Environet ltd
Air Quality & IT Specialists

# Blenheim Air Emission Inventory - 2005

**Prepared by Emily Wilton**

**Environet Ltd**
**11 Lachie Griffin Rise**
**R D 1**
**Lyttelton**

**October 2005**

# Executive Summary

Air quality monitoring for $PM_{10}$ has been carried out in Blenheim since 2000. Concentrations in excess of ambient air quality guidelines and the National Environmental Standard (NES) for $PM_{10}$ of 50 µg $m^{-3}$ (24-hour average) occurred on around 37% of winter days at the Redwoodtown Brooklyn Street air monitoring site during 2004. All exceedences occurred during the winter months. The NES allows one exceedence per year of 50 µg $m^{-3}$. The maximum measured $PM_{10}$ concentration at the Redwoodtown site during 2004 was 81 µg$m^{-3}$.

The purpose of this study is to estimate the amount of emissions contributing to $PM_{10}$ concentrations during the winter and to provide information that can be used in the management of $PM_{10}$ concentrations in Blenheim. Emissions data are also to be used in establishing the straight-line path to compliance with the NES by 2013, as specified in the NES regulations.

A household survey of domestic home heating methods and fuels was used as the basis for estimating emissions from domestic heating. This was conducted in 2005 as a part of the Ministry for the Environment's "warm homes" project. The survey collected detailed information on home heating methods, fuels and seasonal variations in heating behaviour. Other sources included in the inventory were motor vehicles, industry and outdoor burning.

The domestic heating survey showed around 52% of households in Blenheim used wood burners for domestic home heating, with 5% using open fires and 7% using multi fuel burners. On an average winter's day around 95 tonnes of wood (including wood pellets) and 2 tonnes of coal are burnt in Blenheim. This would increase to around 125 tonnes of wood and 4 tonnes of coal if all households were to use their solid fuel heating methods on the same night.

The inventory shows that solid fuel burning for domestic home heating is the main source of $PM_{10}$, contributing around 85% of the $PM_{10}$ in Blenheim on an average winter's day. Outdoor rubbish burning is estimated to contribute 6%, with 2% coming from industry and 7% from motor vehicles. On average just over one tonne of $PM_{10}$ is estimated to be discharged into the air over Blenheim on an average winter's day.

# Contents

# 1 Introduction

Air quality monitoring for suspended particles ($PM_{10}$) has been carried out in Blenheim since 2000 at the Blenheim Renwick Road monitoring site and at Redwoodtown since September 2001. Two sites in Redwoodtown have been used over this period; the existing Bowling Club site and a site in Brooklyn Street during 2004. Results show concentrations of suspended particulate in excess of the MfE ambient air quality guideline and National Environmental Standard (NES) of 50 $\mu gm^{-3}$ (24-hour average). Other air quality monitoring for the Marlborough Region includes monitoring in Renwick during winter 2002 and in Picton during 2000. No guideline or NES breaches have been recorded in these locations to date, although further monitoring is planned in Picton.

Some monitoring has also been carried out for other contaminants in Blenheim. This monitoring has focused on passive sampling methods and included both $NO_2$ and $SO_2$. Results are difficult to interpret relative to guideline values and the NES because these are based on 24-hour and hourly average concentrations and the sampling method used provides only a three-month average concentration. However, a report on monitoring of $NO_2$, $SO_2$ and other contaminants in New Zealand (Environet, 2003) indicates guideline or NES breaches are unlikely for ambient air concentrations of most contaminants in smaller urban areas of New Zealand. One exception may be benzo(a)pyrene, although no NES has been established for this contaminant.

Based on monitoring carried out to date, the maximum recorded $PM_{10}$ concentration for Blenheim is 81 µg $m^{-3}$, and was measured in July 2004 at the Brooklyn Street Redwoodtown site. Monitoring at this site was carried out based on a one-day in three sampling regime during 2004. The number of measured breaches of 50 µg $m^{-3}$ during 2004 was 10. If these data are statistically extrapolated for non-sample days the number of breaches may have been as high as 27. The NES allows for one breach of 50 µg $m^{-3}$ per year and is effective from September 2005.

The regulations specify that if the NES is not met by 2013, Councils will be unable to grant resource consents for discharges to air for that airshed. In addition, between September 2005 and 2013 consents for discharges to air can only be granted if Councils can demonstrate a “straight-line path” to compliance that will not be impinged on by the granting of the consent. This applies only to the airshed which is non-compliant with the NES and if the proposed discharge is likely to result in a significant increase in $PM_{10}$ concentrations. The amended regulation (August, 2005) includes slightly different specifications for areas where an operative air quality plan specifies a curved line path to achieving the NES by 2013.

The main variables involved in setting a straight or curved-line path to compliance include:

1. Monitoring data to determine the starting point; that is the extent to which existing concentrations exceed the NES.
2. Emissions data, to determine what level of emissions resulted in the existing concentrations and consequently how effective reductions in emissions will be.
3. Meteorological data and airshed modelling to determine the relationship between emissions and concentrations.

The Ministry for the Environment provides no guidance on the setting of straight or curved-line paths. The straight-line paths, and compliance with them, are determined by Councils and can be revised at any stage. Whilst there are a number of options for selecting the starting point for the straight-line path, arguably the most defensible is the use of monitoring data, in particular the 99.7 percentile concentration for each area, for areas where there are sufficient monitoring data to do this[1]. The path should be revised as further monitoring data becomes available if this shows concentrations in excess of previous 99.7 percentile concentrations.

Emission inventories are the primary tool used in New Zealand to estimate quantities of emissions to air. In addition to providing information on the relative contribution of different sources to emissions of a contaminant, an inventory provides an estimate of the quantity of emissions contributing to the maximum measured concentrations and allows for the evaluation of the effectiveness of different management options in reducing concentrations.

The third variable involved in the setting of the straight-line path is meteorological modelling to determine the relationship between emissions and concentrations. This modelling indicates the relationship between the reduction required in $PM_{10}$ concentrations relative to the reduction required in emissions. Many areas do not have detailed modelling data illustrating the relationship between 24-hour emissions and concentrations of $PM_{10}$. One detailed study for Christchurch suggests that the relationship is linear in that a 1% reduction in emissions would result in a 1% reduction in concentrations (Gimson & Fisher, 1997). Thus in the absence of modelling information for other areas, the relationship has often been assumed to be linear.

This report details the results of an air emission inventory carried out for Blenheim for 2005. The purpose of the inventory is to estimate the amount of $PM_{10}$ discharged into the air over Blenheim on a worst-case and average winter's night and to provide information from which management measures to reduce $PM_{10}$ can be evaluated.

[1] Other options such as meteorological modelling may be considered for locations where monitoring data are limited.

# 2 Inventory Design

The inventory was designed in accordance with specifications contained within the Good Practice Guide for Preparing Air Emission Inventories (MfE, 2002). This recommends focusing on the main contaminants of concern and designing an inventory specifically to deal with the key air quality issues. The Blenheim inventory was therefore designed with a focus on emissions of $PM_{10}$, although emissions estimates have been made for other contaminants.

## 2.1 Selection of sources

The inventory includes estimates of emissions from domestic heating, outdoor burning, motor vehicles and industry. Aviation and marine emissions are not included because of the distance of the sources of these emissions to the urban area of Blenheim. Emissions from a number of other minor sources are discussed in the report. These include:

- lawn mowers
- orchard heaters (frost pots)
- dusts from farming activities
- railway emissions

## 2.2 Selection of contaminants

Contaminants included in the inventory are suspended particles ($PM_{10}$), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC), carbon dioxide ($CO_2$), fine particles ($PM_{2.5}$) and benzene. Sources were selected based on emissions of $PM_{10}$, however, so potentially significant sources of other contaminants e.g, VOCs from spraypainting are not included.

Emissions of $PM_{10}$, CO, SOx and NOx are included as these contaminants comprise class one air quality indicators as described by MfE (1994) because of their potential for adverse health impacts. Carbon dioxide is typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas $CO_2$ emissions. In its proposed ambient air quality guidelines (2000), the Ministry for the Environment includes a guideline for hazardous air pollutants including benzene, and a guideline for $PM_{2.5}$ will be considered within the next few years. Consequently both have been included in the emissions assessment.

Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. While not generally of concern in most southern areas of New Zealand, VOC emissions have been retained in the inventory to allow for assessments of photochemical pollution should future investigations into this source be considered necessary. If this does become a priority in future years, including additional sources of VOCs, such as spraypainting operations should be considered.

## 2.3 Selection of areas

Figure 2.1 shows land use in and around Blenheim, including the Wairau Plain as at October 2005. The urban areas of Blenheim are relatively compact with the majority of the surrounding land use to the west compromising vineyards. The Blenheim emission inventory area was selected based on the following census area units:

- Springlands
- Mayfield
- Blenheim Central
- Whitney
- Redwoodtown
- Witherlea

These were selected because they comprise the main urban area of Blenheim and because of the practicalities of using census area units for this type of assessment. The areas selected for the 2005 air emission inventory area correspond closely with the Blenheim "airshed" gazetted as a requirement under the NES for air quality management purposes. Figure 5.1 (industry section) shows the CAU boundaries and the Blenheim "airshed" areas.

## 2.4 Temporal distribution

Daily data were collected based on average and worst-case wintertime emissions. Data were also collected by month of the year to provide an estimate of the relative contributions of different sources to annual average $PM_{10}$ concentrations. No differentiation was made for weekday and weekend emissions, as variances are likely to be minimal for most sources. One exception is outdoor rubbish burning which may occur with greater frequency during the weekend.

No time of day breakdown was obtained for these data. However, methods are available for allocating emissions data by time of day should this be required.

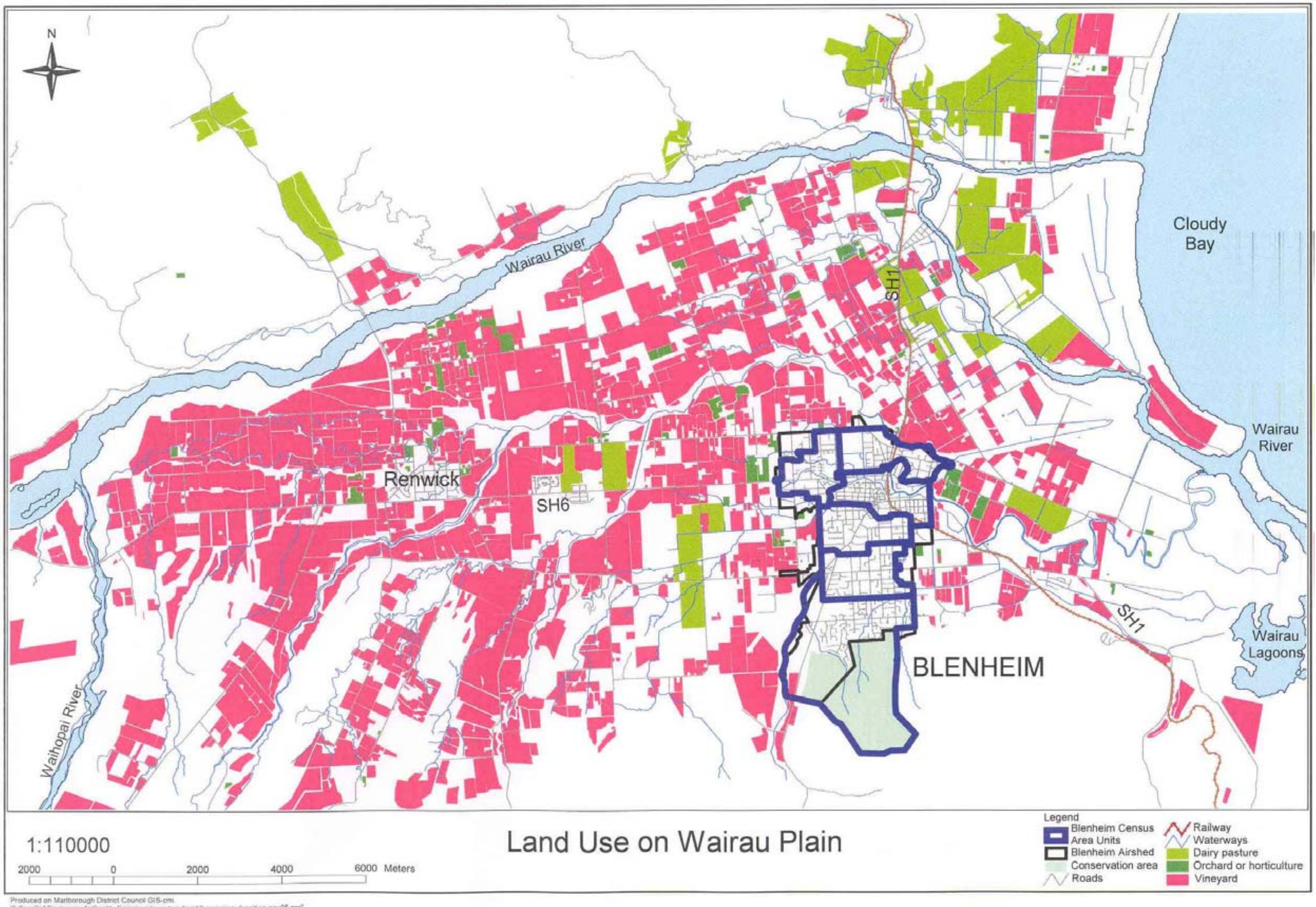


Figure 2.1: Land use on the Wairau Plain as October 2005 (map provided Carol Mills, MDC)

# 3 Domestic Heating

## 3.1 Methodology

The methodology for collecting information for the domestic heating component of the inventory was a telephone survey of 150 households in Blenheim. This was carried out during 2005 and was consistent with the methodology recommended in the Good Practice Guide for Preparing Emission Inventories (MfE, 2003). The survey was carried out by Digipol for the Ministry for the Environment as a part of its “warm homes” project. The survey questionnaire is detailed in Appendix A.

The results of the domestic home heating survey were analysed for heating methods and fuel use. Emission factors were then applied to these data to provide an estimate of emissions. Summary data for the 2005 survey and study area is shown in Table 3.1. The number of households for 2005 are based on census data for 2001 which indicates 8451 households in the study area, scaled up based on population projections of 13% for the Marlborough Region.

Table 3.1: Home heating survey area and sample details

| | Households | Sample size | Area (ha) | Sample error |
|---|---|---|---|---|
| Blenheim | 8671 | 152 | 1853 | 7.9% |

Home heating methods were classified as electricity, open fires, pre-1995 wood burners, 1995-1999 wood burners, post 2000 wood burners, pellet burners, multi fuel burners, gas burners and oil burners. Multi fuel burners refer to burners that are designed to burn coal as well as or instead of wood and include potbelly stoves, incinerators and coal ranges as well as more modern multi fuel burners.

Emission factors for domestic home heating have been developed based on emission testing of appliances under simulated operating conditions and have been used widely throughout New Zealand. More recently testing has been undertaking based on “in situ” monitoring of emissions from wood burners. For wood burners, emission factors are higher on average for older burners. The emission factors used for the 2005 Blenheim domestic heating emission inventory are shown in Table 3.2. Further details on the derivation of these factors is given in Appendix B.

Table 3.2: Emission factors for domestic heating

| | $PM_{10}$ g/kg | CO g/kg | NOx g/kg | $SO_2$ g/kg | VOC g/kg | $CO_2$ g/kg | Benzene g/kg | $PM_{2.5}$ g/kg |
|---|---|---|---|---|---|---|---|---|
| **Open fire - wood** | 10 | 100 | 1.6 | 0.2 | 30 | 1600 | 0.97 | 10 |
| **Open fire - coal** | 21 | 80 | 4 | 5.0 | 15 | 2600 | 0.00065 | 21 |
| **Pre-1995 wood burner** | 11 | 110 | 0.5 | 0.2 | 39 | 1600 | 0.97 | 11 |
| **1995-1999 wood burner** | 7 | 70 | 0.5 | 0.2 | 24 | 1800 | 0.97 | 7 |
| **Post 2000 wood burner** | 6 | 60 | 0.5 | 0.2 | 19.5 | 1800 | 0.97 | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Multi fuel[1] - wood** | 13 | 130 | 0.5 | 0.2 | 39 | 1600 | 0.97 | 13 |
| **Multi fuel[1]- coal** | 28 | 120 | 1.2 | 3.0 | 15 | 2600 | <0.001 | 28 |
| **Oil** | 0.3 | 0.6 | 2.2 | 3.8 | 0.25 | 3200 | <0.001 | 0.219 |
| **Gas** | 0.03 | 0.18 | 1.3 | <0.001 | | 2500 | 0.002 | 0.03 |

*[1] - includes potbelly, incinerator, coal range and any enclosed burner that is used to burn coal*

Emissions for each contaminant and season were calculated based on the following equation:

Equation 3.1 **CE (g/day) = EF (g/kg) x FB (kg/day)**

Where:

CE = contaminant emission

EF = emission factor

FB = fuel burnt

The estimate of the amount of fuel burnt per day per appliance type was derived from responses to the domestic home heating survey. In the case of wood, householders were queried as to the number of logs used on their fires per day on average during the winter, and for those that burnt during non-winter months, the average for those months. These data were used to estimate average daily fuel use for Blenheim. If households were unable to estimate their average daily fuel consumption, the average fuel consumption for that appliance and fuel type across other respondents was used.

Emissions were calculated based on two scenarios. Firstly, emissions from an average winter's day were estimated based on the daily fuel use, adjusted based on the average number of days per week each household used their heating method. The second scenario was to estimate the worst-case winter's day emissions. This estimate was based on the assumption that all households that used solid fuel for home heating were using it on a given day. The amount of fuel burnt on this day was based on the household's estimated average fuel consumption per day during the winter.

Daily emissions were also calculated for each month of the year to give an indication of the annual profile of $PM_{10}$ emissions. These data were based on the average fuel use allowing for households not using particular heating methods on some nights during the week.

The main assumptions underlying the emissions calculations are as follows:

- The average weight of a log of wood is 1.9 kg. This weight was based on a survey carried out in Christchurch during 2002 (Lamb, 2003).
- The average weight of a bucket of coal is 9 kg.

There are uncertainties in both the estimates of fuel use and the emission factors used to estimate emissions from solid fuel burning. Fuel use uncertainties include the ability of householders to accurately estimate their daily fuel consumption, the conversion of pieces of wood to kilograms of fuel and in the case of small subgroups of appliance types, for example open fires, the applicability of the average fuel use of the small number of respondents in the sample size to the rest of the population of that burner category.

It is likely that some houses will overestimate average daily fuel consumption and some will underestimate consumption. For the larger appliance categories (e.g., wood and multi fuel burners) these are likely to balance out. There is a much higher degree of uncertainty for the smaller appliance categories such as open fires and pellet burners. While comparisons of average fuel use for different appliance types for other locations may give some indication of the general ballpark for these categories, differences in climate and other factors such as lifestyle make comparisons difficult. For example, variations in demographics can impact on the proportion of households that heat homes during the daytime, which in turn impacts on the daily fuel consumption.

The uncertainty surrounding emission factors for domestic home heating is also high. Emission factors used are based on a combination of results of laboratory simulations of real life operation and “in situ” measurements where burners were operated by householders (e.g., Scott et. al., 2005). Emission factors used in this report are based on current best available information.

## 3.2 Home heating methods

The main methods of home heating in Blenheim during 2005 were electricity (61%) and wood burners (52%) (Table 3.3). Around 14% of households used gas for heating with the majority using unflued gas systems. Open fires, multi fuel burners, and pellet burners were the least common methods with 5%, 7% and 1% of households using these methods respectively. Note, many households rely on more than one method of heating their main living area during the winter months.

About 95 tonnes of wood is burnt on a typical average-case winter’s night in Blenheim as well as around 2 tonnes of coal. These fuel use estimates are based on the average appliance use, which allows for households not using their heating methods every night of the week during the winter. The estimate for wood use includes around 200 kilograms of wood pellets used on pellet style burners. The estimates of fuel use increase to 125 tonnes of wood and 4 tonnes of coal for the worst-case scenario, which assumes all households are using their solid fuel burning heating method on a given night.

It is important to note that there is a high degree of uncertainty for categories with only a small number of respondents, particularly with respect to fuel use. In particular, fuel use on pellet style burners is dependent on averages across a small number of respondents. The impact of this uncertainty in terms of emission estimates is small however, because of the small number of households using these heating methods.

Table 3.3: Home heating methods and fuels in Blenheim

| | Households | | Winter Fuel Use (July) average case | |
|---|---|---|---|---|
| | % | Number | t/day | % |
| **Electricity** | 61% | 5,248 | | |
| **Total Gas** | 14% | 1,255 | 0.38 | 0% |
| **Flued gas** | 0% | - | | |
| **Unflued gas** | 14% | 1,255 | | |
| **Oil** | 0% | - | | |
| **Open fire** | 5% | 456 | | |
| **Open fire - wood** | 4% | 342 | 10 | 10% |
| **Open fire – coal** | 1% | 57 | 1 | 1% |
| **Total wood burner** | 52% | 4,507 | 76 | 77% |
| **Pre-1995 wood burner** | 29% | 2,482 | 42 | 40% |
| **1995-1999 wood burner** | 12% | 1,045 | 18 | 25% |
| **Post 2000 wood burner** | 11% | 980 | 17 | 13% |
| **Multi fuel burners** | 7% | 570 | | 0% |
| **Multi fuel burners-wood** | 7% | 570 | 9 | 10% |
| **Multi fuel burners-coal** | 3% | 285 | 2 | 2% |
| **Pellet burners** | 1% | 57 | 0.2 | 0% |
| | | | | |
| **Total wood** | 63% | 5,419 | 95 | 97% |
| **Total coal** | 4% | 342 | 2 | 3% |
| | | | | |
| **Total** | | 8,671 | 98 | |

## 3.3 Emissions from domestic heating

Daily wintertime $PM_{10}$ emissions from domestic home heating in Blenheim are estimated at just less than one tonne based on an average use or 1.28 tonnes if all households used their solid fuel heating methods on any given night (Tables 3.4 and 3.5).

Although estimates are made based on average case and worst case scenarios unless specified, results, including graphs are reported based on the average case scenario. The inventory also indicates:

- The majority (97%) of the $PM_{10}$ is in the finer $PM_{2.5}$ size fraction, which is the size fraction likely to have the greatest impact on health.
- About 93% of the $PM_{10}$ emissions come from the burning of wood with 7% from the burning of coal.
- The greatest amount of $PM_{10}$ from domestic heating comes from older wood burners (47%). Multi fuel burners and open fires contribute 19% and 11% respectively (Figure 3.1).

Monthly variations in appliance use and average days per week used are shown in Figures 3.2 and 3.3. Most households do not heat their main living areas during the summer months in Blenheim. Table 3.6 shows seasonal variations in contaminant emissions.

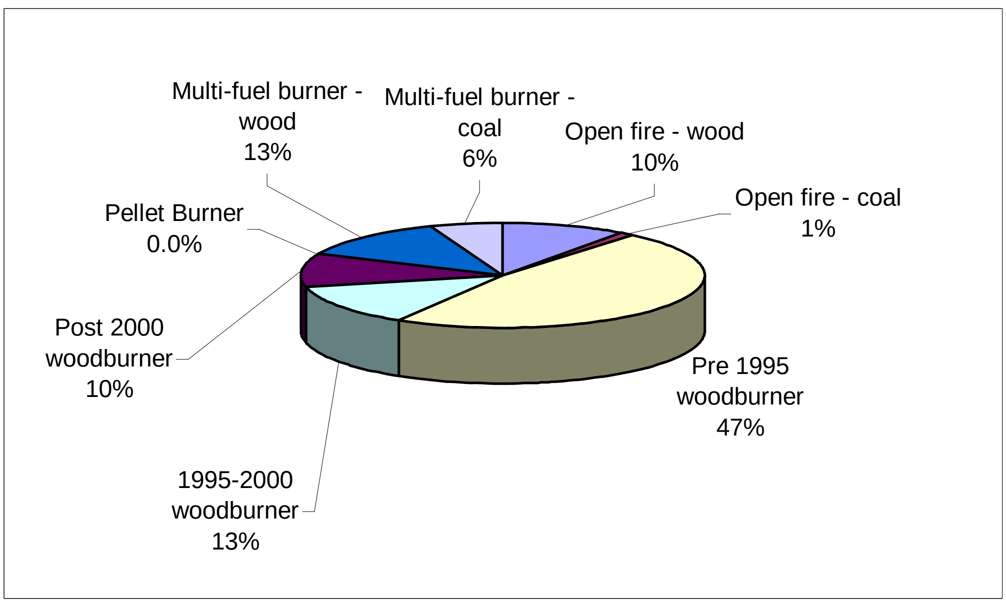


Figure 3.1: Relative contribution of different heating methods to $PM_{10}$ from domestic heating in Blenheim

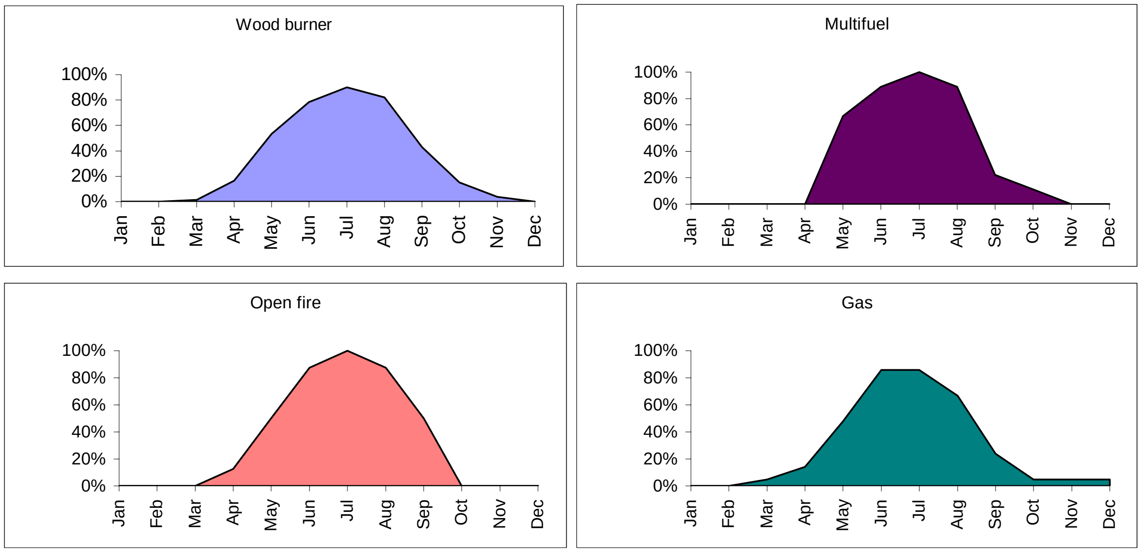


Figure 3.2: Monthly variations in appliance use in Blenheim

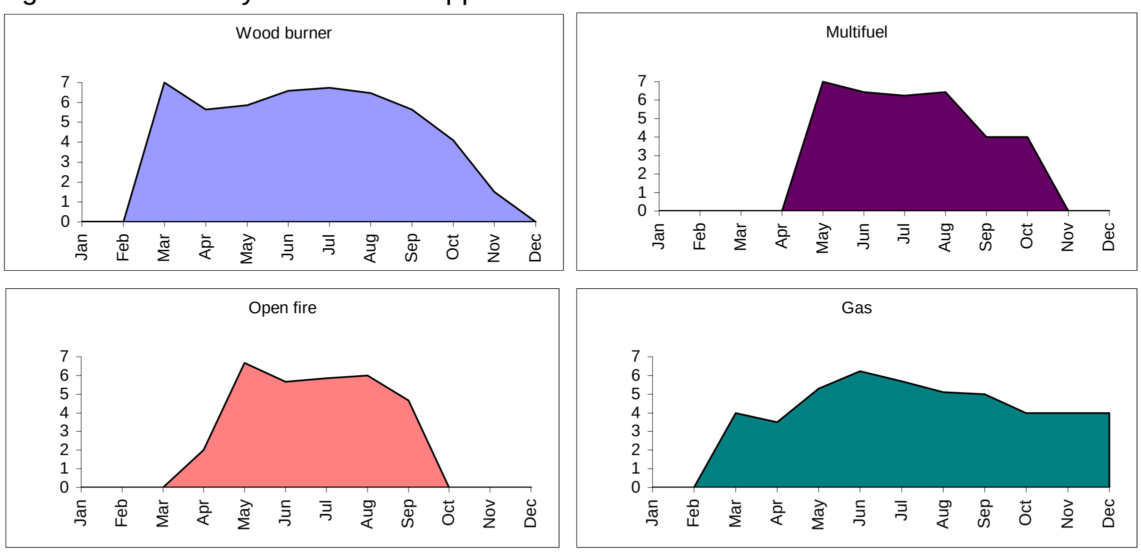


Figure 3.3: Average number of days per week appliances are used in Blenheim per month

Table 3.4: Blenheim average-case winter domestic heating emissions by appliance type

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | | Benzene | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **t/day** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **t** | **kg/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** |
| **Open fire** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Open fire - wood** | 9.8 | 10% | 98 | 53 | 10% | 975 | 526 | 10% | 16 | 8 | 25% | 2 | 1 | 7% | 293 | 158 | 11% | 16 | 8 | 10% | 98 | 53 | 10% | 9 | 5 | 10% |
| **Open fire - coal** | 0.5 | 1% | 11 | 6 | 1% | 41 | 22 | 0% | 2 | 1 | 3% | 3 | 1 | 9% | 8 | 4 | 0% | 1 | 1 | 1% | 6 | 3 | 1% | 0 | 0 | 0% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1990 wood burner** | 41.9 | 43% | 461 | 249 | 47% | 4612 | 2489 | 49% | 21 | 11 | 33% | 8 | 5 | 30% | 1384 | 747 | 50% | 67 | 36 | 42% | 461 | 249 | 49% | 41 | 22 | 44% |
| **1991-1995 wood burner** | 17.7 | 18% | 124 | 67 | 13% | 1236 | 667 | 13% | 9 | 5 | 14% | 4 | 2 | 13% | 371 | 200 | 13% | 28 | 15 | 18% | 124 | 67 | 13% | 17 | 9 | 18% |
| **1996-2000 wood burner** | 16.6 | 17% | 99 | 54 | 10% | 993 | 536 | 11% | 8 | 4 | 13% | 3 | 2 | 12% | 298 | 161 | 11% | 26 | 14 | 17% | 99 | 54 | 11% | 16 | 9 | 17% |
| **Pellet Burner** | 0.2 | 0% | 0 | 0 | 0% | 4 | 2 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 9.5 | 10% | 123 | 66 | 13% | 1231 | 664 | 13% | 5 | 3 | 7% | 2 | 1 | 7% | 369 | 199 | 13% | 15 | 8 | 9% | 123 | 66 | 13% | 9 | 5 | 10% |
| **Multi fuel burner – coal** | 2.0 | 2% | 55 | 30 | 6% | 238 | 128 | 3% | 2 | 1 | 4% | 6 | 3 | 22% | 30 | 16 | 1% | 5 | 3 | 3% | 32 | 17 | 3% | 0 | 0 | 0% |
| **Gas** | 0.4 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 1% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Oil** | 0.0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 95.5 | 97% | 905 | 488 | 93% | 9052 | 4885 | 97% | 59 | 32 | 92% | 19 | 10 | 69% | 2716 | 1465 | 99% | 153 | 83 | 95% | 905 | 488 | 96% | 93 | 50 | 100% |
| **Total Coal** | 2.5 | 3% | 66 | 36 | 7% | 279 | 150 | 3% | 4 | 2 | 7% | 9 | 5 | 31% | 37 | 20 | 1% | 6 | 3 | 4% | 38 | 20 | 4% | 0 | 0 | 0% |
| **Total** | 98 | | 971 | 524 | | 9331 | 5035 | | 63 | 34 | | 28 | 15 | | 2753 | 1486 | | 160 | 87 | | 943 | 509 | | 93 | 50 | |

Table 3.5: Blenheim worst case winter domestic heating emissions by appliance type

| | Fuel Use | | $PM_{10}$ | | | CO | | | $NO_x$ | | | $SO_x$ | | | VOC | | | $CO_2$ | | | $PM_{2.5}$ | | | Benzene | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **t/day** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** | **t** | **kg/ha** | **%** | **kg** | **g/ha** | **%** | **kg** | **g/ha** | **%** |
| **Open fire** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Open fire - wood** | 9.8 | 8% | 98 | 53 | 8% | 975 | 526 | 8% | 16 | 8 | 20% | 2 | 1 | 5% | 293 | 158 | 8% | 16 | 8 | 7% | 98 | 53 | 8% | 9 | 5 | 8% |
| **Open fire - coal** | 0.5 | 0% | 11 | 6 | 1% | 41 | 22 | 0% | 2 | 1 | 3% | 3 | 1 | 7% | 8 | 4 | 0% | 1 | 1 | 1% | 6 | 3 | 0% | 0 | 0 | 0% |
| **Wood burner** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre 1990 wood burner** | 56.9 | 44% | 626 | 338 | 49% | 6256 | 3376 | 51% | 28 | 15 | 36% | 11 | 6 | 31% | 1877 | 1013 | 52% | 91 | 49 | 43% | 626 | 338 | 51% | 55 | 30 | 46% |
| **1991-1995 wood burner** | 23.9 | 19% | 168 | 90 | 13% | 1676 | 905 | 14% | 12 | 6 | 15% | 5 | 3 | 13% | 503 | 271 | 14% | 38 | 21 | 18% | 168 | 90 | 14% | 23 | 13 | 19% |
| **1996-2000 wood burner** | 22.5 | 17% | 135 | 73 | 11% | 1347 | 727 | 11% | 11 | 6 | 14% | 4 | 2 | 12% | 404 | 218 | 11% | 36 | 19 | 17% | 135 | 73 | 11% | 22 | 12 | 18% |
| **Pellet Burner** | 0.2 | 0% | 0 | 0 | 0% | 4 | 2 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 1 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Multi fuel burner** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Multi fuel burner – wood** | 11.7 | 9% | 153 | 82 | 12% | 1526 | 824 | 13% | 6 | 3 | 7% | 2 | 1 | 6% | 458 | 247 | 13% | 19 | 10 | 9% | 153 | 82 | 12% | 11 | 6 | 9% |
| **Multi fuel burner – coal** | 3.1 | 2% | 86 | 47 | 7% | 370 | 199 | 3% | 4 | 2 | 5% | 9 | 5 | 25% | 46 | 25 | 1% | 8 | 4 | 4% | 49 | 27 | 4% | 0 | 0 | 0% |
| **Gas** | 0.6 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 1 | 0 | 1% | 0 | 0 | 0% | 0 | 0 | 0% | 2 | 1 | 1% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Oil** | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% |
| **Total Wood** | 125 | 97% | 1179 | 636 | 92% | 11786 | 6360 | 97% | 73 | 40 | 92% | 25 | 13 | 68% | 3536 | 1908 | 98% | 200 | 108 | 95% | 1179 | 636 | 96% | 121 | 65 | 100 % |
| **Total Coal** | 4 | 3% | 97 | 52 | 8% | 411 | 222 | 3% | 6 | 3 | 7% | 12 | 6 | 32% | 54 | 29 | 2% | 9 | 5 | 4% | 55 | 30 | 4% | 0 | 0 | 0% |
| **Total** | 129 | | 1276 | 688 | | 12196 | 6582 | | 80 | 43 | | 37 | 20 | | 3590 | 1937 | | 211 | 114 | | 1234 | 666 | | 121 | 65 | |

Table 3.6: Monthly variations in contaminant emissions in Blenheim

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC kg/ day | $CO_2$ t/ day | $PM_{2.5}$ kg/ day | Benzene kg/ day |
|---|---|---|---|---|---|---|---|---|
| January | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| April | 36 | 364 | 2 | 1 | 109 | 6 | 36 | 4 |
| May | 291 | 2745 | 16 | 9 | 802 | 46 | 279 | 26 |
| June | 625 | 5976 | 38 | 19 | 1760 | 104 | 605 | 60 |
| July | 971 | 9331 | 63 | 28 | 2753 | 160 | 943 | 93 |
| August | 829 | 7954 | 54 | 24 | 2345 | 137 | 804 | 79 |
| September | 436 | 4364 | 24 | 10 | 1309 | 76 | 436 | 46 |
| October | 121 | 1214 | 7 | 3 | 364 | 21 | 121 | 13 |
| November | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| December | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (kg/year) | 101549 | 979636 | 6275 | 2808 | 289533 | 16893 | 98884 | 9819 |

# 4 Motor Vehicles

## 4.1 Methodology

Motor vehicle emissions' assessments for inventory purposes typically involve collecting data on vehicle kilometres travelled (VKT) per day under different levels of congestion, and the application of emission factors to these data. Estimates of VKTs have been made in a number of urban centres of New Zealand using local road network models. As no such model exists for Blenheim (and they are extremely resource intensive to develop), estimates of VKTs for the inventory were based on the ratio of VKTs to households for other urban areas of New Zealand (Table 4.1).

Estimates of emissions were made for the lower end of the range (33 VKT per household) and the higher end of the range (68 VKT per household). This gave VKT estimates for Blenheim of 286,000 (lower range) and 590,000 (upper range). It is likely that VKT estimates nearer the higher range are more appropriate for Blenheim given the presence of State Highway 1, which passes near to the town centre.

Table 4.1: Ratios of daily VKT to households for urban areas in New Zealand

| | VKT/ day | No. of households | VKT/HH /day |
|---|---|---|---|
| Nelson | 916,007 | 14340 | 64 |
| Hamilton | 2,463,143 | 40698 | 60 |
| Taupo | 446,258 | 6973 | 64 |
| Kaiapoi | 215,509 | 3188 | 68 |
| Timaru - excluding Washdyke | 348,742 | 10696 | 33 |
| Christchurch | 4,764,837 | 100470 | 47 |
| Napier | 878,629 | 19521 | 45 |
| Havelock North | 142,046 | 3927 | 36 |
| Hastings | 472,747 | 10746 | 44 |
| Flaxmere | 88,816 | 2733 | 33 |

The emission factors used to estimate motor vehicle emissions for $PM_{10}$, CO, NOx and VOC were taken from the New Zealand Traffic Emission Rates (NZTER) database based on a vehicle fleet profile derived from motor vehicle registrations for Marlborough District for the year ending December 2004 (Table 4.2). The NZTER database was developed by the Ministry of Transport (MOT) based on measured emissions rates from actual vehicle emissions tests on New Zealand vehicles under various road/traffic conditions. Emission rates for SOx and $CO_2$ are not included in the NZTER database and were selected based on emission rates derived by the Fuel and Energy Group for the national vehicle fleet profile. Estimates made for these latter contaminants should be considered indicative only.

Benzene emission factors were derived based on a weight fraction of motor vehicle VOC emissions from the Australian National Pollutant Inventory. These were 6.58% for petrol vehicles, 1.01% for diesel vehicles and 0.943% for LPG vehicles. These data were apportioned using the Marlborough District vehicle fleet profile. Because of differences in the composition of New Zealand and Australian petrol, these data should be treated as rough estimates that provide an indication of order of magnitude only.

The emission factors for $PM_{2.5}$ were based on estimates of $PM_{10}$ emissions using data from the British Colombia Lower Fraser Valley adjusted for the Marlborough District vehicle fleet profile. This indicated that around 55% of the $PM_{10}$ tailpipe emissions would be in the $PM_{2.5}$ size fraction in the Blenheim area. In addition to tailpipe emissions, $PM_{10}$ from the wearing of brakes and tyres were also included in the emissions assessments. Emission factors for $PM_{10}$ and $PM_{2.5}$ from these sources were also derived from the British Colombia Lower Fraser Valley data adjusted for the Marlborough District vehicle fleet profiles. However, the extent to which these conversions based on overseas data are applicable to New Zealand vehicle emissions is uncertain. Consequently emission estimates for $PM_{2.5}$ from motor vehicles and $PM_{10}$ from the wearing of tyre and brakes should be treated with caution.

Table 4.2: Vehicle registrations for the Marlborough District for the year ending 31 December 2004

| | **Petrol** | **Diesel** | **LPG** | **Other** | **Total** |
|---|---|---|---|---|---|
| Cars | 22,587 | 3,311 | 4 | 2 | 25,904 |
| LCV | 2,132 | 3,493 | 4 | 1 | 5,630 |
| Bus | 36 | 151 | 1 | | 188 |
| Heavy truck | | 1164 | | | 1,164 |
| Miscellaneous | 310 | 439 | | | 749 |
| Motorcycle | 786 | | | | 786 |
| Total | 25,851 | 8,558 | 9 | 3 | 34,421 |
| **Total percentage** | 75.1% | 24.9% | 0.0% | 0.0% | |

Emissions from motor vehicles increase significantly when traffic is congested. Thus different emission rates are used for kilometres travelled when traffic is congested or semi congested. The three different levels of congestion/ driving conditions typically used in emission inventory studies are free flow conditions, interrupted flow conditions and congested flow conditions. A fourth category representing emissions under cold running conditions is also included. Because of the relative free flowing nature of vehicle movements in Blenheim all VKTs were treated as free flowing.

The emission factors for each contaminant are shown in Table 4.3. These are based on the assumption that 30% of the VKTs occur under cold start conditions.

Table 4.3: Emission factors for Blenheim based on a suburban driving regime and free flow conditions

| | **CO g/VKT** | **$CO_2$ g/VKT** | **VOC g/VKT** | **NOx g/VKT** | **SOx g/VKT** | **$PM_{10}$ g/VKT** | **$PM_{2.5}$ g/VKT** | **Benzene g/VKT** |
|---|---|---|---|---|---|---|---|---|
| Free flow conditions | 10.19 | 365 | 1.65 | 1.59 | 0.215 | 0.12 | 0.066 | 0.086 |

Emissions for each time period were calculated by multiplying the appropriate average emission factor by the VKT for that time period and level of service.

$$\text{Emissions (g)} = \text{Emission Rate (g/km)} \times \text{VKT}$$

Separate estimates of emissions were made for $PM_{10}$ and $PM_{2.5}$ from brake and tyre wear.

An alternative methodology based on estimates made for the National Pollution Inventory (NPI) was considered for this inventory assessment. However, a comparison of the VKT estimates from that model to the road network model approach showed significant differences with the NPI method estimating $PM_{10}$ concentrations more than five times higher than methods based on road network modelling. It is uncertain whether the differences relate to the method of distributing the Regional VKTs used in the NPI to the different CAUs or whether the NPI represents an overestimate of total VKTs or the road network modelling represents an underestimate. The NPI estimates of VKTs were based on traffic counts at 31 sites on average per local authority area. These data were statistically extrapolated for other roads in the local authority area. In the absence of a more detailed study comparing the relative methodologies it is assumed that the road network modelling approach represents a more accurate estimate of VKTs.

## 4.2 Motor vehicle emissions

Based on daily VKTs (lower limit) of around 286,000, motor vehicles in Blenheim would emit about 39 kg of $PM_{10}$ per day (24-hour period). This compares to around 81 kg per day if the upper limit of 590,000 VKT per day is used. Results shown in subsequent figures and tables are based on the upper limit estimate of 590,000 VKT per day.

The breakdown of motor vehicle emissions by tailpipe and the wearing of brakes and tyres is shown in Figure 4.1. Based on overseas emission data adjusted for the Marlborough vehicle fleet, approximately 55% of the tailpipe and 34% of the brake and tyre wear $PM_{10}$ emissions are in the finer $PM_{2.5}$ size fraction. If these data are applicable to motor vehicle emissions in Blenheim, about 67% of the $PM_{10}$ emissions from motor vehicles are likely to be in the finer $PM_{2.5}$ size fraction.

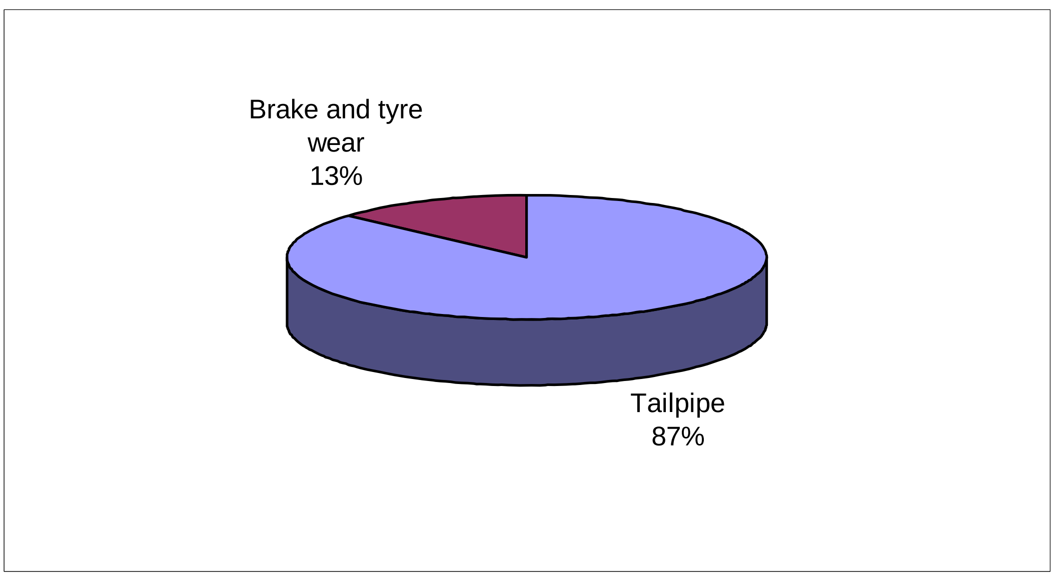


Figure 4.1: Breakdown of $PM_{10}$ emissions from motor vehicles

Emissions of other contaminants from motor vehicles in Blenheim include around 6 tonnes of CO, 0.9 tonnes of NOx and 51 kg of benzene per day. In comparison, in Christchurch, where CO concentrations exceed ambient air quality guidelines at least once during most winters, motor vehicles emit over 100 tonnes of CO within the main urban area.

Table 4.6 shows emissions from motor vehicles in Blenheim by weight and in terms of grams per hectare.

Table 4.6: Summary of motor vehicle emissions in Blenheim (worst-case VKTs)

| | | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|---|
| | **Hectares** | **kg** | **g/ha** | **kg** | **g/ha** | **kg** | **g/ha** | **kg** | **g/ha** |
| **Blenheim** | 1853 | 81 | 44 | 6009 | 3243 | 936 | 505 | 127 | 69 |
| | | **VOC** | | $CO_2$ | | **Benzene** | | $PM_{2.5}$ | |
| | **Hectares** | **kg** | **g/ha** | **t** | **kg/ha** | **kg** | **g/ha** | **kg** | **g/ha** |
| **Blenheim** | 1853 | 975 | 526 | 215 | 116 | 51 | 27 | 54 | 29 |

# 5 Industrial and Commercial

## 5.1 Methodology

There are a number of relatively small-scale industrial and commercial activities that discharge contaminants to air in Blenheim. In Blenheim even smaller combustion activities burning wood or coal, including educational institutes are included in the Marlborough District Council consents database. This database was used to identify industrial activities included in the inventory (Figure 5.1). Around 20 industrial or commercial activities in the urban area of Blenheim were included in the emission inventory assessment. Figure 5.1 shows the locations of activities holding resource consents for discharges to air for $PM_{10}$ related activities in Blenheim.

The selection of industries for inclusion in the inventory was based on potential for $PM_{10}$ emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge only volatile gases (VOC) were not included in the assessment. The assessment is therefore not comprehensive with regard to estimates of VOCs and additional studies should be undertaken if this contaminant and source is considered to be of concern in the future.

The majority of industrial and commercial activities discharging to air with significant $PM_{10}$ discharges in Blenheim are combustion processes. The activity data required to be collected to estimate emissions for combustion processes is the type and quantity of fuel burnt. Estimates of emissions are made from these data by applying emission rates as show in Equation 5.1.

Equation 5.1 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

The methodology recommended in the Good Practice Guide for Preparing Emission Inventories (MfE, 2002) gives preference to the use of emission test data for industry where this is available. Emission test data were available for relatively few industrial discharges in Blenheim. In the absence of site-specific test data, average emissions factors were used to estimate the quantity of emissions discharged from combustion processes (Table 5.1). The coal fired boiler emission factors for $PM_{10}$ are based on coal research limited emission factors. Emission factors for $PM_{2.5}$ are based on USEPA AP42 particle size distribution factors, as are emission factors for $PM_{10}$ from wood fired boilers and diesels and CO, NOx, SOx and benzene factors for all sources. The VOC and $CO_2$ emission factors are based on factors derived by NIWA for the Christchurch 1996 emission inventory. Emission factors are much lower than for domestic home heating because of the higher temperatures of combustion and increased efficiency of industrial boilers.

Emission factors for non-combustion activities included in the inventory were based on the USEPA AP-42 emission rates.

Table 5.1: Emission factors for industrial discharges (combustion processes)

| | $PM_{10}$ g/kg | $PM_{2.5}$ g/kg | CO g/kg | Nox g/kg | $SO_2$ g/kg | VOC g/kg | $CO_2$ g/kg | Benzene g/kg |
|---|---|---|---|---|---|---|---|---|
| Coal boiler (chaingrate) | 1.8 | 0.7 | 3.0 | 3.8 | 18.0 | 0.1 | 2400 | 0.00065 |
| Coal boiler (lowram) | 3.1 | 1.9 | 5.5 | 4.8 | 13.5 | 0.1 | 2400 | 0.00065 |
| Diesel boiler | 0.47 | 0.11 | 0.67 | 3.24 | 10.5 | 0.2 | 3194 | 0.022 |
| LPG boiler | 0.06 | 0.06 | 0.71 | 2.6 | 0.01 | 0.1 | 2885 | |
| Wood fired boiler | 3.2 | 2.7 | 6.8 | 0.8 | 0.0 | 0.1 | 1069 | 0.97 |

## 5.2 Industrial and commercial emissions

Around 21 kilograms of $PM_{10}$ are estimated to be discharged per day during the winter in Blenheim as a result of emissions from industrial and commercial activities, including educational institutions. The main sources are relatively small-scale coal burners used for heating in small industries, the hospital and local schools.

Daily wintertime emissions of $PM_{10}$ and other contaminants from industrial and commercial activities in Blenheim are shown in Table 5.2. Daily emissions during other months of the year are shown in Table 5.3, as is the estimate of annual emissions from industry.

Table 5.2: Summary of daily (winter) industrial/ commercial emissions

| | $PM_{10}$ | | CO | | NOx | | SOx | |
|---|---|---|---|---|---|---|---|---|
| Hectares | kg/day | g/ha | kg/day | g/ha | kg/day | g/ha | kg/day | g/ha |
| 1853 | 21 | 12 | 18 | 10 | 20 | 11 | 72 | 39 |
| | VOC | | $CO_2$ | | Benzene | | $PM_{2.5}$ | |
| Hectares | kg/day | g/ha | kg/day | g/ha | kg/day | g/ha | kg/day | g/ha |
| 1853 | 0.4 | 0.2 | 13 | 7 | 0.0 | 0.0 | 13 | 7 |

Table 5.3: Seasonal variations in industrial emissions

| | $PM_{10}$ kg/ day | CO kg/ day | NOx kg/ day | SOx kg/ day | VOC kg/ day | $CO_2$ t/ day | $PM_{2.5}$ kg/ day | Benzene kg/ day |
|---|---|---|---|---|---|---|---|---|
| January | 30 | 11 | 13 | 52 | 0.2 | 8 | 30 | 0.00 |
| February | 30 | 11 | 13 | 52 | 0.2 | 8 | 30 | 0.00 |
| March | 33 | 12 | 14 | 54 | 0.3 | 9 | 33 | 0.01 |
| April | 33 | 12 | 14 | 54 | 0.3 | 9 | 33 | 0.01 |
| May | 33 | 12 | 14 | 54 | 0.3 | 9 | 33 | 0.01 |
| June | 21 | 18 | 20 | 72 | 0.4 | 13 | 13 | 0.02 |
| July | 21 | 18 | 20 | 72 | 0.4 | 13 | 13 | 0.02 |
| August | 21 | 18 | 20 | 72 | 0.4 | 13 | 13 | 0.02 |
| September | 33 | 11 | 13 | 53 | 0.4 | 8 | 32 | 0.01 |
| October | 33 | 11 | 13 | 53 | 0.4 | 8 | 32 | 0.01 |
| November | 33 | 11 | 13 | 53 | 0.4 | 8 | 32 | 0.01 |
| December | 30 | 11 | 13 | 52 | 0.2 | 8 | 30 | 0.00 |
| Total (kg/year) | 10674 | 4738 | 5476 | 21149 | 118 | 3439 | 9882 | 3 |

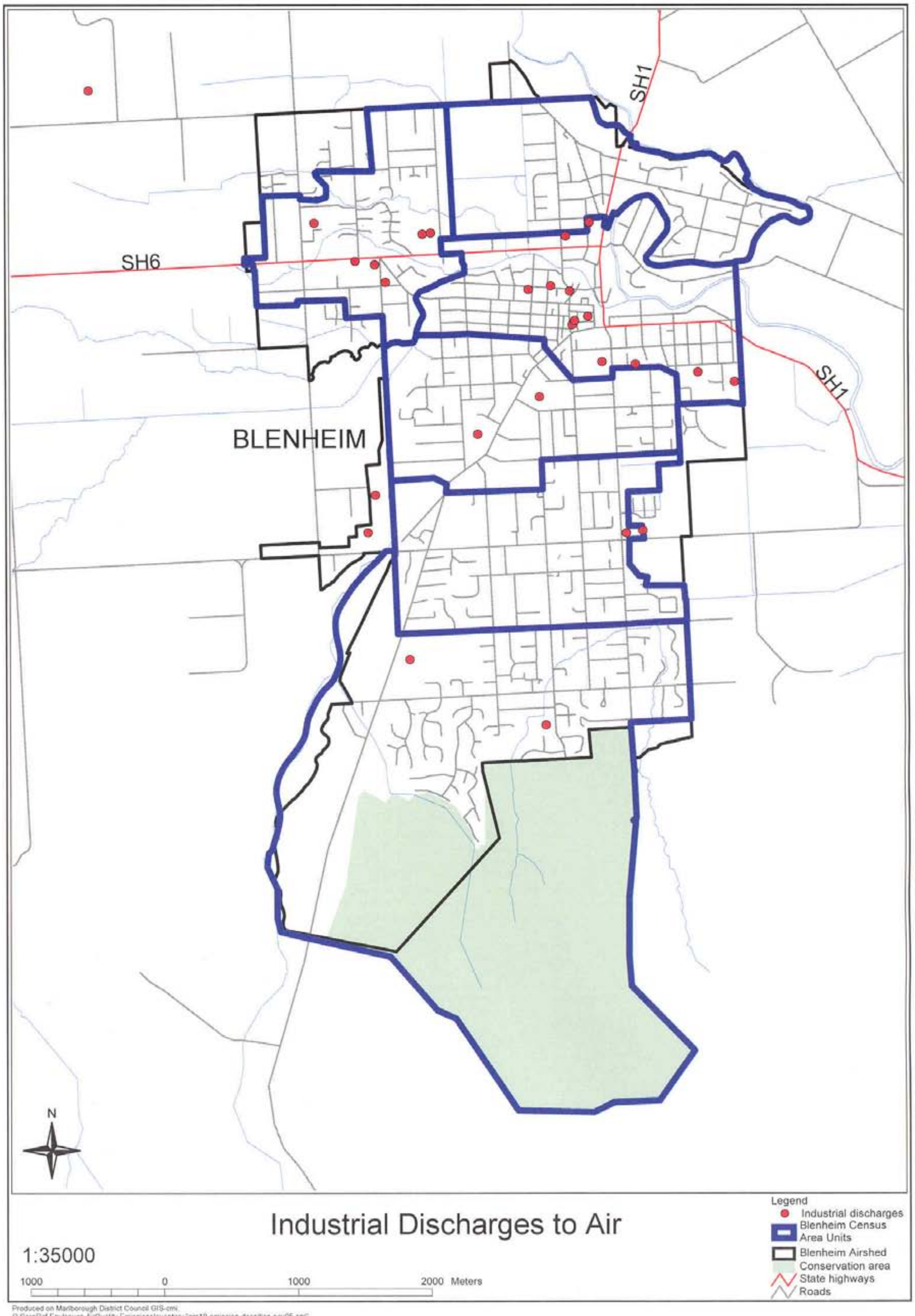


Figure 5.1: Locations of activities with resource consents for discharges to air in Blenheim

# 6 Outdoor burning

Outdoor burning includes any backyard burning of household or garden wastes in a drum, incinerator or open air. The frequency and extent of outdoor burning during the winter months have been estimated for a number of locations in New Zealand based on household surveys. Emissions from domestic outdoor burning for these areas have been estimated using the emission factors shown in Table 6.1. No question relating to outdoor rubbish burning was included in the MfE "warm homes" survey used for this inventory. Figure 6.1 shows the relationship between the estimated $PM_{10}$ emission rates (kilograms of $PM_{10}$ per household) and the size of the urban area, and indicates less outdoor burning in larger urban areas.

Table 6.1: Outdoor burning emission factors (source AP-42)

| | $PM_{2.5}$ g/kg | $PM_{10}$ g/kg | CO g/kg | NOx g/kg | SOx g/kg | VOC g/kg | $CO_2$ g/kg | Benzene g/kg |
|---|---|---|---|---|---|---|---|---|
| Garden rubbish | 8 | 8 | 42 | 3 | 0.5 | 4 | 1470 | 0.0 |
| Household rubbish | 17 | 19 | 42 | 3 | 0.5 | 4.278 | 1470 | 1.2 |

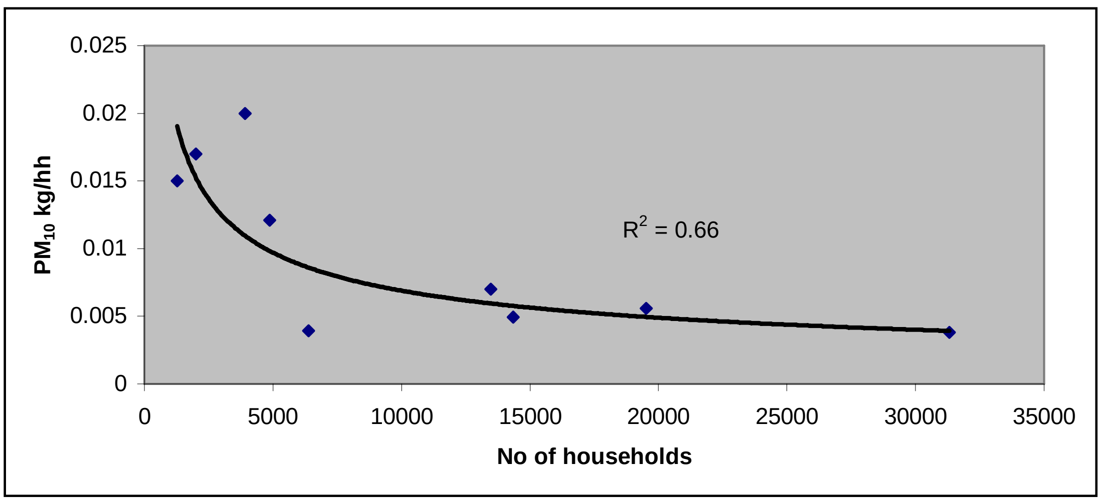


Figure 6.1: Relationship between number of households and $PM_{10}$ emissions from outdoor rubbish burning in urban areas of New Zealand

The relationship between the urban area's size and emission rates for other urban areas of New Zealand was used to estimate emissions from outdoor rubbish burning in Blenheim. Seasonal variations in emissions were estimated based on seasonal profiles established for other urban areas of New Zealand where season specific data for outdoor rubbish burning were available. Table 6.2 shows the estimated emissions from outdoor burning per day in Blenheim.

Table 6.2: Daily winter emissions from outdoor rubbish burning in Blenheim

| | $PM_{10}$ | CO | NOx | $SO_2$ | VOC | $CO_2$ | $PM_{2.5}$ | Benzene |
|---|---|---|---|---|---|---|---|---|
| | kg/day | kg/day | kg/day | kg/day | kg/day | t/day | kg/day | kg/day |
| Summer (Dec-Feb) | 72 | 241 | 17 | 3 | 25 | 8 | 67 | 3 |
| Autumn (Mar-May) | 57 | 193 | 14 | 2 | 20 | 7 | 54 | 2 |
| Winter (June-Aug) | 64 | 215 | 15 | 3 | 22 | 8 | 60 | 3 |
| Spring (Sept-Nov) | 71 | 239 | 17 | 3 | 24 | 8 | 67 | 3 |

# 7 Other sources of emissions

The main sources of $PM_{10}$ emissions in urban areas of New Zealand are typically domestic home heating, outdoor burning, industry and motor vehicles. Under some conditions, e.g., elevated wind speeds, emissions from other sources such as sea spray may also be a significant source of $PM_{10}$ measurements. This source isn't typically included in emission inventories because of difficulties in quantifying emissions. Source apportionment studies for Christchurch and Masterton indicate around 6-8% of $PM_{10}$ concentrations in these areas may come from sea spray (Scott, 2005; Davy, 2005).

Other sources not included in the Blenheim inventory are aircraft and marine/ shipping emissions. The Blenheim airport and nearest Port are both located well outside of the Blenheim urban area and are unlikely to contribute to $PM_{10}$ emissions in the urban area. Other sources of emissions not included in the inventory include vegetation, which can emit VOC and NOx. Neither of these contaminants is likely to be an air quality concern in Blenheim and vegetation is unlikely to be a significant source in these predominantly urban areas.

Emissions of $PM_{10}$ from wind blown dusts from the erosion of soils and from the tilling of land are also potential contributors. Although unlikely within the urban areas and with the typical surrounding land use being vineyards, some contribution from the more rural areas surrounding Blenheim is possible. Limited emission data available for tilling suggests around 1.26 kg $PM_{10}$ and 0.6 kg $PM_{2.5}$ is produced per hectare tilled (GVRD, 1998). Thus if 10 hectares were being tilled on the outskirts of urban Blenheim, emissions might be in the order of 12 kilograms of $PM_{10}$ and 6 kg of $PM_{2.5}$.

Emissions from outdoor rubbish burning or orchard and vineyard burning in rural areas and emissions from orchard heaters (frost pots) may also contribute to $PM_{10}$ concentrations in Blenheim. As the emissions from these sources occur outside of the study area, they are not included in the inventory.

It is estimated that around 66 kilograms of $PM_{10}$ per day could occur as a result of the burning of vineyard prunings in the Marlborough Region[2]. This is based on the assumption that burning occurs evenly over the autumn and winter months and that around 5% of vineyards in the Region burn prunings. In reality, burning is unlikely to be evenly spread across days during these months so total emissions may be many times this amount on a given day. It is therefore likely that emissions from vineyards on the outskirts of the urban areas of Blenheim do contribute to measured $PM_{10}$ concentrations in Blenheim, particularly when the wind is blowing from a westerly direction.

The use of orchard or vineyard heaters (e.g., return stack burners) may contribute to $PM_{10}$ emissions near to the urban areas of Blenheim during the spring months, when heaters are used to protect budding vines from frost damage. This is likely to occur only on around five days per year and could give rise to $PM_{10}$ emissions of around 0.1 kilograms per day. Consequently, even if this burning were carried out during the winter months, and all emissions culminated in the urban area of Blenheim the contribution to total $PM_{10}$ emissions would be minor (<1%).

A small amount of $PM_{10}$ from rail activities is likely for Blenheim as the South Island's main north line, which goes between Christchurch and Picton traverses the Blenheim urban

[2] Based on a prunings to yield ratio of 1:5 and an average yield of 10 tonnes per hectare

area. Estimates of annual $PM_{10}$ emissions were made for the main rail centres by the Ministry of Transport in 1999. These suggest around 0.5 tonnes per year or 0.14 kilograms per day of $PM_{10}$ for the Picton Rail Centre. The contribution to the urban area of Blenheim is therefore likely to be less than 0.14 kilograms of $PM_{10}$ per day.

Lawn mowers, leaf blowers and chainsaws can also contribute small amounts of particulate. These are not typically included in emission inventory studies owing to the relatively small contribution, particularly in areas where solid fuel burning is a common method of home heating. Based on data for other areas, $PM_{10}$ emissions from lawn mowing in Blenheim is likely to be much less than 10 kg per day.

# 8 Total Emissions

Domestic home heating is the main source of $PM_{10}$ concentrations in Blenheim during the winter months when guideline exceedences for this contaminant occur. The estimated amount of $PM_{10}$ from this source is just under one tonne for an average winter's day. Figure 8.1 shows that domestic heating is estimated to contribute around 85% of the $PM_{10}$ emissions in Blenheim and 88% of the finer $PM_{2.5}$ size fraction. The relative contribution of sources to other contaminants is shown in Table 8.1.


Figure 8.1: Relative contribution of sources to $PM_{10}$ and $PM_{2.5}$ in Blenheim

Estimated contaminant emissions for an average winter's day and for a day when all households are using their solid fuel burning methods are shown in Tables 8.2 and 8.3. Around 1.1 tonnes and 1.4 tonnes of $PM_{10}$ are emitted per day under these scenarios respectively.

Domestic heating is also the major contributor to wintertime carbon monoxide and benzene emissions producing around 60% of CO and 64% of the benzene in Blenheim (Figure 8.2). Motor vehicles are the other main source of CO and benzene contributing around 39% and 35% of the total emissions. The uncertainties surrounding estimates of benzene concentrations however, are high. Motor vehicles are the main source of NOx contributing around 90% of the emissions in Blenheim. It should be noted, however, that concentrations of $NO_2$, CO and benzene are unlikely to be of concern in Blenheim.

Table 8.1: Relative contribution of different sources to contaminant emissions (average case)

| | $PM_{10}$ | CO | NOx | SOx | VOC | $CO_2$ | $PM_{2.5}$ | Benzene |
|---|---|---|---|---|---|---|---|---|
| **Domestic heating** | 85% | 60% | 6% | 12% | 73% | 40% | 88% | 64% |
| **Motor vehicle** | 7% | 39% | 90% | 55% | 26% | 54% | 5% | 35% |
| **Outdoor burning** | 6% | 1% | 1% | 1% | 1% | 2% | 6% | 2% |
| **Industry** | 2% | 0% | 2% | 32% | 0% | 3% | 1% | 0% |

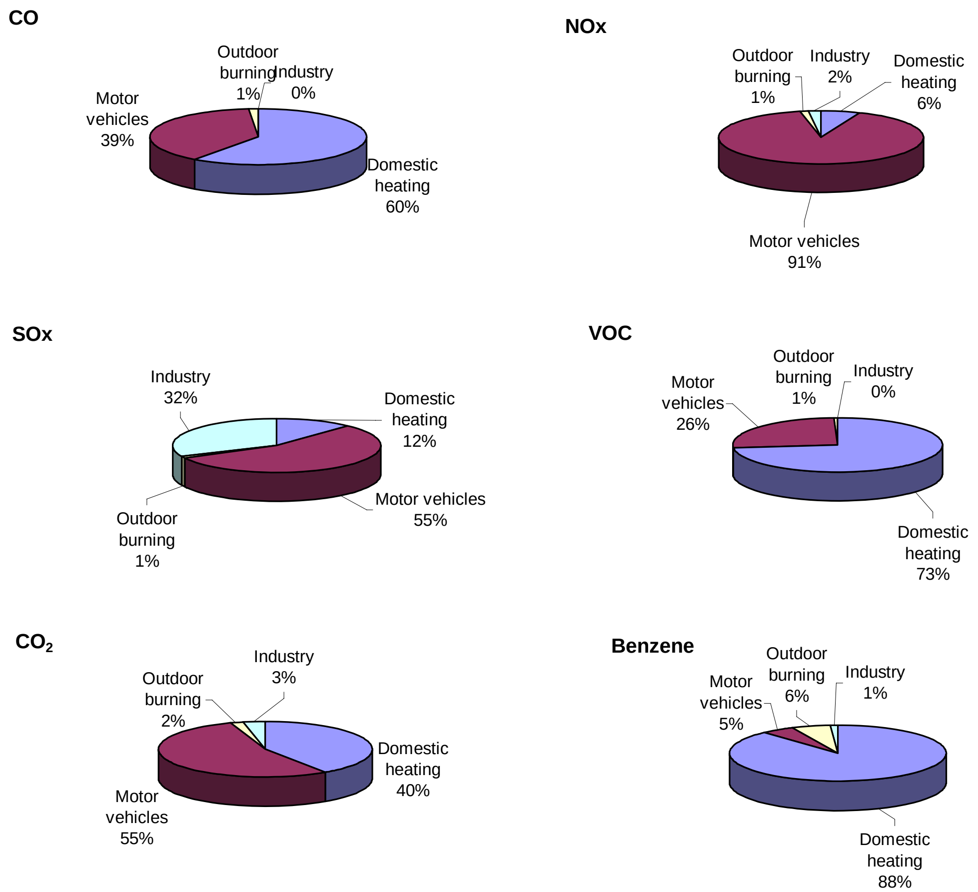


Figure 8.2: Relative contribution of sources to contaminant emissions (average case)

Table 8.2: Total emissions estimates for Blenheim based on average-case domestic heating scenario

| | $PM_{10}$ **kg/ day** | CO **kg/ day** | Nox **kg/ day** | Sox **kg/ day** | VOC **kg/ day** | $CO_2$ **t/ day** | $PM_{2.5}$ **kg/ day** | Benzene **kg/ day** |
|---|---|---|---|---|---|---|---|---|
| **Domestic Heating** | 971 | 9331 | 63 | 28 | 2753 | 160 | 943 | 93 |
| **Motor vehicles** | 81 | 6,009 | 936 | 127 | 975 | 215 | 54 | 51 |
| **Outdoor burning** | 64 | 215 | 15 | 3 | 22 | 8 | 60 | 3 |
| **Industry** | 21 | 18 | 20 | 72 | 0 | 13 | 13 | 0 |
| **Total** | 1138 | 15573 | 1035 | 230 | 3751 | 396 | 1070 | 146 |

Table 8.3: Total emissions estimates for Blenheim based on worst-case domestic heating scenario

| | $PM_{10}$ **kg/ day** | CO **kg/ day** | Nox **kg/ day** | Sox **kg/ day** | VOC **kg/ day** | $CO_2$ **t/ day** | $PM_{2.5}$ **kg/ day** | Benzene **kg/ day** |
|---|---|---|---|---|---|---|---|---|
| Domestic Heating | 1276 | 12196 | 80 | 37 | 3590 | 211 | 1234 | 121 |
| Motor vehicles | 81 | 6009 | 936 | 127 | 975 | 215 | 54 | 51 |
| Outdoor burning | 64 | 215 | 15 | 3 | 22 | 8 | 60 | 3 |
| Industry | 21 | 18 | 20 | 72 | 0 | 13 | 13 | 0 |
| Total | 1442 | 18439 | 1051 | 239 | 4587 | 447 | 1361 | 174 |

Table 8.4 and Figure 8.3 show seasonal variations in $PM_{10}$ emissions in Blenheim. Domestic home heating is the main source of annual $PM_{10}$ emissions and the dominant source of emissions during the winter and spring months. Motor vehicles and outdoor burning are the dominant sources of $PM_{10}$ emissions during the summer months.

Table 8.4: Seasonal variations in daily $PM_{10}$ emissions by source

| | Domestic Heating **kg/day** | Outdoor burning **kg/day** | Industry **kg/day** | Motor vehicles **kg/day** | Total |
|---|---|---|---|---|---|
| January | 0 | 72 | 30 | 81 | 183 |
| February | 0 | 72 | 30 | 81 | 183 |
| March | 0 | 57 | 33 | 81 | 171 |
| April | 36 | 57 | 33 | 81 | 207 |
| May | 291 | 57 | 33 | 81 | 462 |
| June | 625 | 64 | 21 | 81 | 792 |
| July | 971 | 64 | 21 | 81 | 1138 |
| August | 829 | 64 | 21 | 81 | 996 |
| September | 436 | 71 | 33 | 81 | 621 |
| October | 121 | 71 | 33 | 81 | 306 |
| November | 0 | 71 | 33 | 81 | 185 |
| December | 0 | 72 | 30 | 81 | 183 |
| Total kg year | 101551 | 24107 | 10674 | 29522 | 165854 |

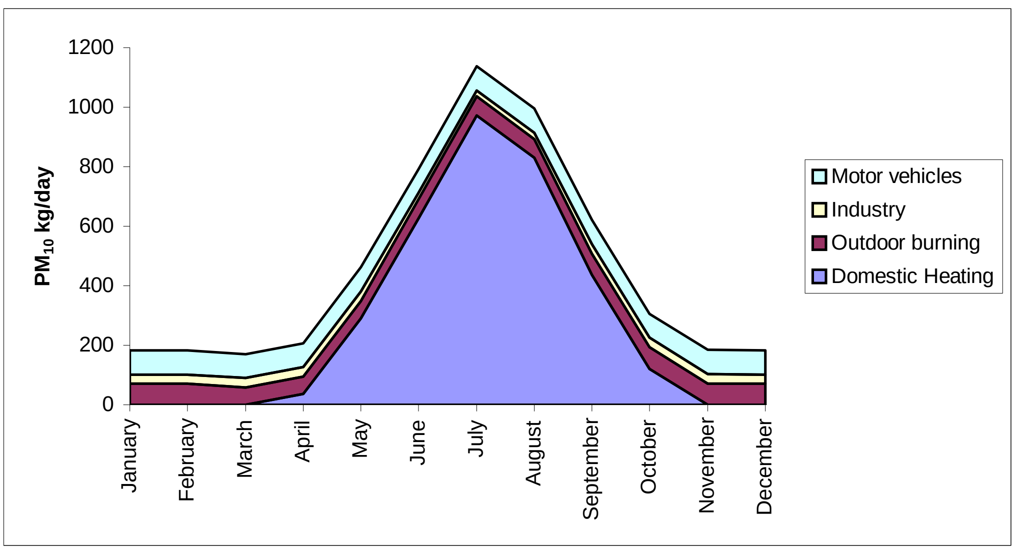


Figure 8.3: Seasonal variations in total $PM_{10}$ emissions in Blenheim by source

An estimate of spatial variations in daily $PM_{10}$ emissions in Blenheim was made based on the population density in each census area unit and the geographical location of specific point source discharges (Table 8.5). Figure 8.4 shows the highest density of emissions occurs around the Redwoodtown area.

Table 8.5: Emission densities for $PM_{10}$ by source

| | Area | Domestic | Transport | Industry | Outdoor burning | Total |
|---|---|---|---|---|---|---|
| **Census Area Unit Name** | **$km^2$** | **$kg/km^2$** | **$kg/km^2$** | **$kg/km^2$** | **$kg/km^2$** | **$kg/km^2$** |
| Springlands | 1.7 | 76 | 6 | 3 | 5 | 89 |
| Mayfield | 2.0 | 57 | 5 | 0 | 4 | 65 |
| Blenheim Central | 2.2 | 59 | 5 | 5 | 4 | 72 |
| Whitney | 2.0 | 96 | 8 | 0 | 6 | 110 |
| Redwoodtown | 2.2 | 104 | 9 | 0 | 7 | 119 |
| Witherlea (less conservation area) | 4 | 46 | 4 | 2 | 3 | 55 |

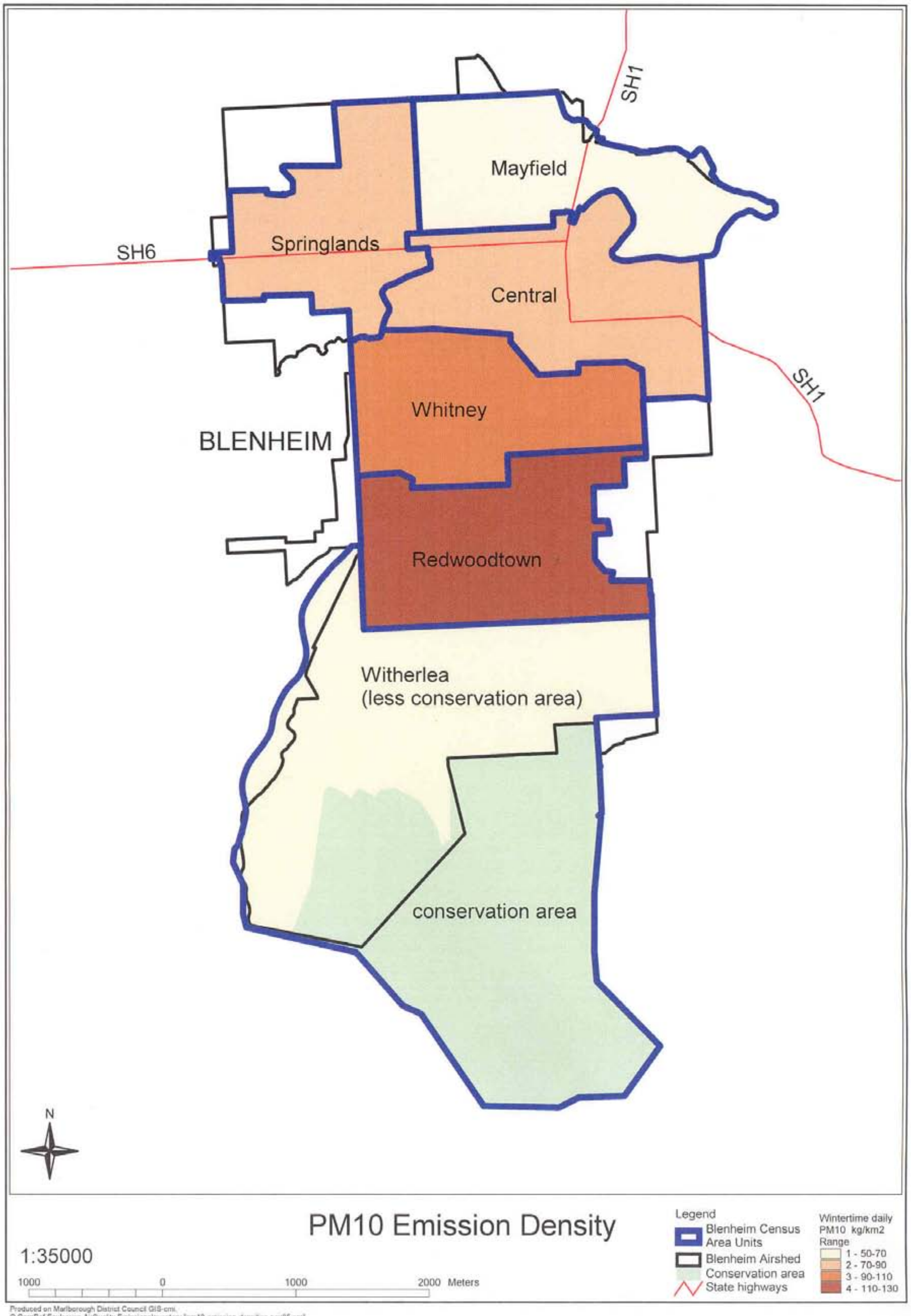


Figure 8.4: Total emission density by CAU for the urban areas of Blenheim

# 9 Evaluation of straight-line path to compliance with NES in Blenheim

## 9.1 Reductions required in $PM_{10}$ concentrations

The first stage in evaluating the straight-line path to compliance is determining the reduction required in $PM_{10}$ concentrations to meet the NES of 50 µg $m^{-3}$ (24-hour average) with one allowable exceedence per year. There are a few options available for doing this. The most robust method is to use air quality monitoring data, if this is available for the likely worst-case air quality location, and preferably for a number of years. The reason the latter is important is that annual variations in worst-case meteorological conditions can result in different maximum concentrations for the same amount of emissions.

If limited monitoring data are available, airshed modelling of meteorological conditions may be used to estimate the likely worst-case concentration. However, there are significant uncertainties in this methodology. A good agreement between modelled results and measured concentrations should be obtained for the monitoring data that are available before proceeding with this option. The other option for setting the starting point for the straight-line path in areas where there is limited monitoring data, that has been raised as an option by air quality specialists, is to artificially increase the maximum measured concentration by a given amount (e.g., 20%) to account for the uncertainty of the monitoring data. However, the latter is a very subjective approach and is unlikely to withstand scientific scrutiny.

If sufficient monitoring data are available, the reduction required to achieve the NES could be based on the 99.7 percentile concentration as this provides an indication of the second worst likely concentrations per year. In Blenheim monitoring data are available for the Redwoodtown site from September 2002. The maximum measured $PM_{10}$ concentration at this site was 81 µg $m^{-3}$ (24-hour average), measured in July 2004. The 99.7 percentile concentration for the same year is 80 µg $m^{-3}$. The reduction required in $PM_{10}$ concentrations to meet the NES based on this value is 37%.

This estimate is based on air quality monitoring carried out at the Redwoodtown site to date. This includes one-day in three sampling from September 2002. It is possible that the sample days during this period have not captured worst-case meteorological conditions. Notwithstanding this uncertainty, the data provides the best available information on the reductions required in each area and the likely start point for the straight-line path to compliance with the NES. If additional monitoring indicates a higher maximum concentration, revisions can be made to the straight-line path and management measures to compensate for additional reductions that may be required.

## 9.2 Setting the straight-line path for Blenheim

Figure 9.1 shows the reduction required in $PM_{10}$ concentrations in Blenheim and the straight-line path to compliance as a proportion of 2005 emission levels and in terms of estimated emissions of $PM_{10}$. Estimates are based on the assumption of a linear relationship between emissions and concentrations as no meteorological modelling has been carried out to evaluate the relationship. Starting point emissions estimates for 2005 are based on the inventory $PM_{10}$ emission estimates with an additional 8% allowed for natural sources and 5% for the potential contribution from sources such as industry and vineyard burning within the rural area surrounding Blenheim.

Results indicate a required reduction of around 60 kilograms of daily wintertime $PM_{10}$ per year.


Figure 9.1: Straight-line path to compliance with the NES for Blenheim as a proportion of 2005 emissions (top) and in terms of kilograms of $PM_{10}$ per day (bottom)

# References

Dasch, J. M. 1982: Particulate and Gaseous Emissions from Wood Burning Fireplaces, Environ. Sci. and Technol., Vol. 16, No 10, pg 639-645.

Davy, P., Trompetter, W. J., Markwitz, A., Weatherburn, D. C., 2005, Elemental analysis and source apportionment of ambient particulate matter at Masterton, New Zealand. 2005 Biopixe conference, Wellington New Zealand 17-21 January 2005.

Environet, 2003, Monitoring of CO, $SO_2$, $NO_2$, ozone, benzene and benzo(a)pyrene in New Zealand. Ministry for the Environment Technical Report no 42.

Environment Australia, 2001, National Pollutant Inventory, http://www.environment.gov.au/epg/npi/handbooks/aedmanuals/aedmanuals.html

Gimson, N., & Fisher, G., 1997, The Relationship Between Emissions to Air and Measured Ambient Air Concentrations of Contaminants in Christchurch, Report U97(67), Environment Canterbury.

GVRD 1998, 1995 Emission inventory for the Lower Fraser Valley Airshed: Technical Appendix: Detailed Listing of Methodology and Results. Greater Vancouver Regional District and Fraser Valley Regional District.

Hennessy, W., 1999, Evidence presented at Christchurch Coal Ban Hearings 1999. Unpublished.

Lamb, C., 1999, Christchurch Home Heating Survey: A survey of domestic home heating methods and fuels in the Christchurch metropolitan area. Environment Canterbury Report U00/34.

Lamb, C., 2003, Household solid fuel heating: 2002 Christchurch home heating diary panel, Environment Canterbury Technical Report, unnumbered.

MfE, 1994, Ambient Air Quality Guidelines. Ministry for the Environment, Wellington.

Ministry for the Environment, 1997. Environmental performance indicators (Proposals for air, fresh water and land).

Ministry for the Environment, 2002. *Ambient Air Quality Guidelines for New Zealand.* Ministry for the Environment.

Environet, 2003, Monitoring of CO, NO2, SO2, ozone, benzene and benzo(a)pyrene in New Zealand. Ministry for the Environment technical report number 42.

Ministry for the Environment, 2004, *National Environmental Standards for Air Quality, September 2004.* Ministry for the Environment.

Ministry of Transport, 1998, Vehicle fleet emission control strategy – final report. Ministry of Transport.

Scott, A., 2005, Source Apportionment and Chemical characterisation of airborne fine particulate matter in Christchurch, New Zealand, draft PhD thesis, University of Canterbury – unpublished.

Scott, A., 2005, Real-life emissions from residential wood burning appliances in New Zealand. Ministry for the Environment.

Stern, C. H.; Jaasma, D.R.; Shelton, J.W.; Satterfield G. 1992: Parametric Study of Fireplace Particulate Matter and Carbon Monoxide Emissions, Journal Air Waste Manage. Assoc. Vol 42, No6, pg 777-783.

USEPA AP42, 2001, Emissions Database http://www.epa.gov/ttn/chief/ap42/

# Appendix A: Domestic heating survey 2005

1. Good morning / afternoon/evening - Is this a home or business number?(- terminate if business)
Hi, I'm _________from DigiPoll and I am calling on behalf of the Ministry for the Environment.
May I please speak to an adult in your household who knows about your home heating systems? We are currently undertaking a survey in your area on methods of home heating. We wish to know what you use to heat your main living area during a typical year. The survey will take about 5 minutes. Is it a good time to talk to you now?

2. (a) Do you use any type of electrical heating in your MAIN living area during a typical year?

What type of electrical heating do you use? Would it be...

- ☐ Night Store
- ☐ Radiant
- ☐ Portable Oil Column
- ☐ Panel
- ☐ Fan
- ☐ Heat Pump
- ☐ Don't Know/Refused
- ☐ Other (specify)

2b. Do you use any other heating system in your main living area in a typical year? *(If yes then question 3 otherwise Q8)*

3. (a) Do you use any type of gas heating in your MAIN living area during a typical year? *(If No then question 4)*

(b) Is it flued or unflued gas heating? If necessary: (A flued gas heating appliance will have an external vent or chimney)

(c) Which months of the year do you use your gas burner

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(d) How many days per week would you use your gas burner during

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(e) Do you use mains or bottled gas for home heating?

(f) What size gas bottle do you use?

(f.2) How many times in a winter would you refill your x kg gas bottle? Interviewer: Winter is defined as May to August inclusive.

4. (a) Do you use a log burner in your MAIN living area during a typical year? (This is a fully enclosed burner but does not include multi fuel burner i.e., those that burn coal) *(If No then question 5)*

(b) Which months of the year do you use your log burner

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(b) How many days per week would you use your log burner during?

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(d) How old is your log burner?

(e) In a typical year, how many pieces of wood do you use on an average winters day? Interviewers note : winter is defined as May to August inclusive.

(f) ask only If they used their log burner during non winter months How many pieces of wood do you use per day during the other months? Interviewers note : winter is defined as May to August inclusive.

(g) In a typical year, how much wood would you use per year on your log burner? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks, one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)

5. (a) Do you use an enclosed burner which burns coal as well as wood – i.e., a multi fuel burner in your MAIN living area during a typical year? (This includes incinerators, pot belly stoves, McKay space heaters etc but does not include open fires.) *(If No then question 6)*

(b) Which months of the year do you use your multi-fuel burner?

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(c) How many days per week would you use your multi fuel burner during?

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(d) How old is your multi fuel burner?

(e) What type of multi fuel burner is it?

(f) In a typical year, how much wood do you use on your multi-fuel burner per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as May to August inclusive

(g) ask only If they used their multi fuel burner during non winter months How much wood do you use per day during the other months?

(h) In a typical year, how much wood would you use per year on your multi-fuel burner?_____ (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with

(i) Do you use coal on your multi fuel burner?

(j) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day) Interviewer: Winter is defined as May to August inclusive .

(k) Ask only If they used their log burner during non winter months How much coal do you use per day during the other months?

6. (a) Do you use an open fire (includes a visor fireplace which is one enclosed on three sides but open to the front) in your MAIN living area during a typical year? *(If No then question 7)*

(b) Which months of the year do you use your open fire

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(c) How many days per week would you use your open fire during?

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(d) Do you use wood on your open fire?

(e) On a typical year, how much wood do you use per day during the winter? (ask them how many pieces of wood (logs) they use on an average winters day) Interviewer: Winter is defined as may to August inclusive

(f) Ask only If they used their log burner during non winter months How much wood do you use per day during the other months?

(g) In a typical year, how much wood would you use per year on your open fire? (record wood use in cubic metres - note 1 cord equals 3.6 cubic meters of loosely piled blocks one trailer equals about 1.65 cubic metres without cage, or 2.2 with cage)

(h) Do you use coal on your open fire?

(i) How many buckets of coal do you use per day during the winter? (how many buckets of coal used on an average winters day)____ Interviewer: Winter is defined as may to August inclusive

(j) Ask only If they used their log burner during non winter months How much coal do you use per day during the other months?

7. (a) Do you use a pellet burner in your MAIN living area during a typical year? *(If No then question 8)*

(b) Which months of the year do you use your pellet burner

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(c) How many days per week would you use your pellet burner during?

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(d) How old is your pellet burner?

(e) What make and model is your pellet burner? First, can you tell me the make?

(e) and what model is your pellet burner?

(f) In a typical year, how many kilograms of pellets do you use on an average winters day? Interviewers note : winter is defined as May to August inclusive.

(g) Ask only If they used their pellet burner during non winter months How many kgs of pellets do you use per day during the other months? Interviewers note : winter is defined as May to August inclusive.

(h) In a typical year, how many kilograms of pellets would you use per year on your pellet burner?

8. (a) Do you use any other heating system in your MAIN living area during a typical year? *(If No then question 9)*

(b) What type of heating system do you use (if they respond with diesel or oil burner go to question c otherwise go to Q8)

(c) Which months of the year do you use your oil burner

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(d) How many days per week would you use your diesel/oil burner during?

| | | | | | |
|---|---|---|---|---|---|
| ☐ Jan | ☐ Feb | ☐ March | ☐ April | ☐ May | ☐ June |
| ☐ July | ☐ Aug | ☐ Sept | ☐ Oct | ☐ Nov | ☐ Dec |

(e) How much oil do you use per year ?

9. Does you home have insulation?

- ☐ Ceiling
- ☐ Under floor
- ☐ Wall
- ☐ Cylinder wrap
- ☐ Double glazing
- ☐ None
- ☐ Don't know
- ☐ Other

DEMOGRAPHICS We would like to ask some questions about you now, just to make sure we have a cross-section of people for the survey. We keep this information strictly confidential.

d1. Would you mind telling me in what year you were born ?

D2. Which of the following describes you and your household situation?

- ☐ Single person below 40 living alone
- ☐ Single person 40 or older living alone
- ☐ Young couple without children
- ☐ Family with oldest child who is school age or younger
- ☐ Family with an adult child still at home
- ☐ Couple without children at home
- ☐ Flatting together
- ☐ Boarder

D3 With which ethnic group do you most closely relate?

Interviewer: tick gender.

How many people live at your address?

Do you own your home or rent it?

How old is the dwelling you live in?

How many bedrooms in the dwelling you live in?

D4 Would you estimate your total combined household income before tax to be:

- ☐ Less than $20,000
- ☐ $20,000 to $30,000
- ☐ $30,000 to $40,000
- ☐ $40,000 to $50,000
- ☐ $50,000 to $70,000
- ☐ $70,000 to $100,000
- ☐ More than $100,000
- ☐ Don’t know/ Refused

D5 What is your employment status:

Thank you for your time today. Your answers will be very helpful. In case you missed it, my name is ---------- from DigiPoll in Hamilton. Have a nice day/evening.

# Appendix B: Emission factors for domestic heating.

Emission factors for domestic heating were those used in the Ministry for the Environment's (2005) assessment of burner removals to meet the NES in 31 urban areas of New Zealand. With the exception of gas, oil and post 1990 wood burners, these were based largely on the review of New Zealand emission rates carried out for the Christchurch 1999 emission inventory with adaptations made for different burner age categories. The latter review resulted in revised factors for open fires burning wood and the burning of coal on open fires and multi fuel burners. The open fire wood emission factor was reduced from 15 g/kg (used in previous inventories) to 10 g/kg. This was based on a combination of overseas literature, in particular the studies by Stern (1992) and Dasch (1982), and the results of a limited number of tests carried out in New Zealand. The New Zealand tests were carried out by Applied Research and gave emission rates of around 7 g/kg.

An emission factor of 22 g/kg was selected for coal burning on an open fire and was based on the average of the tests carried out in New Zealand, weighted for the more predominant use of bituminous coals, based on the 80% to 20% figures quoted by Hennessy (1999). Previous emission factors were around 33 g/kg. An emission factor for $PM_{10}$ for multi fuel burners burning coal of 28 g/kg was selected based on a weighted average of the test results available for different appliance types.

Emission factors for the post 1995 wood burner categories were based on data collected in Nelson on burner types in different age categories. Gas and oil emission factors were based on factors derived by Angie Scott (pers comm., 2004) based on more recent testing of these appliances.

Domestic heating emission factors for CO, NOx, SOx and $CO_2$ for all but post 1995 burners were also based on the Christchurch 1999 emission factor revisions.

Emission factors for benzene and $PM_{2.5}$ were selected based on data from overseas studies. Benzene emission factors for wood burning were based on USEPA AP-42 emission rates for a "conventional burner". The description of this burner suggests that it is appropriate for a pre-baffle burner type and therefore is likely to be most appropriate for the older multi-fuel burners and open fires. As no emission factors for a more modern burner were available for benzene, one emission rate based on a "conventional burner" is used for all wood burning. Benzene emissions from a coal burner and light industrial oil burner (AP-42) were used for domestic coal and oil burning, as no data for domestic use were available. Benzene emission factors for the domestic use of gas were based on data from the Australian National Pollutant Inventory. Because of the uncertainties associated with these emission factors, benzene estimations should be treated as indicative only.

Emission factors for $PM_{2.5}$ data for the burning of wood are based on the assumption that 100% of the $PM_{10}$ emissions are $PM_{2.5}$ (USEPA, 1997). For coal burning USEPA AP-42 generalised particle size distributions for the $PM_{2.5}$ component were used. Oil burning emission rates were based on AP-42 data for a utility boiler. No data for LPG gas use was available so it was assumed that 100% of the $PM_{10}$ would be in the finer $PM_{2.5}$ size fraction, based on AP-42 data for natural gas.