Blenheim Air Emission Inventory – 2012

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July 2012

Executive Summary

An emission inventory was carried out for Blenheim to estimate emissions to air of air contaminants, in particular PM_{10}. The inventory estimates emissions to air from domestic heating, motor vehicle, industrial and commercial activities and outdoor burning. Natural source contributions (for example; sea salt and soil) are not included because the methodology to estimate emissions is less robust. A previous air emissions inventory for Blenheim was carried out in 2005.

The inventory focuses on suspended particles (PM_{10}) the main contaminant of concern in urban areas of New Zealand but also makes estimates of emissions of carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds, carbon dioxide and benzene.

A domestic home heating survey was undertaken to determine the proportions of households using different heating methods and fuels. In Blenheim the main method of home heating is electricity which is used by 65% of households. In 2012 around 45% of households used wood burners in their main living area. This compares with 52% households in the 2005 air emission inventory. Many householders use more than one method to heat the main living area of their home.

Domestic heating is the main source of PM_{10} emissions, accounting for 92% of all emissions. Other sources included transport (2%), industry (1%) and outdoor burning (5%). On an average winter's night, around 678 kilograms of PM_{10} are discharged from these sources.

Results suggest emissions have decreased by around 26% since 2005, with the majority of the reduction coming from domestic home heating.

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1 Introduction

Emission inventories are used by Governments and Local Government internationally to provide an estimate of the quantities of contaminants from anthropogenic sources that are emitted into the air and the relative contribution of sources to total emissions. The sources that are included in emissions inventories in New Zealand are generally the domestic heating, motor vehicle, industrial and commercial and outdoor burning sector. Natural source contributions (for example; sea salt and soil) are not included because methodologies are less robust.

In New Zealand the main air contaminant of concern in urban areas is PM_{10}. In Blenheim concentrations of PM_{10} breach the National Environmental Standard for PM_{10} (50 µg m^{-3} – 24-hour average with one allowable exceedence per year). In 2011 the NES was breached on five occasions at the main air quality monitoring site in Redwoodtown.

This report primarily focuses on emissions of particles (PM_{10}) from domestic heating, motor vehicles, industrial and commercial activities and outdoor burning. Other contaminants included in this emission inventory are carbon monoxide, nitrogen oxides, sulphur oxides volatile organic compounds, carbon dioxide and benzene.

A previous emission inventory for Blenheim was carried out in 2005. The main methods of home heating in Blenheim in 2005 were electricity (61%) and wood burners (52%). Open fires were used by 5% of households and multi fuel burners were used by 7%.

Domestic heating was found to emit around 971 kilograms per day of PM_{10} (average winters night) and contributed 85% of the anthropogenic PM_{10} emissions in the Blenheim airhshed.

2 Inventory Design

The main air contaminant of concern in urban areas of the Marlborough District is PM_{10}. This inventory focuses on PM_{10} emissions and sources of PM_{10}, although estimate of other key contaminants are also made. It is unlikely that concentrations of other key contaminants are likely to exceed national environmental standards (NES).

2.1 Selection of sources

Estimates of emissions from the domestic heating, motor vehicles, industry and outdoor burning sector are included in the emissions inventory. The report also discusses PM_{10} emissions from a number of other minor sources.

2.2 Selection of contaminants

The inventory included an assessment of emissions of suspended particles (PM_{10}), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC), carbon dioxide (CO_2) and benzene.

Emissions of PM_{10}, CO, SOx and NOx are included as these contaminants are in the NES because of their potential for adverse health impacts. Carbon dioxide has been typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas CO_2 emissions. However, these data are now generally collected nationally and for a broader range of greenhouse gases. Estimates of CO_2 have been retained in the inventory but readers should be directed to national statistics (e.g., www.climatechange.govt.nz.) should detailed data on this source be required. Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. It is unlikely that ozone formation from emissions within Blenheim would cause ozone problems. In this report, VOC emissions have been estimated for existing sources but data on emissions from VOC specific sources (e.g., spray painting) has not been included.

2.3 Selection of areas

The Blenheim inventory study area is based on the 2005 inventory area which includes the following CAUs: Springlands, Mayfield, Blenheim Central, Whitney, Redwoodtown and Witherlea.

Figure 2.1 shows the inventory study area (includes all blue CAU areas) and the Blenheim airshed area as well as the location of the air quality monitoring sites in Blenheim. The inventory study area comprises the majority of the airshed area and has been retained as the study area for 2012 to enable direct comparisons between the 2005 and 2012 emission inventories.

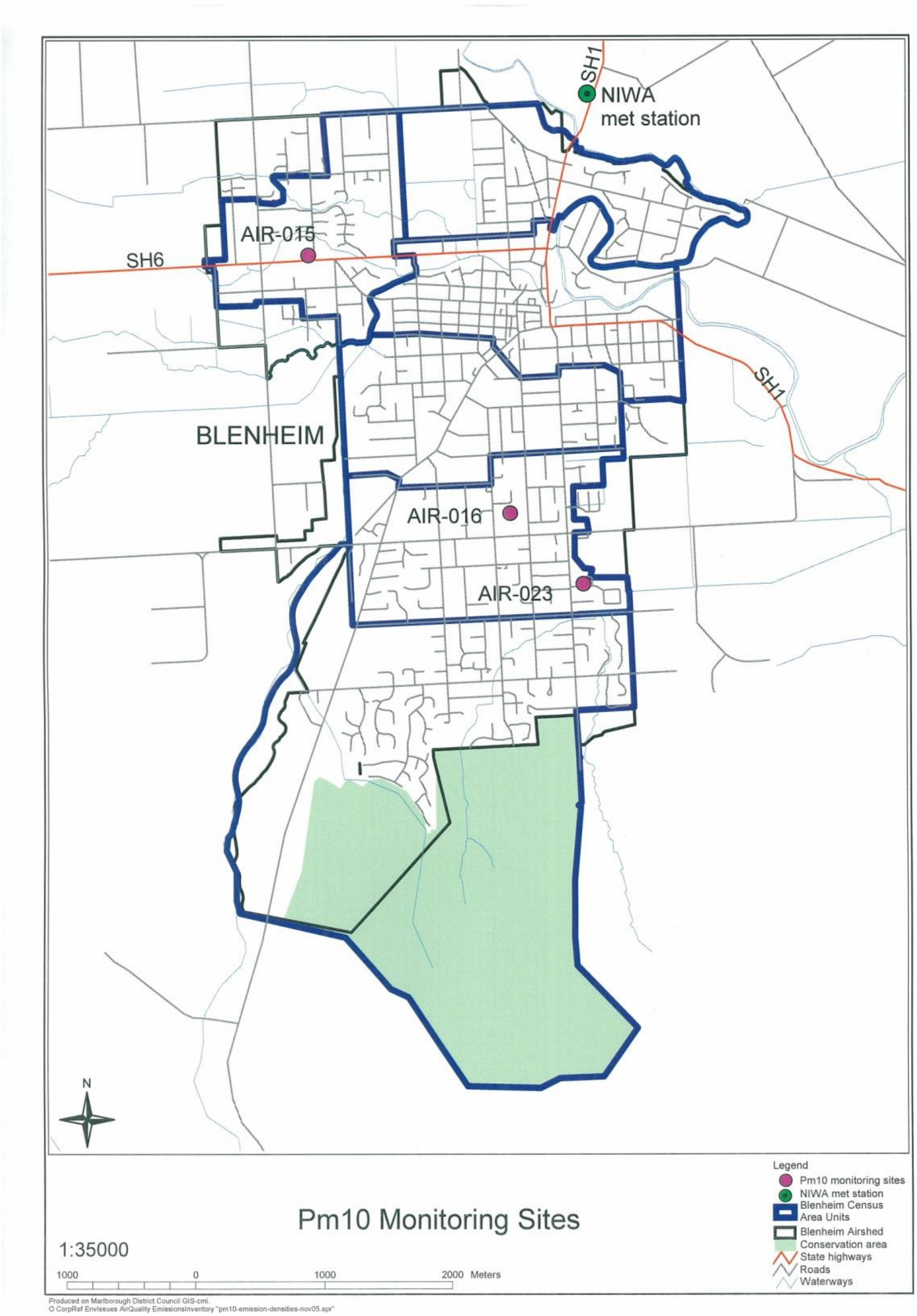

Figure 2.1: Blenheim Airshed (source Marlborough District Council).

2.1 Temporal distribution

Data were collected based on daily data with some seasonal variations. Domestic heating data were collected based on average and worst-case wintertime scenarios and by month of the year. Motor vehicle data were collected for an average day as data sources do not contain seasonal variations in vehicle movements. Industrial data were collected by season as was outdoor burning data.

No differentiation was made for weekday and weekend sources.

Limited time of day breakdowns were obtained for the data.

3 Domestic heating

3.1 Methodology

Domestic heating methods and fuel use used by households in Blenheim was collected using a household survey carried out by Digipol during June 2012 (Appendix A). Table 3.1 shows the number of households based on 2006 census data for the Airshed area, the estimated households for 2012, and survey details. The 2012 estimate for Blenheim was made using the Statistics New Zealand population projected increase of 0.4% per year for the Marlborough District.

Table 3.1: Summary household, area and survey data for the Blenheim inventory area.

Households by census area unit 2006	Estimated households 2012	Sample size	Area (ha)	Sample error
9177	9397	365	1930	5%

Home heating methods were classified as; electricity, open fires, wood burners 10 years or older (pre 2002), wood burners five to 10 years old (2003-2007), wood burners less than five years old (post 2007), pellet fires, multi fuel burners, gas burners and oil burners. The post 2007 wood burner category includes all wood burners meeting the NES design criteria and the 2003-2007 category includes a mix of NES compliant and non NES compliant wood burners.

Emission factors were applied to the results of the home heating survey to provide an estimate of emissions for each study area. The emission factors used to estimate emissions from domestic heating are shown in Table 3.2. The basis for these is detailed in Appendix B.

Table 3.2: Emission factors for domestic heating methods.

	PM_{10} g/kg	CO g/kg	NOx g/kg	SO_2 g/kg	VOC g/kg	CO_2 g/kg	Benzene g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	0.97
Open fire - coal	21	80	4	5.0	15	2600	0.00065
Pre 2002 burners	11	110	0.5	0.2	33	1600	0.97
2002-2006 burners	7	70	0.5	0.2	21	1600	0.97
Post 2007 burners	4	30	0.5	0.2	9	1600	0.97
Pellet burners	2	20	0.5	0.2	6	1600	0.97
Multi-fuel[1] - wood	13	130	0.5	0.2	39	1600	0.97
Multi-fuel[1] – coal	28	120	1.2	3.0	15	2600	0.97
Oil	0.3	0.6	2.2	3.8	0.25	3200	0.00065
Gas	0.03	0.18	1.3	7.6E-09	0.2	2500	2.16E-05

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

The average weight for a log of wood is one of the assumptions required for this inventory to convert householder's estimates of fuel use in logs per evening to a mass measurement required for estimating emissions. Average log weights used for inventories in New Zealand have included 1.6 kilograms, 1.4 kilograms and 1.9 kilograms. The latter value is based on a survey of 219 households in Christchurch during 2002 and was the value used in the 2005 air emission inventory. A 2005 burner emission testing programme carried out in Tokoroa gave an average log weight of 1.3 kilograms. The sample size (pieces of wood weighed) for this study was 845. These were spread across only 12 households so it is uncertain how representative of the Tokoroa population a fuel weight of 1.3 kilograms per log might be. More recently a similar study was carried out in Nelson, Rotorua and Taumaranui. Results of fuel use from that study indicated an average fuel weight of 1.7 kilograms per log. A value of 1.6 kilograms is recommended for use in this inventory.

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

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

Where:

CE = contaminant emission

EF = emission factor

FB = fuel burnt

The main assumptions underlying the emissions calculations are as follows:

- The average weight of a log of wood is 1.6 kilograms.
- The average weight of a bucket of coal is 9 kilograms.

3.2 Home heating methods

Home heating methods and fuels used in Blenheim during 2012 are shown in Table 3.3. Electricity was the main heating method, with 65% of households using this method to heat their main living area. The second most common method for home heating was wood burners which were used by 42% of households. Gas is only used by 7% of households in Blenheim.

Only one percent of Blenheim residents reported using an open fire and two percent use a multi fuel burner. Around 154 households use wood fired cooking stoves. Many households rely on more than one method of heating their main living area during the winter months. No respondents reported using pellet fires in Blenheim.

Around 70 tonnes of wood is estimated to be burnt in Blenheim on a typical winter's night. Coal use is not common in Blenheim and less than one tonne per night is estimated to be used.

Table 3.3: Home heating methods and fuels.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	65%	6,076		
Total Gas	7%	669	0.2	0%
Flued gas	3%	257		
Unflued gas	4%	412		
Oil	1%	51	0.3	0%
Open fire	1%	103		
Open fire – wood	1%	103	1.2	2%
Open fire – coal	<1%	26	0.1	0%
Total Wood burner	42%	3,965	66.0	91%
Pre 2002 wood burner	16%	1,512	25.2	35%
2002-2006 wood burner	13%	1,243	20.7	29%
Post 2007 wood burner	13%	1,210	20.1	28%
Multi fuel burners	2%	154		
Multi fuel burners-wood	1%	103	2.8	4%
Multi fuel burners-coal	1%	77	0.7	1%
Wood fired stove	2%	154	1.3	2%
Total wood	44%	4,171	70	96.5%
Total coal	1%	103	0.8	1.1%
Total		9,397	73	98%

3.3 Emissions from domestic heating

In Blenheim a total of 627 kilograms of PM_{10} is emitted on an average winters' day from domestic home heating. Older wood burners are responsible for around 44% of this. Figure 3.1 shows the relative contributions of other heating methods.

Tables 3.4 and 3.5 show the estimates of wintertime contaminant emissions for different heating methods under average and worst-case scenarios. Days when households may not be using specific home heating methods are accounted for in the "average" method shown in Table 3.6 and the worst-case scenario of all households burning on a given night is shown in Table 3.7. Under the latter scenario around 701 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night. On an average winter's night (June to August) most (97%) of domestic PM_{10} emissions come from the burning of wood, with only three percent from the burning of coal.

Figures 3.2 and 3.3 and Table 3.6 show the monthly variation in appliance use and average days per week used. The seasonal variation in contaminant emissions is shown in Table 3.7. Figure 3.4 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

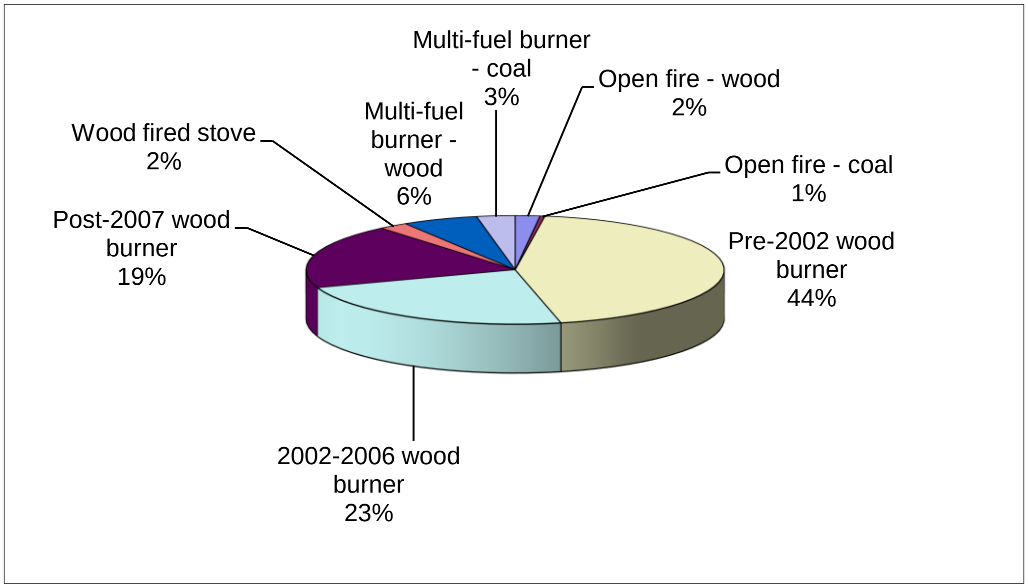

Figure 3.1: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Blenheim.

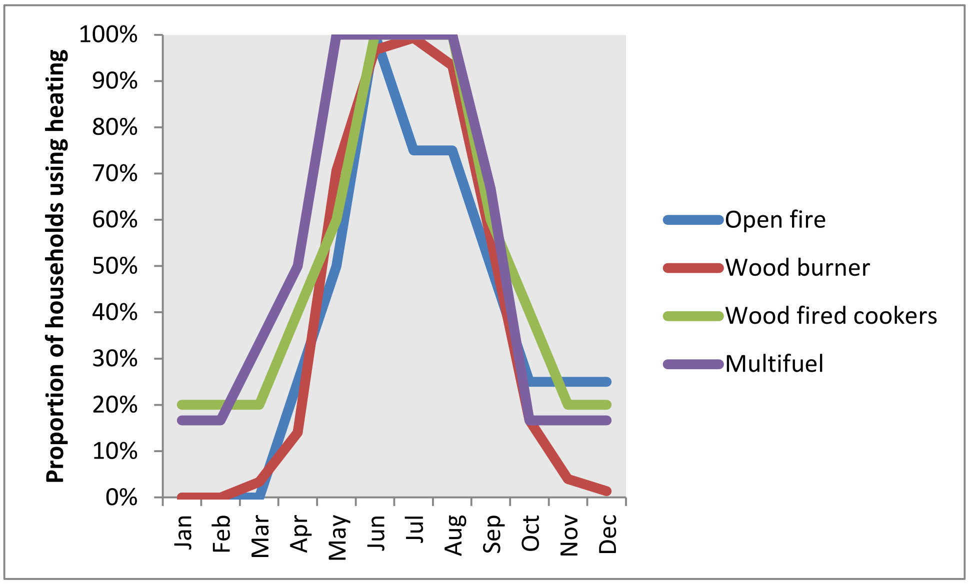

Figure 3.2: Monthly variations in appliance use in Blenheim.

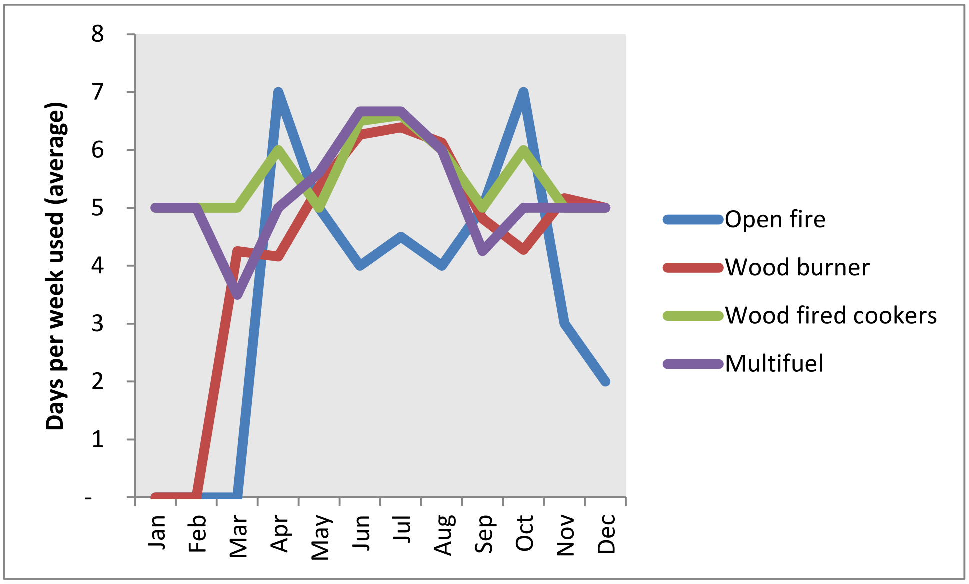

Figure 3.3: Average number of days per week appliances are used in Blenheim.

Table 3.4: Blenheim winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	1.2	2%	12	6	2%	119	62	2%	2	1	5%	0	0	1%	36	19	2%	2	1	2%	1	1	2%
Open fire - coal	0.1	0%	2	1	0%	9	5	0%	0	0	1%	1	0	3%	2	1	0%	0	0	0%	0	0	0%
Wood burner	67.3																						
Pre 2002wood burner	25.2	35%	277	144	44%	2770	1435	45%	13	7	32%	5	3	28%	831	431	45%	40	21	34%	24	13	35%
2002-2006 wood burner	20.7	29%	145	75	23%	1450	751	24%	10	5	26%	4	2	23%	435	225	24%	33	17	28%	20	10	29%
Post 2007 wood burner	20.1	28%	121	63	19%	1209	626	20%	10	5	26%	4	2	23%	363	188	20%	32	17	27%	20	10	28%
Wood fired stove	1.3	2%	14.1	7	2%	141	73	2%	1	0	2%	0	0	1%	42	22	2%	2	1	2%	1	1	2%
Multi fuel burner																							
Multi fuel– wood	2.8	4%	37	19	6%	367	190	6%	1	1	4%	1	0	3%	110	57	6%	5	2	4%	3	1	4%
Multi fuel – coal	0.7	1%	19	10	3%	79	41	1%	1	0	2%	2	1	11%	10	5	1%	2	1	1%	0	0	0%
Gas	0.2	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	1	0	1%	0	0	0%
Oil	0.3	0%	0	0	0%	0	0	0%	1	0	1%	1	1	6%	0	0	0%	1	0	1%	0	0	0%
Total Wood	71.3	98%	606	314	97%	6056	3138	99%	37	19	95%	14	7	80%	1817	941	99%	114	59	97%	69	36	100%
Total Coal	0.8	1%	21	11	3%	88	46	1%	1	1	3%	3	1	14%	12	6	1%	2	1	2%	0	0	0%
Total	73		627	325		6145	3184		39	20		18	9		1828	947		118	61		69	36	

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

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	2.5	3%	25	13	4%	247	128	4%	4	2	9%	0	0	2%	74	38	4%	4	2	3%	2	1	3%
Open fire - coal	0.2	0%	5	3	1%	19	10	0%	1	0	2%	1	1	6%	3	2	0%	1	0	0%	0	0	0%
Wood burner	72.8																						
Pre 2002wood burner	27.8	34%	305	158	44%	3054	1583	44%	14	7	30%	6	3	27%	916	475	45%	44	23	34%	27	14	35%
2002-2006 wood burner	22.8	28%	160	83	23%	1598	828	23%	11	6	25%	5	2	22%	479	248	23%	37	19	28%	22	11	29%
Post 2007 wood burner	22.2	27%	133	69	19%	1333	691	19%	11	6	24%	4	2	22%	400	207	20%	36	18	27%	22	11	28%
Wood fired stove	1.4	2%	15	8	2%	150	77	2%	1	0	1%	0	0	1%	45	23	2%	2	1	2%	1	1	2%
Multi fuel burner																							
Multi fuel– wood	3.0	4%	39	20	5%	386	200	6%	1	1	3%	1	0	3%	116	60	6%	5	2	4%	3	1	4%
Multi fuel– coal	0.7	1%	19	10	3%	83	43	1%	1	0	2%	2	1	10%	10	5	1%	2	1	1%	0	0	0%
Gas	0.4	0%	0	0	0%	0	0	0%	0	0	1%	0	0	0%	0	0	0%	1	0	1%	0	0	0%
Oil	0.37	0%	0	0	0%	0	0	0%	1	0	2%	1	1	7%	0	0	0%	1	1	1%	0	0	0%
Total Wood	80	98%	677	351	97%	6768	3507	99%	43	22	93%	16	8	77%	2030	1052	99%	127	66	97%	77	40	100%
Total Coal	1	1%	24	13	3%	102	53	1%	2	1	4%	3	2	16%	14	7	1%	2	1	2%	0	0	0%
Total	81		701	363		6870	3559		46	24		21	11		2044	1059		132	68		77	40	

Table 3.6: Monthly variations in domestic heating appliance use.

	Percentage of houses using this method that use it during each month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gas	0%	0%	0%	4%	50%	92%	83%	83%	29%	4%	4%	0%
Open fire	0%	0%	0%	25%	50%	100%	75%	75%	50%	25%	25%	25%
Wood burner	0%	0%	3%	14%	71%	97%	99%	93%	56%	17%	4%	1%
Wood fired cooker	20%	20%	20%	40%	60%	100%	100%	100%	60%	40%	20%	20%
Multi fuel	17%	17%	33%	50%	100%	100%	100%	100%	67%	17%	17%	17%
Oil	0%	0%	0%	0%	0%	100%	100%	100%	0%	0%	0%	0%
	Average number of days per week house is heated (by those that actually use heat during that month)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gas	-	-	-	3	5	5	6	5	4	5	2	-
Open fire	-	-	-	7	5	4	5	4	5	7	3	2
Wood burner	-	-	4	4	5	6	6	6	5	4	5	5
Wood fired cooker	5	5	5	6	5	7	7	6	5	6	5	5
Multi fuel	5	5	4	5	6	7	7	6	4	5	5	5
Oil	-	-	-	-	-	5	5	6	-	-	-	-

Table 3.7: Monthly variations in contaminant emissions from domestic heating.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day
January	5	38	0	0	11	1	5
February	5	38	0	0	11	1	5
March	15	142	1	0	41	3	15
April	52	495	3	1	146	9	52
May	387	3775	24	11	1120	71	387
June	604	5916	38	17	1760	113	604
July	627	6145	39	18	1828	118	627
August	564	5533	35	16	1647	106	564
September	196	1935	12	5	577	37	196
October	55	542	3	1	162	10	55
November	18	177	1	1	52	3	18
December	9	83	0	0	24	1	9
Total (kg/year)	77728	760778	4808	2199	226182	14500	77728

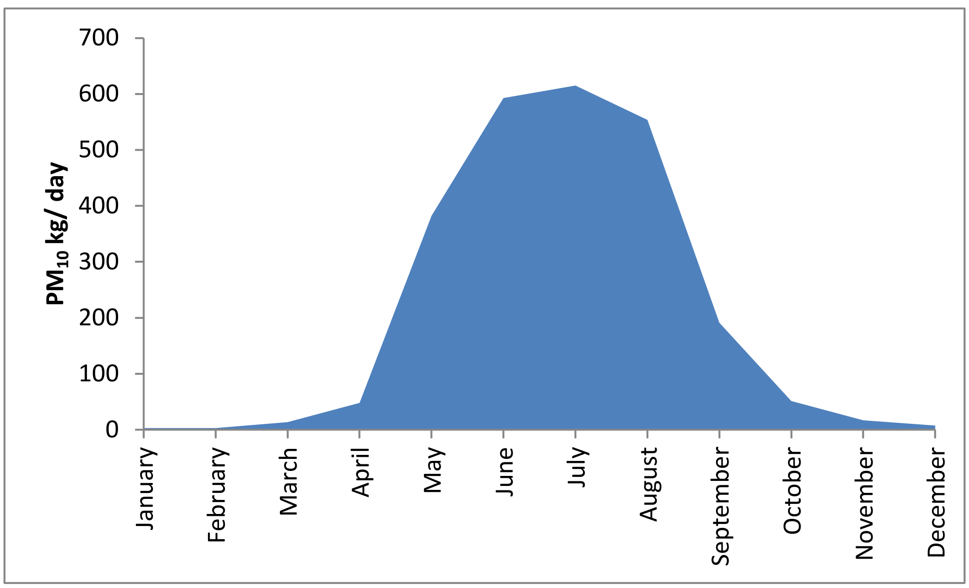

Figure 3.4: Monthly variations in PM_{10} emissions from domestic heating as a proportion of annual emissions.

4 Motor vehicles

Motor vehicle emissions to air include tailpipe emissions (all contaminants) and particulate emissions occurring as a result of the wear of brakes and tyres. Assessing emissions from motor vehicles involves collecting data on vehicle kilometres travelled (VKT) and the application of emission factors to these data.

Historically the emission factors used for motor vehicle emissions assessments in New Zealand were taken from the New Zealand Traffic Emission Rates (NZTER) database using local vehicle fleet profiles derived from motor vehicle registrations. 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 and traffic conditions. However, assumptions underpinning the model were not documented. As a result, the Auckland Regional Council developed the Vehicle Emission Prediction Model (VEPM 3.0). Emissions factors for PM_{10}, CO, NOx, VOCs and CO_2 for this study have been based on VEPM 5.0. Default settings were used for all variables except:

- Vehicle fleet profile
    - based on vehicle registrations for Marlborough District for the year ending 30 April 2012
- Annual average temperature
    - Blenheim – based on a winter average temperature of 8 °C for 2011

Emission factors for SOx were estimated for diesel vehicles based on the sulphur content of the fuel (0.01%) and the assumption of 100% conversion to SOx. Total VKT for diesel vehicles were estimated based on the proportion of diesels in the vehicle fleet.

Table 4.2 details the emission factors used to estimate motor vehicle emissions for 2012 for Blenheim.

Table 4.1: Vehicle registrations in Marlborough for the year ending April 2012.

Blenheim	Petrol	Diesel	LPG	Other	Total
Cars	22,060	3,162	7	1	25,230
LCV	1,552	3,862	5	1	5,420
Bus	29	241			270

HCV		2,629			2,629
Miscellaneous	440	1203	9	0	1,652
Motorcycle	767				767
Total	24848	11097	21	2	35,968

Table 4.2: Emission factors for 2012 for Blenheim

	Hamilton g/VKT	**Source**
CO	5.4	VFEM 5.0
CO_2	250	VFEM 5.0
VOC	0.3	VFEM 5.0
NOx	0.73	VFEM 5.0
PM_{10}	0.05	VFEM 5.0
PM_{10} Brake and Tyre	0.01	VFEM 5.0
$PM_{2.5}$	0.03	British Columbia Lower Fraser Valley
$PM_{2.5}$ Brake and Tyre	0.006	British Columbia Lower Fraser Valley
Benzene	0.02	Proportion of VOC from Australian Pollution Inventory
SOx	0.004	Order of magnitude estimate only based on S content of diesel

Estimates of VKT were obtained from the Ministry of Transport by CAU for the year ending 2010 (Badger, 2012, pers comm). These are based on modelling and overestimate VKTs relative to vehicle registration information for 2010 (MOT, 2012) by around 8%. To align the model estimates to the vehicle registration data VKTs were adjusted downwards by 8%.

Table 4.3 shows the estimated number of VKTs for Blenheim for 2010 which are considered the best available information from which to estimate 2012 motor vehicle emissions. Time of day estimates were based on the time of day breakdown from the Havelock North - 2005 vehicle data because there was not any time of day data available for Blenheim.

Table 4.3: VKT by time of day for Blenheim.

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Blenheim	207937	49718	84422	63386	10411

Emissions for each time period were calculated by multiplying the emission factor by the VKT for that time period.

Emissions (g) = Emission Rate (g/VKT) * VKT (A-B)

4.1 Motor vehicle emissions

Around 12 kilograms per day of PM_{10} are estimated to occur from motor vehicle emissions in Blenheim. Around 22% of this is estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Blenheim include around 1.21 tonnes of CO, 152 kilograms of NOx and one kilograms of SOx (Table 4.4). In comparison, in Christchurch, where CO concentrations occasionally exceed ambient air quality guidelines during winter months, motor vehicles emit around 109 tonnes of CO within the main urban area.

Table 4.4: Summary of daily motor vehicle emissions in Blenheim.

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Blenheim	1930	12	6	1123	582	152	79	1	0
		VOC		CO_2		Benzene		BaP	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha	kg	g/ha
Blenheim	1930	68	35	52	27	3	2	7	4

5 Industrial and Commercial

5.1 Methodology

An evaluation of potential discharges to air from industrial and commercial sources in Blenheim was undertaken to identify activities that discharge PM_{10}. Marlborough District Council staff provided information on consented activities.

Schools in Blenheim with resource consents for air discharges were also surveyed by phone to determine the status of their source of their heating and to gather up to date fuel consumption data. The results showed eight schools in Blenheim used coal boilers for home heating. A number of these schools had expired resource consents for air discharges.

The selection of industries for inclusion in this inventory was based on potential for PM_{10} emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge primarily VOCs were not included in the assessment.

As site specific emissions data were not available, emissions were estimated using activity data and emission factor information, as indicated in Equation 5.2. Activity data from industry includes information such as the quantities of fuel used, or in the case of non-combustion activities, materials used or produced. Activity data was collected using a phone survey or data provided by Marlborough District Council staff. Data were collected for winter, autumn, spring and summer.

Equation 5.2 Emissions (kg) = Emission factor (kg/tonne) x Fuel use (tonnes)

The emission factors used to estimate the quantity of emissions discharged are shown in Table 5.1. The coal fired boiler emission factors for PM_{10} are based on New Zealand specific emission factors as described in Wilton et. al. 2007. Other emission factors are from the USEPA AP42 database[1] with the exception of LFO boilers for which the PM_{10} emission factor is based on Wilton & Baynes (2010).

Fugitive dust emissions from industrial and commercial activities were not included in the inventory assessment because of difficulties in quantifying the emissions.

[1] http://www.epa.gov/ttn/chief/ap42/index.html

Table 5.1: Emission factors for industrial discharges.

	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO_2 g/kg	
Underfeed stokers	2.0	5.5	4.8	13.5	0.1	2400	
LFO boiler	4.2	0.67	6.3	40.0	0.2	3194	
Vekos coal boiler	3.8	2.5	5.0	18.0	0.1	2400	
Diesel boiler	0.3	0.67	3.2	0.1	0.2	3194	
Crematorium kg/hr	0.04		0.1			78	

5.2 Industrial and commercial emissions

Discharges from eleven industrial and commercial activities were included in the assessment. Two additional industrial activities (Flight Timbers and Musgrove) are located to the west of Blenheim but outside of the inventory area and Talleys to the north was also outside of the inventory area, but within the airshed area. Both Flight Timbers and Musgroves have wood fired boilers and may contribute to industrial PM_{10} concentrations in the inventory area when the wind is blowing from a westerly direction. Similarly boilers from Talleys are estimated to emit around 12 kilograms of PM_{10} per day but are likely to contribute to elevated PM_{10} concentrations in Redwoodtown less often because of the location to the north of Blenheim.

Around nine kilograms of PM_{10} are discharged to air from industrial and commercial activities in Blenheim on an average winters' day.

The extent of contribution of Flight Timbers and Musgroves is unknown as the inventory includes only discharges from within the inventory area. However, an evaluation of industrial discharges to air undertaken by Specialist Environmental Services (2007) indicates PM_{10} emissions of 65 kg per day from Flight Timbers. If this reflects the existing emission rate and if the discharge occurred within the inventory area the industrial contribution to PM_{10} would be around 74 kilograms per day and the relative contribution of industry would be 10% of total PM_{10}. Air dispersion modelling suggests the contribution of Flight Timbers to 24-hour average PM_{10} at Redwoodtown is around 1.5 µg m^{-3} (SKM, 2007).

Table 5.2: Summary of industrial emissions (daily winter) in Blenheim.

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Blenheim	1930	9	5	24	13	22	11	51	27
		VOC		CO_2		**Benzene**			
	Hectares	**kg**	**g/ha**	**t**	**kg/ha**	**kg**	**g/ha**		
Blenheim	1930	0	0	12	6	0.01	0.00		

6 Outdoor burning

Outdoor burning of green wastes or household material can contribute to PM_{10} concentrations and also discharge other contaminants to air. In some urban areas of New Zealand outdoor burning is prohibited because of the adverse health and nuisance effects associated with these emissions. Outdoor burning includes any burning in a drum, incinerator or open air on residential properties in the study area.

The Wairau/Awatere resource management plan currently permits outdoor burning of vegetative matter. This plan is currently under review as are rules relating to outdoor burning.

6.1 Methodology

Emissions from outdoor burning in Blenheim were estimated for the winter months based on data collected during the 2012 domestic home heating survey. The survey showed 8% of households burnt rubbish in the outdoors during the winter. The average number of fires per day during winter was 33.

Emissions were calculated based on the assumption of an average weight of material per burn of 75 kilograms and using the emission factors in Table 6.1. This was based on an estimated fire size of $1m^2$ and 75 kg/m^2. Emission factors of benzene were based on wood burning for domestic heating and are indicative only. Emissions of these contaminants will be largely influenced by the material burnt.

Estimates of PM_{10} and other emissions for each area are detailed in sections 6.2 to 6.4. It should be noted, however, that there are a number of uncertainties relating to the calculations. In particular it is assumed that burning is carried out evenly throughout the winter, whereas in reality it is highly probable that a disproportionate amount of burning is carried out during weekend days. Thus on some days no PM_{10} from outdoor burning may occur and on other days it might be many times the amount estimated in this assessment.

Table 6.1: Outdoor burning emission factors (AP42, 2002).

	PM_{10} g/kg	CO g/kg	NOx g/kg	SOx g/kg	VOC g/kg	CO_2 g/kg	Benzene g/kg
Outdoor burning	8	42	3	0.5	4	1470	0.97

In Blenheim around 31 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average from outdoor burning. Outdoor burning also produces around four tonnes of carbon dioxide on average per day during winter.

Table 6.2: Outdoor burning emission estimates for Blenheim.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 t/ day	Benzene kg/day
Summer (Dec-Feb)	8	26	2	0	3	1	0
Autumn (Mar-May)	21	69	5	1	7	2	1
Winter (June-Aug)	31	104	7	1	11	4	1
Spring (Sept-Nov)	22	73	5	1	7	3	1

7 Other sources of emissions

This inventory includes all likely major sources of PM_{10} within the inventory area that can be adequately estimated using inventory techniques. Other sources of emissions not included in the inventory that may contribute to measured PM_{10} concentrations at some times during the year include dusts (a portion of which occur in the PM_{10} size fraction) and sea spray.

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 all areas are likely to be less than one kilogram per day[2].

[2] Pacific Air and Environment (1999) indicates around 0.07 grams of PM_{10} are emitted per household per day for the Wellington Region.

8 Total emissions

Around 627 kilograms of PM_{10} is discharged to air on an average winter's day into the air over Blenheim. Figure 8.1 shows that domestic home heating is the main source of these emissions contributing 92% of the daily wintertime emissions. Outdoor burning contributes 5%, industry 1% and transport 2% of the 2012 winter time PM_{10} emissions.

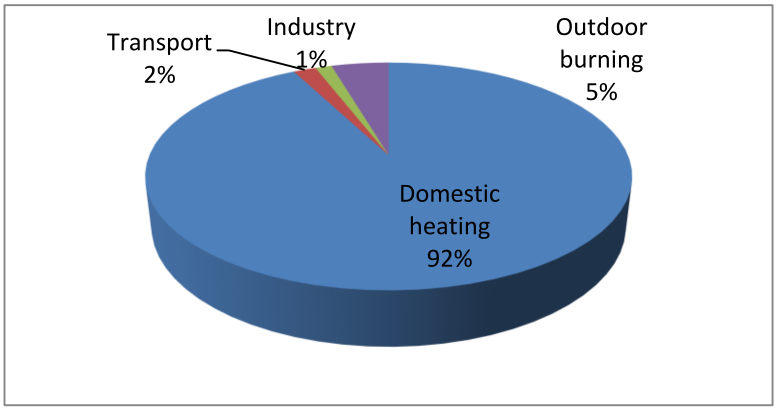

Figure 8.1: Relative contribution of sources to daily winter PM_{10} emissions in Blenheim.

Domestic home heating is also the main source of benzene, CO and CO_2 in Blenheim. Motor vehicles are the main source of NOx and industry is the main source of SO_2 in Blenheim (Figure 8.2).

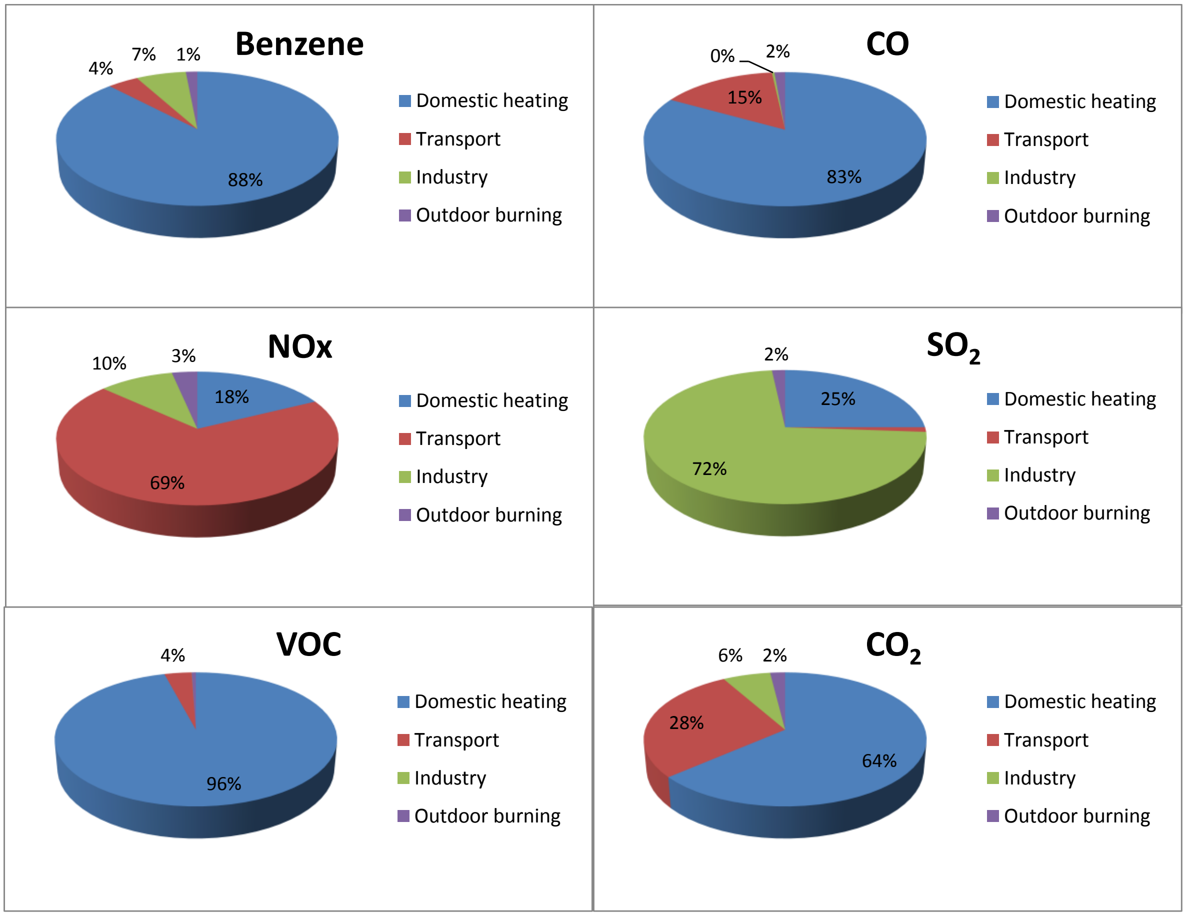

Figure 8.2: Relative contribution of sources to contaminant emissions in Blenheim.

Table 8.1 shows daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) and Table 8.2 shows seasonal variations in PM_{10} emissions. Although domestic home heating is the dominant source of PM_{10} emissions during the winter months, during the summer, industry, motor vehicles and outdoor burning are the dominant contributors to PM_{10} emissions.

Table 8.1: Daily contaminant emissions from all sources (winter average).

	PM_{10}		**CO**		**NOx**		**SOx**	
	Kg	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Domestic home heating	627	325	6145	3184	39	20	18	9
Transport	12	6	1123	582	152	79	1	0
Industry	9	5	24	13	22	11	51	27
Outdoor burning	31	16	104	54	7	4	1	1
Total	678	352	7396	3832	221	114	71	37
	VOC		**CO_2**		**Benzene**			
	kg	**g/ha**	**t**	**g/ha**	**kg**	**g/ha**		
Domestic home heating	1828	947	118	61	69	36		
Transport	68	35	52	27	3	2		
Industry	0	0	12	6	0	0		
Outdoor burning	11	6	4	2	1	1		
Total	1907	988	185	96	654	339		

Table 8.2: Monthly variations in daily PM_{10} emissions.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	**%**	**kg/day**	**%**	**kg/day**	**%**	**kg/day**	**%**	**kg/day**
January	5	12%	8	21%	4	14%	12	33%	37
February	5	12%	8	20%	5	16%	12	31%	39
March	15	22%	21	30%	5	9%	12	18%	68
April	52	49%	21	20%	5	6%	12	12%	105
May	387	88%	21	5%	6	1%	12	3%	441
June	604	90%	31	5%	9	1%	12	2%	669
July	627	91%	31	4%	9	1%	12	2%	691
August	564	90%	31	5%	9	1%	12	2%	629
September	196	80%	22	9%	7	3%	12	5%	246
October	55	53%	22	21%	5	6%	12	12%	103
November	18	27%	22	32%	5	9%	12	18%	67
December	9	21%	8	19%	4	12%	12	29%	42
Total kg year	77728		7413		2226		4449		

9 Comparison to 2005

Table 9.1 compares reported heating methods in 2012 to those from 2005. Results suggest a decrease in the proportion of households using wood burners, gas, open fires and multi fuel burners (although differences in the latter two are within the margin of error of the two surveys).

Table 9.1: Home heating methods and fuels in 2005 and 2012.

	2012 heating methods		2005 heating methods	
	%	HH		
Electricity	65%	6,076	61%	5,248
Total Gas	7%	669	14%	1,255
Flued gas	3%	257	0%	-
Unflued gas	4%	412	14%	1,255
Oil	1%	51	0%	-
Open fire	1%	103	5%	456
Open fire – wood	1%	103	4%	342
Open fire – coal	<1%	26	1%	57
Total Wood burner	42%	3,965	52%	4,507
Older wood burners	16%	1,512	29%	2,482
Mid aged wood burner	13%	1,243	12%	1,045
Newer wood burner	13%	1,210	11%	980
Multi fuel burners	2%	154	7%	570
Multi fuel burners-wood	1%	103	7%	570
Multi fuel burners-coal	1%	77	3%	285
Total wood	44%	4,171	63%	5,419
Total coal	1%	103	4%	342
Total		9,397		8,671

In 2005, 921 kg/day of PM_{10} was estimated from domestic home heating. When this is adjusted for differences in methodology (different wood weight assumptions) a total of 829 kg/day of PM_{10} is estimated for Blenheim. In 2012 the amount of PM_{10} from domestic heating was estimated at 627 kg/day, a 24% reduction.

A reduction in emissions from other sources of around 32 kg/day is also likely. Based on MOT VKT data for 2010 motor vehicle emissions for 2005 are more likely to have been slightly less than the lower limit estimated for Blenheim of 39 kg/day. The 2012 estimate for motor vehicles is 12 kilograms per day and it is likely that emissions from this source have reduced by around 20 kg/day as a result of improvements in vehicle engine technology. Industrial emissions have reduced by around 12 kg/day as a result of a number of industries shutting down and several schools changing from coal burning to diesel or electricity.

Although the 2005 inventory shows around 60 kg/day of PM_{10} from outdoor burning compared with 31 kg/day in 2012 it is uncertain whether any change has occurred as no surveying of outdoor burning in Blenheim took place in 2005.

Overall the inventory suggests a 26% reduction in PM_{10} emissions from 2005 to 2012.

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Appendix A: Home Heating Questionnaire

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 Marlborough District Council

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?

(b) 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)

(c). Do you use any other heating system in your main living area in a typical year? *(If yes then question 3 otherwise Q9)*

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

(c) 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)

(h) Do you buy wood for your log burner, or do you receive it free of charge?

(i) What proportion would be bought?

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 multi fuel burner during non winter months How much coal do you use per day during the other months?

(l) Do you buy wood for your multi fuel burner, or do you receive it free of charge?

(m) What proportion would be bought?

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 open fire 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 open fire during non winter months How much coal do you use per day during the other months?

(k) Do you buy wood for your open fire, or do you receive it free of charge?

(l) What proportion would be bought?

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 decade/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.

D4 How many people live at your address?

D5 Do you own your home or rent it?

D6 Approximately how old is your home?

D7 How many bedrooms does your home have?

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 wood burners 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 and with adjustments made to account for more recent real life testing of pre 1994 and NES compliant wood burners (Wilton & Smith, 2006; Smith, et. al., 2008).

The Christchurch 1999 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 21 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). 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.

The older wood burner emission rates were based on testing of older wood burners “in situ” in Tokoroa during 2005 as detailed in Wilton and Smith, 2006. The burner age category for the latter testing is older (pre 1994) than the category included here (pre 1999). As a result emission factors previously used for pre 1994 burners were adjusted downwards based on the assumption that one third of the burners in this category would be between 1994 and 1999. Previously an emission factor for PM_{10} of 7 g/kg was used for 1994 to 1999 burners. Post 2004 emission factors were based on an emission factor of 3 g/kg based on the results of Smith et. al., 2008. The average of the emission factor for NES compliant burners and older burners of 6 g/kg PM_{10} was used for burners in the age category 1999 to 2004.

The gas and oil PM_{10} emission factors were based on testing in New Zealand (Scott, 2004).

Domestic heating emission factors for CO, NOx, SOx and CO_2 were also based on the Christchurch 1999 emission factor revisions with adjustments made for relationships with PM_{10} where appropriate.

Emissions factors for BaP were based on AP42 factors for conventional wood burners (no baffles) for open fires and on phase II burners (with baffles, non catalytic) for wood burners.

Benzene emission factors were based on AP42 for conventional wood burners. Benzene emission factors for coal burning was based on AP42 coal fired boiler data because no domestic information was available. Emission factors for BaP for coal burning was based on AP42 factors for burning anthracite coal on open fires as no data were available for bituminous or sub bituminous coals.