
Table 1. Statistical summary of day–averaged PM$_{2.5}$ from West Hobart and South Launceston air stations, 29 June to 30 September 2012.

<table>
<thead>
<tr>
<th>Quantity ($\mu g$ m$^{-3}$)</th>
<th>West Hobart</th>
<th>South Launceston</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>6.7</td>
<td>6.2</td>
</tr>
<tr>
<td>Mean</td>
<td>7.9</td>
<td>10.6</td>
</tr>
<tr>
<td>3rd quartile</td>
<td>10.7</td>
<td>16.4</td>
</tr>
<tr>
<td>Maximum</td>
<td>25.2</td>
<td>49.3</td>
</tr>
</tbody>
</table>

Statistical summary information for the day–averaged PM$_{2.5}$ data from the two stations for the interval from 29 June to 30 September 2012 inclusive are presented in Table 1. While the median values at each station are similar over this interval, South Launceston recorded higher mean, third quartile and maximum values.

2. South/East Launceston

2.1. Station data and car–based surveys. Seven car–based ‘Travel BLANkET’ monitoring surveys were conducted on the South/East Launceston study area and surrounds between May and August 2012. The dates of the surveys and relevant data are listed in Table 2.

<table>
<thead>
<tr>
<th>Date</th>
<th>T (C) (18h)</th>
<th>T (C) (22h)</th>
<th>PM$_{2.5}$ calendar day mean</th>
<th>PM$_{2.5}$ midday to midnight</th>
<th>Survey interval (AEST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16th May</td>
<td>11.8</td>
<td>8.1</td>
<td>18.4</td>
<td>24.0</td>
<td>20:00–24:00</td>
</tr>
<tr>
<td>29th May</td>
<td>9.9</td>
<td>5.9</td>
<td>28.1</td>
<td>30.3</td>
<td>20:20–24:20</td>
</tr>
<tr>
<td>7th June</td>
<td>6.8</td>
<td>3.1</td>
<td>37.5</td>
<td>33.2</td>
<td>20:40–24:00</td>
</tr>
<tr>
<td>3rd July</td>
<td>8.2</td>
<td>3.4</td>
<td>note$^1$</td>
<td>31.3</td>
<td>21:00–24:00</td>
</tr>
<tr>
<td>26th July</td>
<td>9.6</td>
<td>7.1</td>
<td>12.5</td>
<td>16.3</td>
<td>20:30–24:30</td>
</tr>
<tr>
<td>1st August</td>
<td>8.9</td>
<td>4.2</td>
<td>10.7</td>
<td>18.0</td>
<td>20:30–24:00</td>
</tr>
<tr>
<td>22nd August</td>
<td>11.6</td>
<td>10.4</td>
<td>7.1</td>
<td>8.9</td>
<td>20:30–23:30</td>
</tr>
</tbody>
</table>

Table 2. South/East Launceston survey metadata. The quoted temperatures, and calendar–day and midday–to–midday average PM$_{2.5}$ values, are from the South Launceston station, not from the car–based survey data. $^1$South Launceston station off–line 01:20–09:00 h, 3rd July 2012.

An example representation of the Travel BLANkET survey data for the 26th of July 2012 is shown in Figure 2, displayed using Google Earth. Each symbol represents one measurement of PM$_{2.5}$. The height of the symbol above ground and the symbol colour both represent the PM$_{2.5}$ level: red represents $\sim 100 \, \mu g \, m^{-3}$ and greater, dark blue is near 10 to 20 $\mu g \, m^{-3}$. 
The elevated PM$_{2.5}$ levels represented as red or brown–coloured symbols are due to smoke plumes from individual chimneys. The exceptions are the cluster of red symbols in Mulgrave St (left centre) which arose from plumes from at least two chimneys, and the elevated symbols at the extreme left which appear to be due to a general high–level of smokiness in the valley where the Midland Highway runs between South and West Launceston. It is worth noting that the individual plumes are apparent even given the generally elevated PM$_{2.5}$ levels in the survey area. In part this is because, in some instances, the car was stopped in order to sample a particular plume. The results do show however that measurements of individual plumes in a high-density urban area is achievable, at least under some circumstances. Important note: The presence of an elevated PM$_{2.5}$ measurement adjacent to any particular house in this and the other surveys does not necessarily mean that residence was the source of the smoke.

2.2. Predicting PM$_{2.5}$. The Air Section of the EPA Division has been developing a ‘predictive tool’ derived from historical relationships between smoke concentrations and meteorological information. More details of the method are given in the full scientific report. In brief, fourier analysis is used to derive a function that relates the historical time-series of smoke and ambient temperature. This function can be convolved with current temperature data to estimate current smoke concentrations. An adjustment for wind speed is also applied. For the 2012 South Launceston BLANkET station data the predicted 2012 PM$_{2.5}$ data are shown in Figure 3. A large measure of the observed daily variation of PM$_{2.5}$ for winter 2012 is captured by this simple approach, although clearly some differences are apparent. In some measure, this approach allows the effects of inter–annual variations in meteorological conditions to be allowed for when comparing air quality data between years.

The question as to why the predictions for the 5th to 9th of July appear poorer than for other intervals in 2012 is considered as open. The residual plot of observed–predicted PM$_{2.5}$ for winter 2012 (lower panel of Figure 3) does not reveal any indication of a significant trend in the residuals over the winter season. The analysis therefore does not provide evidence for a change in overall air quality in South Launceston between 2011 and 2012, once the variations in intra–seasonal meteorology has been accounted for.

2.2.1. Comparison to Ti Tree Bend air station. Comparing day–averaged PM$_{2.5}$ data from South Launceston and Ti Tree Bend air stations for winter 2012 yields the plot shown in Figure 4. There is a large degree of similarity in these time–series. The general agreement between South Launceston and Ti Tree Bend day–averaged PM$_{2.5}$ measurements over this interval also indicates there was not a significant change in air quality at South Launceston.

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This prediction used the measured South Launceston 2011 PM$_{2.5}$ and ambient temperature data to derive the needed convolution function.
Figure 2. A representation, using Google Earth, of a Travel BLANkET survey of South/East Launceston (26 July 2012), looking generally northwards into the study area. Each symbol represents one measurement of PM$_{2.5}$. The height of the symbol above ground and the symbol colour both represent the PM$_{2.5}$ level – red is near 100 µg m$^{-3}$, dark blue is near 10 to 20 µg m$^{-3}$. In most instances, elevated PM$_{2.5}$ levels represented as red or brown–coloured symbols are due to smoke plumes from individual chimneys. **Important note:** The presence of an elevated PM$_{2.5}$ measurement adjacent to any particular house does not necessarily mean that residence was the source of the smoke.

During the 2012 winter. This is consistent with the conclusions drawn from the ‘predictive tool’ analysis presented above.
Figure 3. Top panel: Observed (red squares) and predicted (blue circles) calendar day–averaged PM$_{2.5}$ values for South Launceston, winter 2012. The value of zero for the observed PM$_{2.5}$ for the 3rd of July 2012 results from a PM$_{2.5}$ data gap on this day, hence a valid daily mean could not be calculated.

The similarity of the Ti Tree Bend and South Launceston PM$_{2.5}$ time–series, from stations separated by approximately 3.5 km, suggests (day–averaged) smoke concentrations in Launceston have a large measure of spatial uniformity. This may indicate smoke from a given source mixes into the general background on a time–scale of several hours. Consequently, this could mean that smoke measured at South Launceston station does not just reflect the level of local emissions.
Figure 4. A comparison of day-averaged DRX dustrak PM$_{2.5}$ data from Ti Tree Bend (blue diamonds) and South Launceston (red squares) air stations, winter 2012.
2.3. **Conclusions - Launceston study area air monitoring.** The main findings from the analysis of air quality data from the South/East Launceston *it* Burn Brighter 2012 program are as follows:

- Effective car–based monitoring can be conducted even in a high–density inner urban residential area.
- Direct measurement of individual smoke plumes in an inner urban area is possible, at least under some circumstances.
- In some cases the presence of an excessively smoky chimney was first identified from repeated high PM$_{2.5}$ measurements in a given location.
- Using car–based surveys (to measure the spatial pattern of smoke distributions) and fixed station data (for the seasonal variation and nightly–context) is a very powerful combination.
- There is an indication that smoke levels along the ‘High St ridge' in the study area may not in general be as high as in the valleys to the east and west.
- There is no evidence from the analysis conducted here that air quality in the South Launceston area in winter 2012 had either changed from 2011, once meteorological influences were accounted for, or changed (i.e. improved) during the 2012 winter as judged from a comparison with Ti Tree Bend data.
- There is evidence from visual surveys that many residences in the study area identified as having excessively smoky chimneys modified their woodheater use after receiving *Burn Brighter* material.
- Improvement in local emission levels in the study area may not have been directly reflected in measured concentrations at the South Launceston station as there is now evidence to suggest that not all of the smoke measured at South Launceston is from local sources.
3. West Hobart

3.1. Station data and car–based surveys. Five car–based Travel BLANK surveys were conducted of the West Hobart study area in winter 2012, although one survey, on the afternoon of the 4th of July, was brief and mainly for orientation purposes. The survey details are given in Table 3.

<table>
<thead>
<tr>
<th>Date</th>
<th>T (C)</th>
<th>T (C)</th>
<th>PM$_{2.5}$</th>
<th>PM$_{2.5}$</th>
<th>Survey interval (AEST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th June</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>21:00–23:40</td>
</tr>
<tr>
<td>04th July</td>
<td>7.8</td>
<td>5.9</td>
<td>12.7</td>
<td>14.3</td>
<td>13:50–14:30</td>
</tr>
<tr>
<td>09th July</td>
<td>8.4</td>
<td>7.4</td>
<td>17.9</td>
<td>17.0</td>
<td>21:40–23:40</td>
</tr>
<tr>
<td>23rd July</td>
<td>6.6</td>
<td>7.4</td>
<td>10.7</td>
<td>11.4</td>
<td>20:40–23:10</td>
</tr>
<tr>
<td>15th August</td>
<td>8.6</td>
<td>6.4</td>
<td>4.0</td>
<td>4.4</td>
<td>20:20–22:40</td>
</tr>
</tbody>
</table>

Table 3. West Hobart survey metadata. The quoted temperatures, and calendar–day and midday–to–midday average PM$_{2.5}$ values, are from the West Hobart station, not from the car–based survey data.\textsuperscript{1}The West Hobart station was installed on 28th June 2012. \textsuperscript{2}Short–duration day–time survey, very low smoke levels.

3.2. Predictive Tool. As for the South/East Launceston study area, one aim of the Burn Brighter program was to see if an improvement in air quality may have resulted in consequence of improved knowledge of woodheater operation by residents in the West Hobart study area. Hence the predictive tool was applied to the West Hobart data. Significant handicaps in this case compared to Launceston are the lack of data from any previous year and the fact that the West Hobart data record only commenced on the 28th of June 2012.

The ‘source week’ used to derive the convolution function was selected as the seven days beginning the 29th of June. The resulting predicted and observed day-averaged PM$_{2.5}$ for West Hobart are shown in the top panel of Figure 5. The lower panel of this figure shows the residuals (observed–predicted). In general, the predicted PM$_{2.5}$ is a poor match for the observations for the first half of the data record, but seems to be better after mid August. The apparent downward trend in the residuals over the data record is probably not significant. This, together with the relatively poor predictive power for the first half of the data set, means there is no clear evidence from this analysis for a change in West Hobart’s air quality over the interval of early July–early September 2012.

3.3. Comparison to New Town and Clearys Gates air stations. An alternate means of looking for any improvement or other change in West
Overview of Air Monitoring - Burn Brighter, Winter 2012-13

Figure 5. Top panel: Observed (red squares) and predicted (blue circles) calendar day–averaged PM$_{2.5}$ values for West Hobart, July–September 2012.

Hobart air quality during the 2012 winter is to compare data from this station with New Town air station (2.1 km north of West Hobart).

Figure 6 shows a comparison between day–averaged PM$_{2.5}$ DRX dustrak data from New Town (blue circles) and West Hobart (red squares) for winter 2012. There is clearly a similar pattern of variation in day–averaged PM$_{2.5}$ at New Town and West Hobart, with West Hobart being very similar to the New Town levels from mid July onwards. Inspection of these data shows no evidence for a decrease in day–averaged PM$_{2.5}$ concentrations at West Hobart, relative to New Town, appearing during the 2012 season.

There is a general similarity of the pattern of variation seen in the West Hobart and New Town data. As was noted for the Launceston study, this may indicate that at least some of the smoke measured at West Hobart is not locally generated. Consequently local reductions in smoke emissions...
**Figure 6.** A comparison of day-averaged DRX dustrak PM$_{2.5}$ data from New Town (blue circles) and West Hobart (red squares) air stations, winter 2012.

during the 2012 season (e.g. through improved wood heater use) may not be directly reflected in measured smoke concentrations at West Hobart.
3.4. Conclusions - West Hobart study area air monitoring.

- As also demonstrated in the Launceston work, the West Hobart monitoring shows that car–based smoke measurement surveys of high–density urban areas can provide valuable data, and can measure spatially–localised elevated PM$_{2.5}$ concentrations from specific plumes.
- The eastern, lower–elevation, part of the West Hobart study area generally experienced higher smoke levels than the western (Mt Stuart) part.
- Localised ‘hot–spots’ of elevated PM$_{2.5}$ concentrations were seen on several surveys in particular locations, such as near the intersection of Lower Jordan Hill Rd and Newdegate St, and near the intersection of Lower Jordan Hill Rd and Mellifont St. These hot–spots appear to arise from specific plumes from chimneys identified by visual inspection as emitting excessive smoke.
- There is no evidence suggesting measured smoke concentrations at West Hobart decreased in the 2012 season as a result of the Burn Brighter program. Any decrease in local emissions$^5$ that may have occurred may have been masked by the contribution of non-locally produced smoke to the West Hobart PM$_{2.5}$ concentrations.

4. Travel BLANKET surveys and visual smoke plume identifications

One novel aspect of the Burn Brighter 2012 program was the combination of visual searches for excessively smoky chimneys combined with Travel BLANKET monitoring of the study areas. As noted, the Travel BLANKET data not only provided information of the overall spatial–distribution of smoke concentrations but also allowed individual plumes to be sampled.

It is instructive to look at the degree of commonality between the visual searches and the Travel BLANKET data. An example is shown in Figure 7, which shows the West Hobart Travel BLANKET survey of the 9th of July 2012 (conducted by the EPA Division) and the approximate locations of excessively smoky chimneys identified by Hobart City Council Environmental Health Officers on several nights near the Travel BLANKET survey date. The image is shown here at relatively low–resolution for reasons of privacy – the appearance of plume icon or a high PM$_{2.5}$ reading near a given house does not necessarily mean that house was the source of the smoke. There is a measure of consistency between the visually identified plumes and the locally–elevated PM$_{2.5}$ data.

Figure 8 shows the South/East Launceston Travel BLANKET survey for the 22nd of August 2012 – the last such survey conducted in winter 2012.

$^5$There is evidence that many individual residences in the West Hobart study area, identified early in the 2012 season as having chimneys emitting excessive smoke, responded to the Burn Brighter material and improved woodheater–operation practices.
Several plumes clearly stand out in the data. The dates the plumes from these chimneys were first identified are given in the Figure.

Introductory *Burn Brighter* material was delivered to every residence on the study areas at the commencement of the 2012 program, and supplementary material was supplied during the winter to residences seen to be exhibiting excessively smoky plumes, including to some residences with the plumes seen in Figure 8. Clearly, in some circumstances, individual plumes that were noted early on during the program were still prominent in late August.
Figure 8. South/East Launceston Travel BLANkET survey, 22nd August 2012. This was the final survey of the Launceston study area for winter 2012. Four plumes are labelled with the 2012 date they were first identified as being excessively smoky. Note that the plumes labelled ‘19 June’ and ‘26 July’ were just outside the formal study area.
5. ACKNOWLEDGEMENTS

The EPA Division acknowledges and thanks the Hobart City Council and Launceston City Council Environmental Health Officers who conducted the smoke plume searches. M. Hyland (EPA Division) also participated in the Launceston plume searches.

Ben Lomond Water owns the site and supports the operation of the South Launceston BLANkET station.

The EPA Division thanks the residents of the Lower Jordan Hill Road property who kindly allowed the West Hobart air station to be installed in their backyard from late June to September 2012.

Travel BLANkET surveys were conducted by EPA Division staff W.E. Cox, M. Hyland, J. Phillips, K. Blackburn and J. Innis.

Report compiled by J. Innis.