Environment Waikato Technical Report 2010/13

Air Emission Inventory – Taupo, Thames and Huntly 2009

www.ew.govt.nz
ISSN 1172-4005 (Print)
ISSN 1177-9284 (Online)

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October 2009

Document #: 1559796

Peer reviewed by:
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Approved for release by:
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Air Emission Inventory – Taupo, Thames and Huntly 2009

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October 2009

Executive Summary

The purpose of this emission inventory is to determine the sources of emissions to air from Taupo, Thames and Huntly to assist in the management of the air resource. The sources that are included in the emission inventory are 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.

The contaminants included in the emission inventory are: suspended particles (PM_{10}) carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds, carbon dioxide, benzene and benzo(a)pyrene. The report focuses on PM_{10} as air quality monitoring throughout New Zealand suggests that PM_{10} is the only contaminant that breaches national environmental standards for air quality.

In Taupo, Thames and Huntly, a domestic home heating survey was undertaken to determine the proportions of households using different heating methods and fuels. The results show that in Taupo, wood burners are the most common method of heating the main living area with 45% of households using them. This was closely followed by 44% of households using electricity as the main form of heating. In Thames electricity is the most common type of home heating method in the main living area, with 53% of households using this method. The second most common method of home heating is wood burners with 44% of householders using them to heat their main living area. In Huntly, 46% of households used electricity and 32% of householders used wood burners. In all areas 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 in Taupo, accounting for 91% of all emissions. Other sources included transport (7%) and outdoor burning (2%). The industrial contribution to PM_{10} emissions in urban Taupo was negligible. On an average winter's night, around 747 kilograms of PM_{10} are discharged from these sources. The main source of PM_{10} emissions for Thames was domestic home heating, which accounted for 88% of total emissions. Outdoor burning contributed six percent, industry contributed four percent and transport contributed two percent to total emissions. Around 326 kilograms of PM_{10} are discharged on an average winter's night from these sources in Thames. Domestic heating was also the main source of PM_{10} emissions from within the Huntly airshed, accounting for 91% of total emissions. Other sources in Huntly included outdoor burning (6%) motor vehicles (2%) and industry (1%). On an average winter's night, around 512 kilograms of PM_{10} are discharged from these sources.

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1 Introduction

The purpose of an emission inventory is to determine the sources of emissions in a particular area for air quality management purposes. 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.

Emissions inventories are an important tool to manage air quality. Once the sources of contaminants are known then Regional Councils can begin to develop strategies, through the development of Air Quality Plans to manage key contaminants. In New Zealand the main contaminant of concern is PM_{10}. Air quality monitoring throughout New Zealand shows that PM_{10} concentrations exceed the National Environmental Standard for PM_{10} of 50 µg m^{-3} (24-hour average) in over 30 urban areas.

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, benzene and benzo(a)pyrene.

This emission inventory is for Taupo, Thames and Huntly. Previously, an emission inventory was completed for Taupo in 2004 (Wilton, 2004), and a domestic heating survey was undertaken in Huntly during 2000 (Wilton, 2001). No historical evaluation of sources of air pollution has been carried out for Thames.

This emission inventory provides an estimate of the amount of PM_{10} discharged in to the air for average and worst case winter nights and the relative contribution from domestic, motor vehicles and industrial sources for Taupo, Thames and Huntly. Other minor emissions are also considered.

2 Inventory Design

This emission inventory focuses on PM_{10} emissions as PM_{10} has been identified as the main contaminant of concern in urban New Zealand. It is unlikely that concentrations of other contaminants are likely to exceed national environmental standards (NES).

No NES exists for benzo(a)pyrene (BaP). However, concentrations of this contaminant have been found to be high and in excess of ambient air quality guidelines in Christchurch. A strong correlation was found with PM_{10} concentrations, which in Christchurch occur as a result of emissions from domestic home heating, and BaP concentrations (McCauley, 2005). In Hamilton, where PM_{10} concentrations rarely exceed 50 µg m^{-3} the annual average concentration for BaP was measured as 0.4 ng m^{-3} for the period March 2007 to March 2008. This result was statistically indistinguishable from the annual average guideline for BaP of 0.3 ng m^{-3}. However, the results reinforce the potential for high BaP concentrations within the Waikato Region in areas that have PM_{10} concentrations that are higher than Hamilton and result from domestic home heating.

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), benzene and benzo(a)pyrene (BaP). The latter contaminant has been included here because of the potential issues identified above.

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 Taupo, Thames or Huntly would cause ozone problems. However, ozone formation as a result of emissions from Auckland could impact on areas such as Thames. 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 Taupo, Thames and Huntly inventory study areas are based on census area unit (CAU) boundaries.

Taupo is located on the shores of Lake Taupo, New Zealand's largest lake, north east of where the Waikato River begins. It is located in the centre of a volcanic and geothermal area. Mount Tauhara lies six kilometres to the east of Taupo and the area is surrounded by forestry. The Taupo airshed (Figure 2.1) is unusual in having two distinct areas, one being predominantly urban and the other, to the northeast, being mainly industrial. Under most circumstances, contributions from one area to the other are expected to be minimal. The main focus of this emissions inventory is the urban part of the Taupo airshed, which will be referred to as urban Taupo. However, as part of this work, total PM_{10} emissions from the five significant industrial sources that are located within the industrial part of the Taupo airshed were also estimated.

The census area units used in the emission inventory for urban Taupo are:

- Rangatira
- Nukuhau
- Taupo Central
- Tauhara
- Hilltop
- Waipahihi
- Richmond Heights

Thames is located south east of the Firth of Thames on the banks of the Kauaeranga River. Most of the town occupies a coastal strip of flat land at the western base of the Coromandel Range. The Hauraki Plains are to the south of Thames. Thames is 119 kilometres south east of Auckland and 110 kilometres north east of Hamilton. The census area units used in the emission inventory for Thames are:

- Moanataiari
- Parawai

Huntly is situated on the banks of the Waikato River in a low lying basin. It is approximately 90 kilometres south of Auckland and 45 kilometres north of Hamilton. The town is visually dominated by a thermal (coal and gas fired) power station (Huntly Power Station operated by Genesis Energy) and the district includes the northern part of the Waikato Coalfield where there is underground and opencast mining. The census area units used in the emission inventory for Huntly are:

- Huntly West
- Huntly East

It should be noted that this inventory is not intended to cover emissions from the power station, which is located outside the Huntly airshed boundary. Potential impacts of the power station to ambient air quality in the town of Huntly are addressed as part of the resource consent process and reflected in this operation's resource consent conditions.

Figures 2.1, 2.2 and 2.3 show the airshed boundaries for Taupo, Thames and Huntly. The red numbers on each map depict the location of air discharge resource consents for each area.

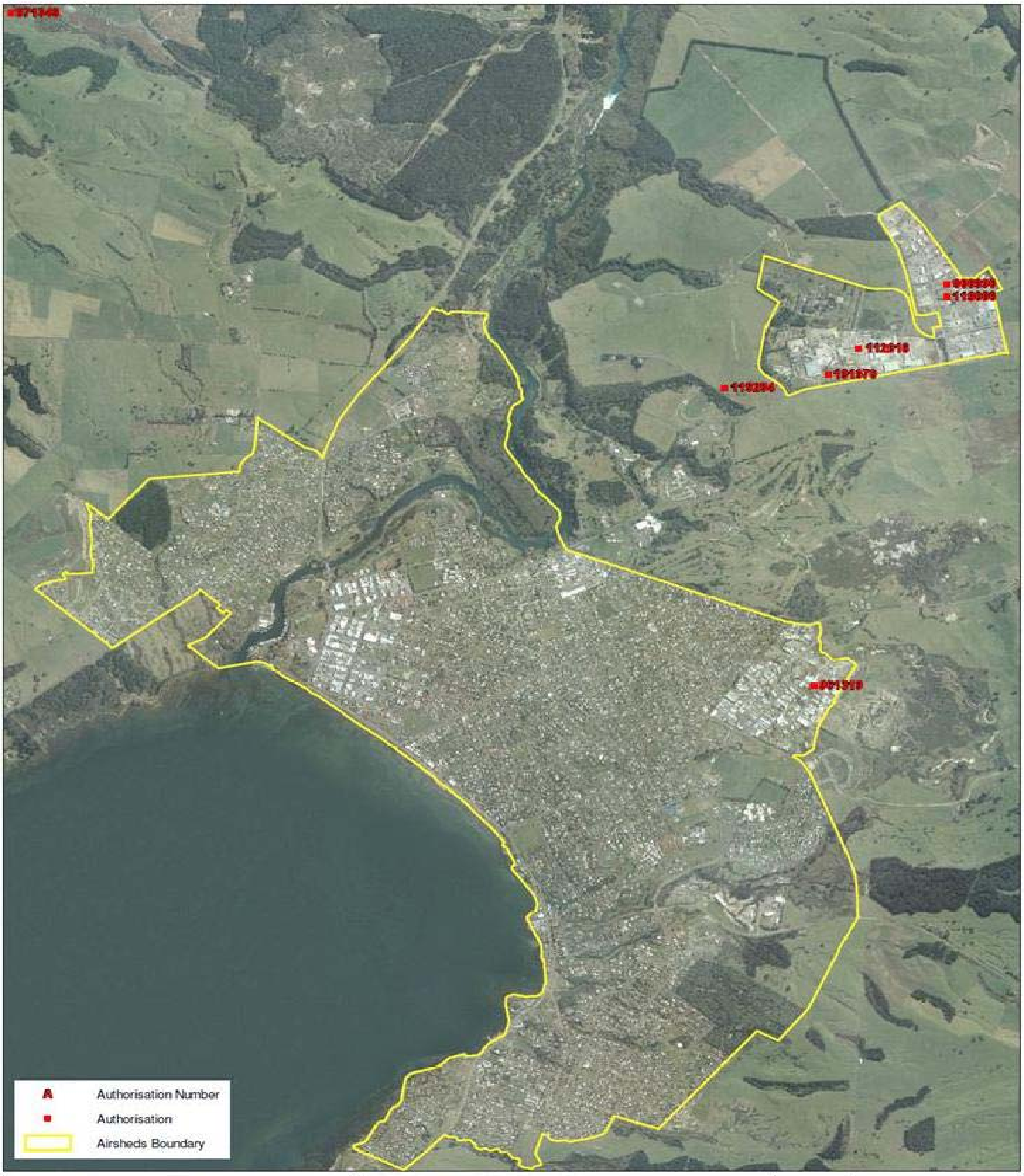


Figure 2.1: Taupo Airshed (source Environment Waikato).

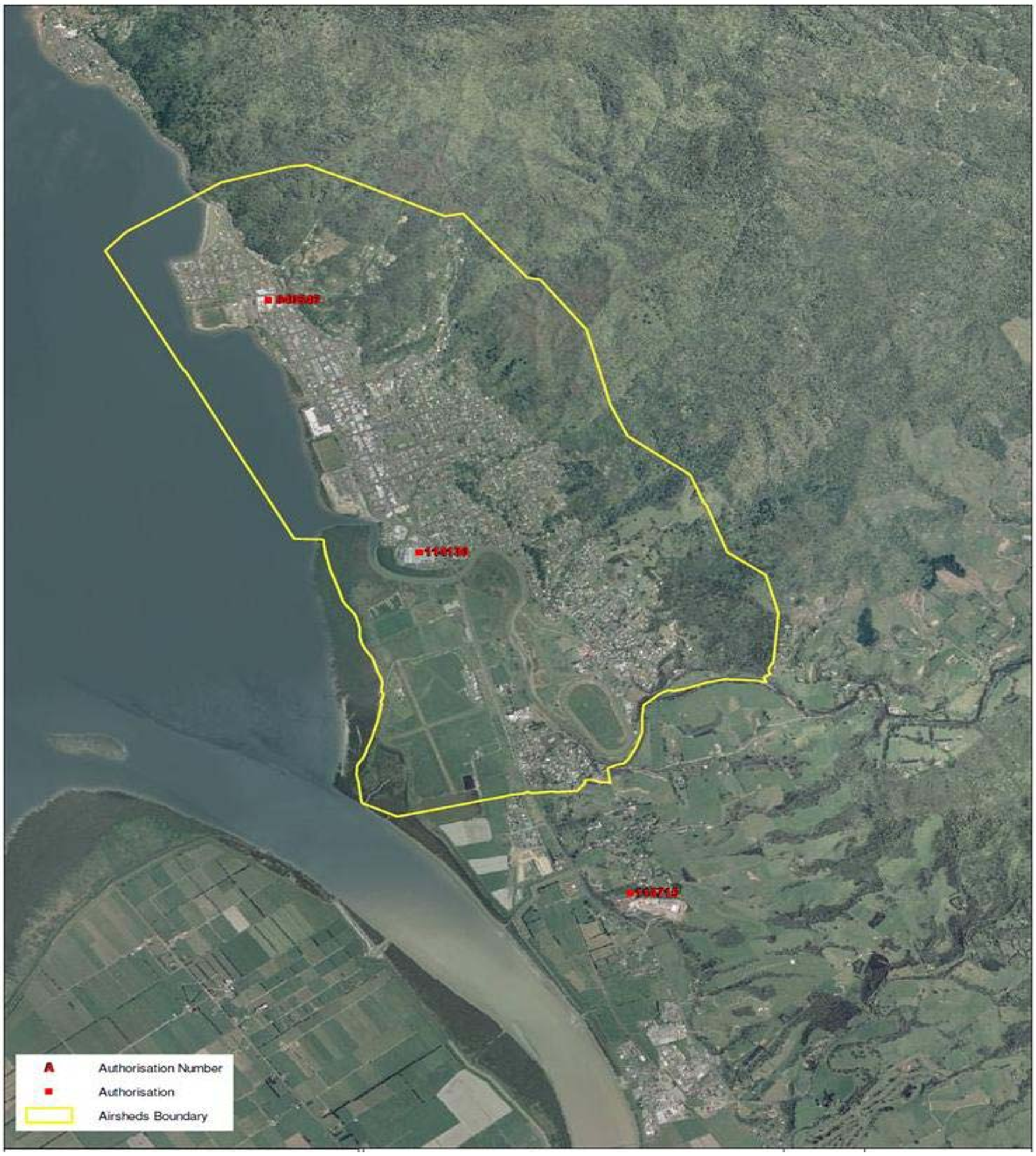


Figure 2.2: Thames Airshed (source Environment Waikato).

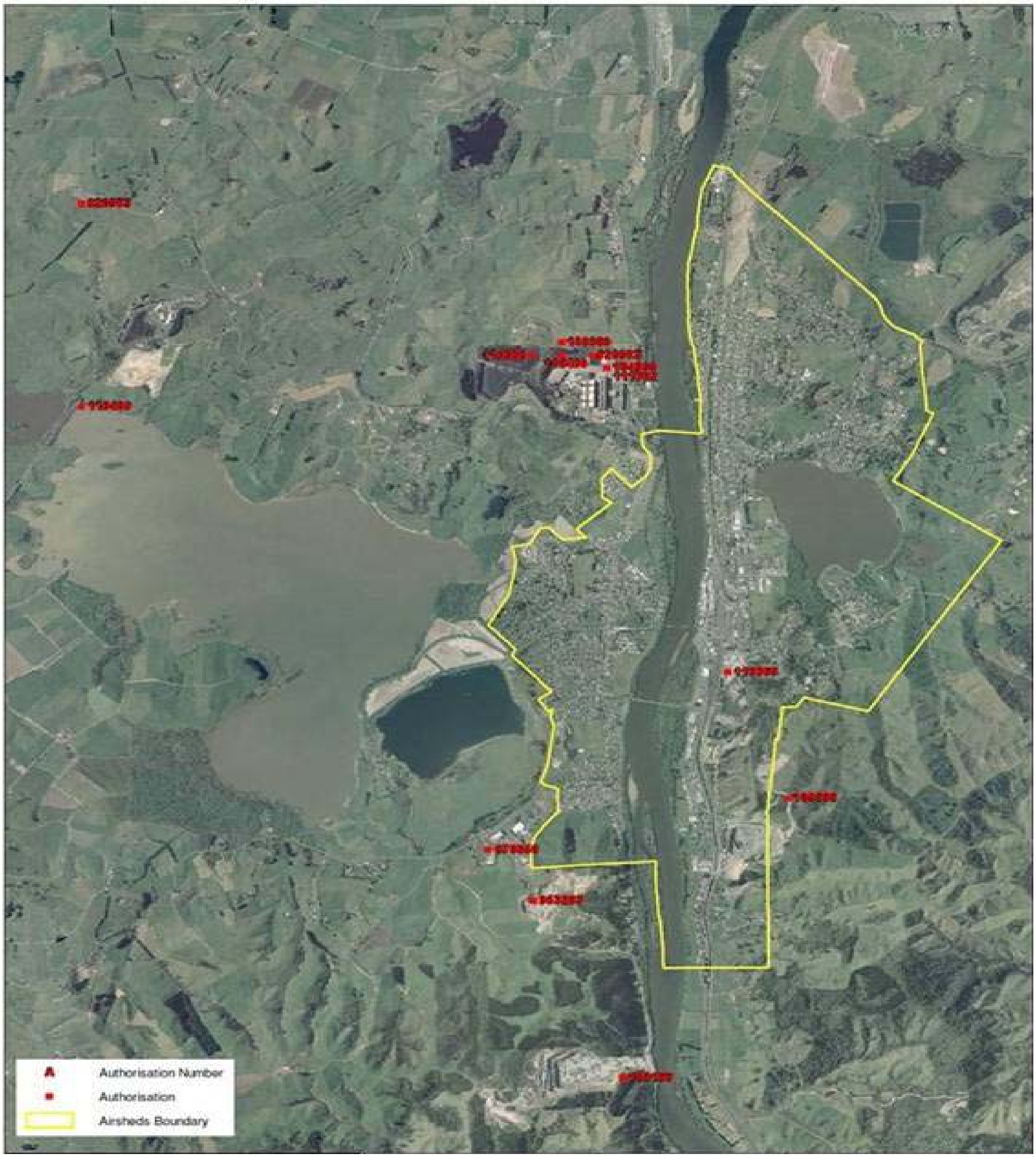


Figure 2.3: Huntly Airshed (source Environment Waikato).

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 models 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 Taupo, Thames and Huntly was collected using a household survey carried out by Digipol during July and August 2009 (Appendix A). Table 3.1 shows the number of households based on 2006 census data for the airshed area, the estimated households for 2009, and survey details. The 2009 estimates were made using Statistics New Zealand population projections for each District[1].

Table 3.1: Summary household, area and survey data for the Taupo, Thames and Huntly airsheds.

	Households by census area unit 2006	Estimated households 2009	Sample size	Area (ha)	Sample error
Taupo	7896	7944	311	1669	5%
Thames	2521	2552	300	1224	5%
Huntly	2717	2717	291	1017	5%

Home heating methods were classified as; electricity, open fires, wood burners 10 years or older (pre 1999), wood burners five to 10 years old (1999-2004), wood burners less than five years old (post 2004), pellet fires, multi fuel burners, gas burners and oil burners. The post 2004 wood burner category roughly corresponds with wood burners meeting the NES design criteria, although the latter was introduced in September 2005 and the post 2004 wood burner category may therefore include some burners that do not comply with the NES.

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.

[1] The exception was Huntly for which no increase in population was projected.

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	BaP g/kg
Open fire - wood	10	100	1.6	0.2	30	1600	0.97	0.002
Open fire - coal	21	80	4	5.0	15	2600	0.00065	2.70E-06
Pre 1999 burners	9.7	97	0.5	0.2	29	1600	0.97	0.003
1999-2004 burners	6	60	0.5	0.2	18	1600	0.97	0.003
Post 2004 burners	3	30	0.5	0.2	9	1600	0.97	0.003
Pellet burners	2	20	0.5	0.2	6	1600	0.97	0.003
Multi-fuel[1] - wood	13	130	0.5	0.2	39	1600	0.97	0.002
Multi-fuel[1] – coal	28	120	1.2	3.0	15	2600	0.97	2.70E-06
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 more recently, 1.9 kilograms. The latter value is based on a survey of 219 households in Christchurch during 2002 and represents the most comprehensive assessment of average fuel weight. A recent burner emission testing programme carried out in Tokoroa during 2005 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. Previous studies for Taupo have used 1.6 kg (2000 inventory) and 1.9 kg (2004) inventory. Because of the more recent data on fuel use collected during the Tokoroa and the Nelson, Rotorua, and Taumaranui testing programmes, the lower of these two values (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

3.2.1 Taupo

Table 3.3 shows that in urban Taupo, during 2009, wood burners were the main heating method, with 45% of households using this method to heat their main living area. The second most common method for home heating was electricity (44%) followed by gas (31%).

Open fires are used by only five percent of Taupo residents and three percent of residents use multi fuel burners to heat their main living area. For households that use gas, less than one third used unflued gas systems. Table 3.3 also shows that households rely on more than one method of heating their main living area during the winter months.

Wood was the most common fuel for households using solid fuel heating methods in Taupo, with 53% of households using this fuel with around 87 tonnes of wood burnt per winter's night. Coal use in Taupo is minimal with one percent of households using coal to heat their main living area. Around 0.9 tonnes of coal is burnt per winter's night.

Table 3.3: Home heating methods and fuels in urban Taupo.

	Heating methods		Fuel Use	
	%	**HH**	**t/day**	**%**
Electricity	44%	3499		
Total Gas	31%	2478	5	5%
Flued gas	19%	1481		
Unflued gas	13%	996		
Oil	0%	-	-	0%
Open fire	5%	434		
Open fire – wood	5%	434	8	9%
Open fire – coal	0%	-	-	0%
Total Wood burner	45%	3576	75	80%
Pre 1999 wood burner	21%	1707	36	36%
1999-2004 wood burner	11%	870	18	21%
Post 2004 wood burner	13%	999	21	22%
Multi fuel burners	3%	230		
Multi fuel burners-wood	3%	230	5	5%
Multi fuel burners-coal	1%	102	0.9	1%
Pellet burners	0%	-	-	0%
Total wood	53%	4240	87	94%
Total coal	1%	102	0.9	1%
Total		7944	93	

3.2.2 Thames

In Thames during 2009, electricity was the most commonly used home heating method, with 53% of households using this method to heat their main living area (Table 3.4). Around 44% of households used wood burners and 21% used gas to heat their main living area. Around three quarters of households using gas used unflued gas systems. Table 3.4 also shows that households rely on more than one method of heating their main living area during the winter months.

In Thames the most common fuel for households using solid fuel heating methods in was wood, with 59% of households using this fuel. Around 28 tonnes of wood is burnt on an average winter's night in Thames. Around five percent of households used coal to heat the main living area in their homes, with 2.2 tonnes being burnt per night.

Table 3.4: Home heating methods and fuels in Thames.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	53%	1352		
Total Gas	21%	536	0	1%
Flued gas	6%	154		
Unflued gas	15%	381		
Oil	0%	-	-	0%
Open fire	7%	179	-	0%
Open fire – wood	7%	179	4	13%
Open fire – coal	1%	34	0.3	1%
Total Wood burner	44%	1123	21	68%
Pre 1999 wood burner	20%	517	10	32%
1999-2004 wood burner	12%	312	6	16%
Post 2004 wood burner	11%	293	6	20%
Multi fuel burners	8%	204		
Multi fuel burners-wood	8%	204	3	11%
Multi fuel burners-coal	4%	94	1.9	6%
Pellet burners	0%	-	-	0%
Total wood	59%	1506	28	91%
Total coal	5%	128	2.2	7%
Total		2552	31	

3.2.3 Huntly

In 2009, electricity was the most commonly used home heating method in Huntly, with 46% of households using this method to heat their main living area. The second most common form of home heating was wood burners and these were used by around 32% of households. Thirty percent of households use gas and over two thirds of these used unflued gas systems. Table 3.5 shows that households rely on more than one method of heating their main living area during the winter months.

In Huntly, wood was the most common fuel for households using solid fuel heating methods with 58% of households using this fuel. On an average winter's night, around 29 tonnes of wood is burnt in Huntly. Twenty percent of households use coal to heat their homes, burning around 7.8 tonnes per night, significantly more than in Taupo and Thames.

Table 3.5: Home heating methods and fuels in Huntly.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	46%	1242		
Total Gas	30%	812	1	2%
Flued gas	8%	215		
Unflued gas	22%	597		
Oil	1%	28	0.0	0%
Open fire	9%	252	-	0%
Open fire – wood	9%	233	4	10%
Open fire – coal	6%	159	1.9	5%
Total Wood burner	32%	859	18	49%
Pre 1999 wood burner	16%	435	9	26%
1999-2004 wood burner	9%	233	5	12%
Post 2004 wood burner	7%	191	4	10%
Multi fuel burners	18%	476		
Multi fuel burners-wood	18%	476	7	19%
Multi fuel burners-coal	14%	392	5.9	16%
Pellet burners	0%	-	-	0%
Total wood	58%	1568	29	78%
Total coal	20%	551	7.8	21%
Total		2717	38	

3.3 Emissions from domestic heating

3.3.1 Taupo

In urban Taupo, 51% of PM_{10} from domestic heating during the winter comes from pre 1999 wood burners (Figure 3.1). Wood burners installed between 1999 and 2004 contribute to 16% of domestic heating PM_{10} emissions. Multi fuel burners contribute 13% of PM_{10} from domestic heating, open fires (11%), followed by wood burners installed post 2004 (9%).

Tables 3.6 and 3.7 show the estimates of wintertime contaminant emissions for different heating methods under average and worst-case scenarios. The tables indicate that from June to August, average daily wintertime PM_{10} emissions are around 683 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method. Under the worst-case scenario around 765 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 (96%) of domestic PM_{10} emissions come from the burning of wood, with four percent from the burning of coal.

Figures 3.2 and 3.3 show the monthly variation in appliance use and average days per week used. The seasonal variation in contaminant emissions is shown in Table 3.8. Figure 3.4 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

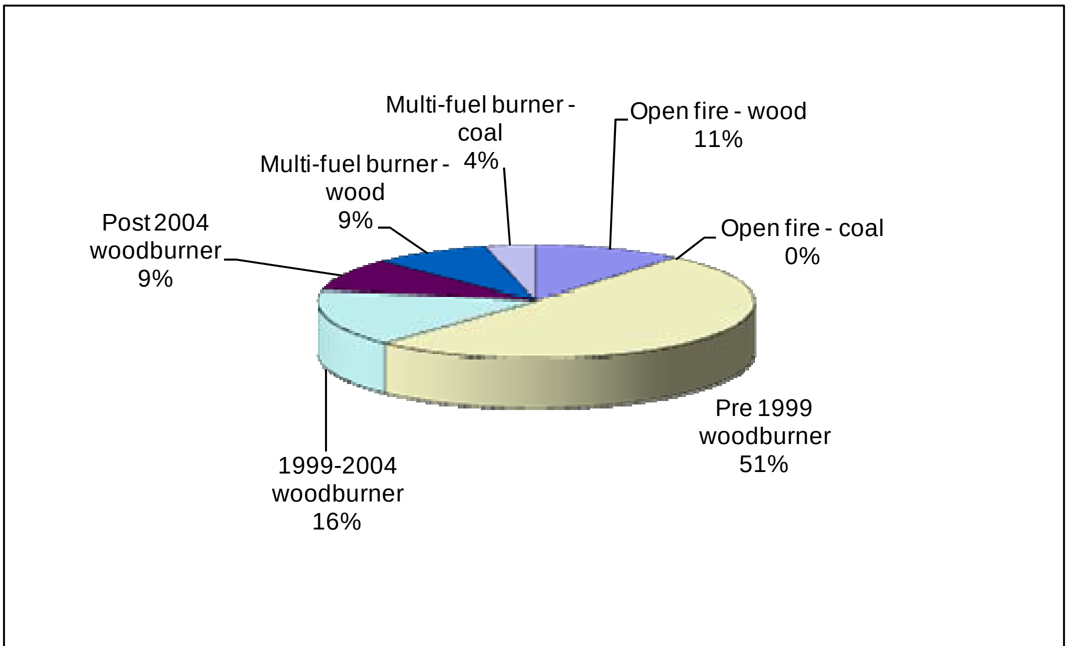


Figure 3.1: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in urban Taupo.

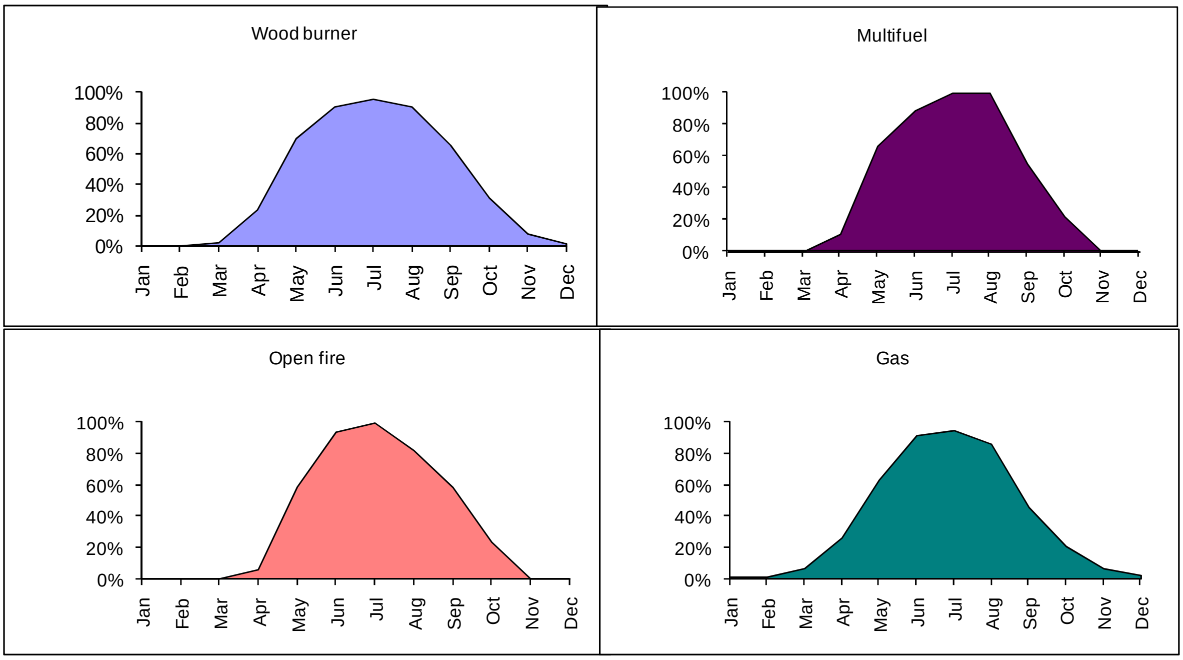


Figure 3.2: Monthly variations in appliance use in Taupo.

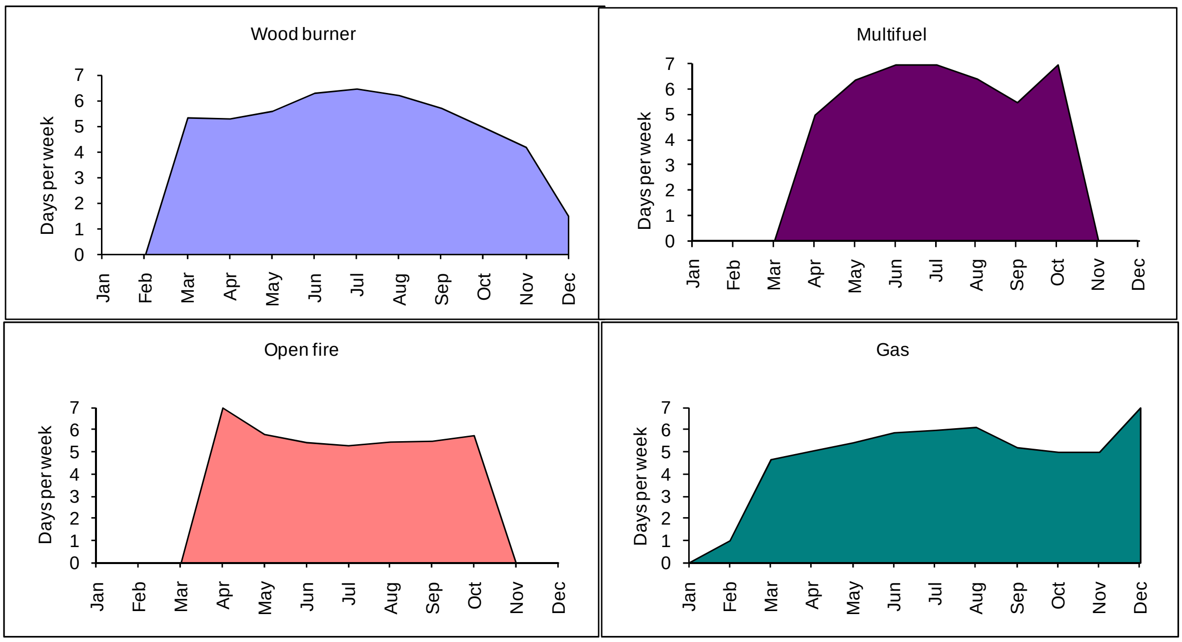


Figure 3.3: Average number of days per week appliances are used in Taupo.

Table 3.6: Taupo winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	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	7.6	8%	76	45	11%	759	455	11%	12	7	21%	2	1	7%	228	136	11%	12	7	8%	7	4	9%	0.0	0.0	6%
Open fire - coal	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	0.0	0%
Wood burner																										
Pre 1999 wood burner	35.9	39%	348	209	51%	3484	2087	52%	18	11	30%	7	4	35%	1042	624	53%	57	34	37%	35	21	41%	0.1	0.1	43%
1999-2004 wood burner	18.3	20%	110	66	16%	1098	658	16%	9	5	15%	4	2	18%	329	197	17%	29	18	19%	18	11	21%	0.1	0.0	22%
Post 2004 wood burner	21.0	23%	63	38	9%	630	378	9%	11	6	18%	4	3	21%	189	113	10%	34	20	22%	20	12	24%	0.1	0.0	25%
Pellet Burner	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	0.0	0%
Multi fuel burner																										
Multi fuel– wood	4.6	5%	60	36	9%	604	362	9%	2	1	4%	1	1	5%	181	108	9%	7	4	5%	5	3	5%	0.0	0.0	4%
Multi fuel – coal	0.9	1%	26	15	4%	110	66	2%	1	1	2%	3	2	14%	14	8	1%	2	1	2%	0	0	0%	0.0	0.0	0%
Gas	4.6	5%	0	0	0%	1	0	0%	6	4	10%	0	0	0%	0	0	0%	12	7	8%	0	0	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	0.0	0%
Total Wood	87.5	94%	657	394	96%	6575	3939	98%	52	31	88%	17	10	86%	1969	1180	99%	140	84	91%	85	51	100%	0.3	0.1	100%
Total Coal	0.9	1%	26	15	4%	110	66	2%	1	1	2%	3	2	14%	14	8	1%	2	1	2%	0	0	0%	0.0	0.0	0%
Total	93		683	409		6686	4006		59	35		20	12		1983	1188		154	92		85	51		0.3	0.1	

Table 3.7: Taupo worst-case winter daily domestic heating emissions by appliance type.

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	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	8.8	8%	88	53	12%	882	528	12%	14	8	21%	2	1	8%	265	158	12%	14	8	8%	9	5	9%	0.0	0.0	6%
Open fire - coal		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%
Wood burner																										
Pre 1999 wood burner	40.7	39%	395	236	52%	3945	2364	53%	20	12	30%	8	5	36%	1179	707	53%	65	39	37%	39	24	41%	0.1	0.1	43%
1999-2004 wood burner	20.7	20%	124	74	16%	1243	745	17%	10	6	15%	4	2	18%	373	223	17%	33	20	19%	20	12	21%	0.1	0.0	22%
Post 2004 wood burner	23.8	23%	71	43	9%	714	428	10%	12	7	18%	5	3	21%	214	128	10%	38	23	22%	23	14	24%	0.1	0.0	25%
Pellet Burner		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%
Multi fuel burner																										
Multi fuel– wood	4.6	4%	60	36	8%	604	362	8%	2	1	3%	1	1	4%	181	108	8%	7	4	4%	5	3	5%	0.0	0.0	3%
Multi fuel– coal	0.9	1%	26	15	3%	110	66	1%	1	1	2%	3	2	12%	14	8	1%	2	1	1%	0	0	0%	0.0	0.0	0%
Gas	5.7	5%	0	0	0%	1	1	0%	7	4	11%	0	0	0%	0	0	0%	14	9	8%	0	0	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	0%
Total Wood	99	94%	739	443	97%	7388	4426	99%	59	35	87%	20	12	88%	2212	1325	99%	158	95	90%	96	57	100%	0.3	0.2	100%
Total Coal	1	1%	26	15	3%	110	66	1%	1	1	2%	3	2	12%	14	8	1%	2	1	1%	0	0	0%	0.0	0.0	0%
Total	105		765	458		7499	4493		68	40		22	13		2226	1334		175	105		96	57		0.3	0.2	

Table 3.8: Monthly variations in contaminant emissions from domestic heating in urban Taupo.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	0	0	0	0	0	0	0	0.0
February	0	0	0	0	0	0	0	0.0
March	0	3	0	0	1	0	0	0.0
April	39	388	3	1	116	9	5	0.0
May	382	3786	31	11	1129	88	50	0.2
June	614	6056	54	18	1802	141	78	0.2
July	683	6686	59	20	1983	154	85	0.3
August	610	5964	50	18	1768	136	76	0.2
September	280	2716	23	9	803	61	35	0.1
October	76	757	6	2	227	17	10	0.0
November	4	41	0	0	12	1	1	0.0
December	0	0	0	0	0	0	0	0.0
Total annual (kg/y except CO_2 in t/y)	82396	809139	6974	2420	240329	18555	10397	31

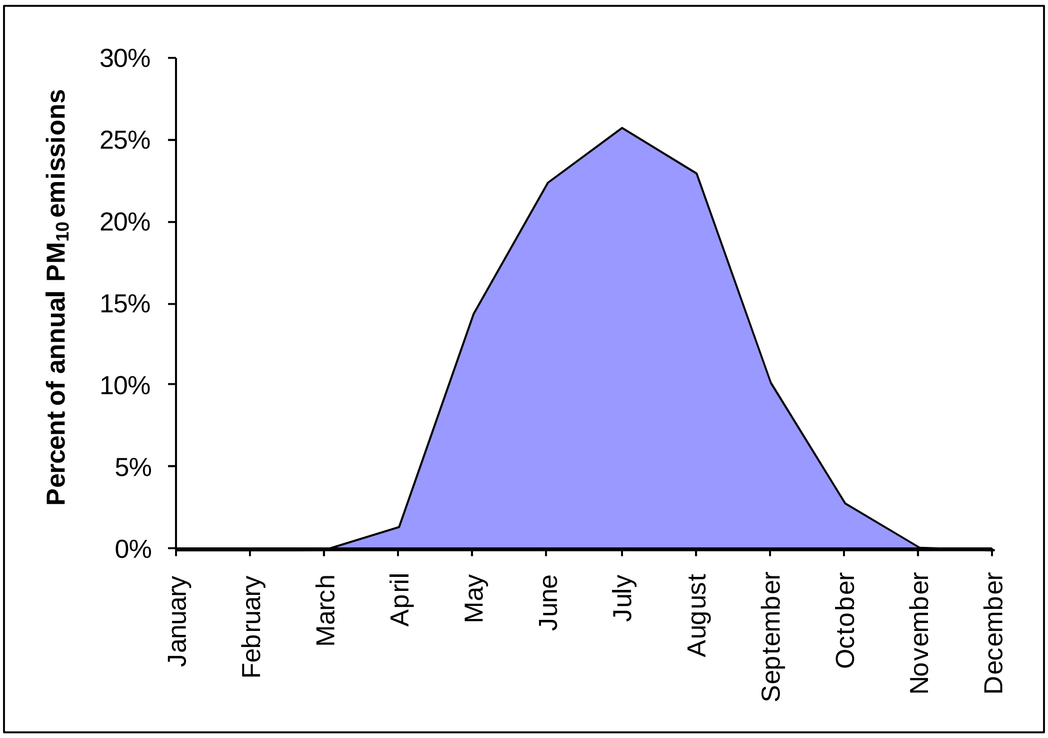


Figure 3.4: Monthly variations in PM_{10} emissions from domestic heating in urban Taupo as a proportion of annual emissions.

3.3.2 Thames

In Thames wood burners installed before 1999, and multi fuel burners produce the greatest amount of PM_{10} from domestic heating during the winter, with each burner category contributing 33% of the daily average wintertime PM_{10}. Open fires contribute 16% of wintertime domestic burning PM_{10} emissions, with wood burners installed between 1999 to 2004 contributing around 12% of PM_{10}. Post 2004 burners contribute six percent of the domestic PM_{10} (Figure 3.5).

Tables 3.9 and 3.10 show the estimates of wintertime contaminant emissions for different heating methods under average and worst-case scenarios. During June to August 2009 the average daily wintertime PM_{10} emissions are estimated to be around 288 kilograms per day, accounting for days when households may not be using specific home heating methods. Under the worst-case scenario around 423 kilograms of PM_{10} are discharged from all households using solid fuel burners on a given night. On an average winter's night (June to August) the majority of domestic PM_{10} emissions come from the burning of wood (79%), with 21% from the burning of coal.

Figures 3.6 and 3.7 show the monthly variations in appliance use and average days per week used. Figure 3.7 shows the frequency (days per week) of wood burning is higher during the summer months, while Figure 3.6 shows that a smaller proportion of households are burning during this time. It appears that the small proportion of the population that use wood burners all year round tend to burn on more days of the week than the average household. Seasonal variations in contaminant emissions are shown in Table 3.11. Figure

3.8 indicates that the majority of the annual PM_{10} from domestic home heating occur during the months June, July and August.

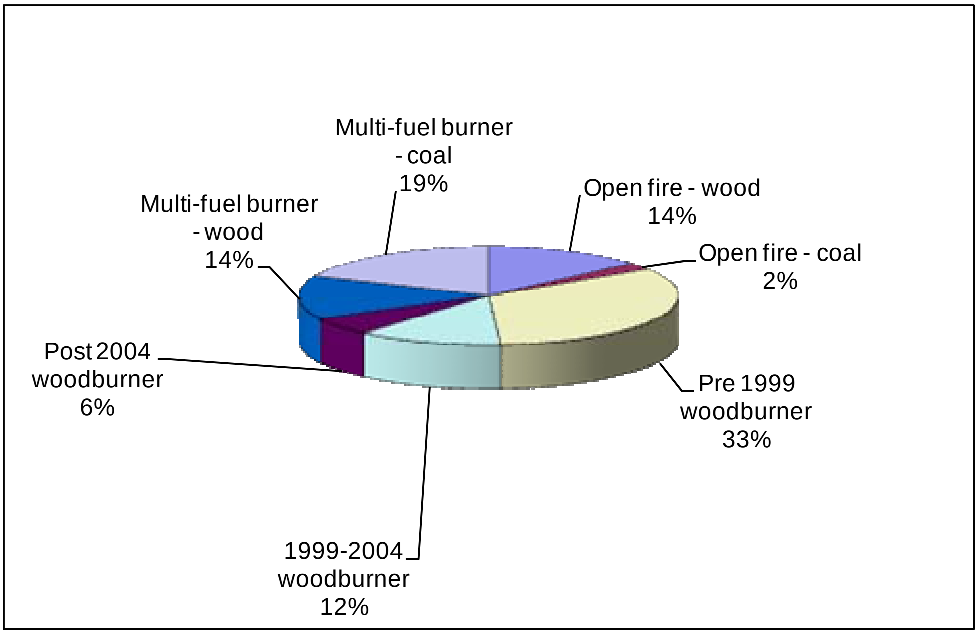


Figure 3.5: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Thames.

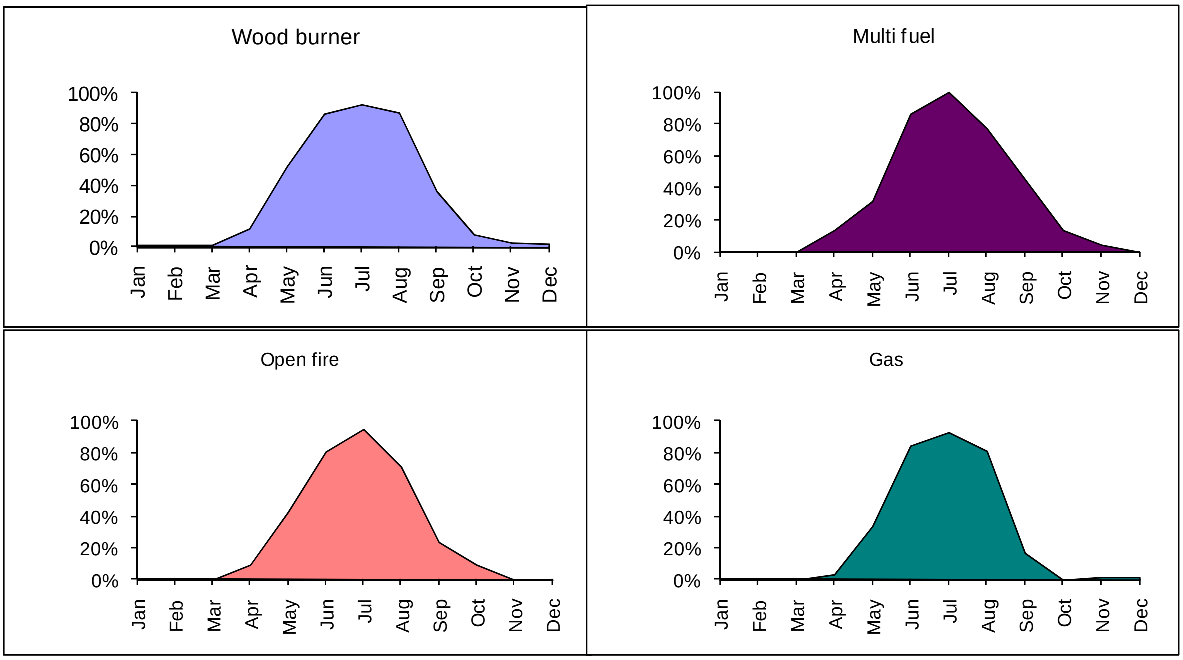


Figure 3.6: Monthly variations in appliance use in Thames.

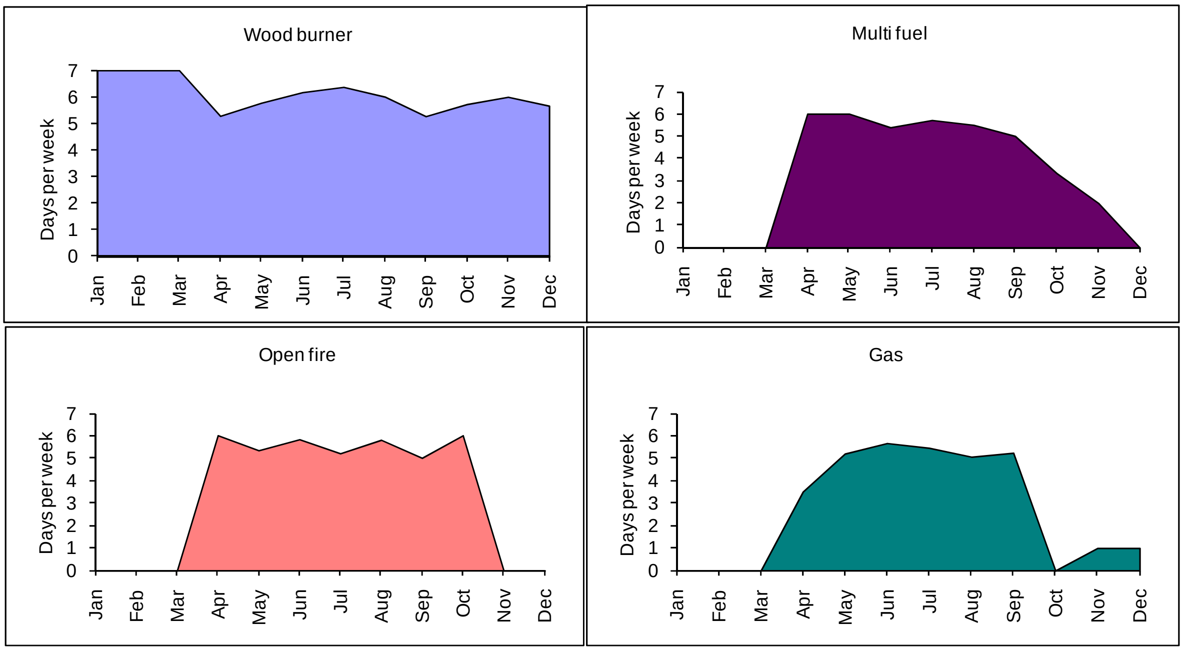


Figure 3.7: Average number of days per week appliances are used in Thames.

Table 3.9: Thames winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	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	3.9	13%	39	32	14%	394	322	16%	6	5	28%	1	1	6%	118	97	16%	6	5	12%	4	3	14%	0.0	0.0	10%
Open fire - coal	0.3	1%	6	5	2%	24	20	1%	1	1	5%	2	1	12%	5	4	1%	1	1	2%	0	0	0%	0.0	0.0	0%
Wood burner	21.3																									
Pre 1999 wood burner	9.8	32%	95	78	33%	953	779	38%	5	4	22%	2	2	15%	285	233	40%	16	13	30%	10	8	35%	0.0	0.0	38%
1999-2004 wood burner	5.9	19%	36	29	12%	356	291	14%	3	2	13%	1	1	9%	107	87	15%	9	8	18%	6	5	21%	0.0	0.0	23%
Post 2004 wood burner	5.6	18%	17	14	6%	167	136	7%	3	2	12%	1	1	9%	50	41	7%	9	7	17%	5	4	20%	0.0	0.0	21%
Pellet Burner	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	0.0	0%
Multi fuel burner																										
Multi fuel – wood	3.2	10%	41	34	14%	411	336	16%	2	1	7%	1	1	5%	123	101	17%	5	4	10%	3	3	11%	0.0	0.0	8%
Multi fuel – coal	1.9	6%	54	44	19%	229	187	9%	2	2	10%	6	5	44%	29	23	4%	5	4	10%	0	0	0%	0.0	0.0	0%
Gas	0.4	1%	0	0	0%	0	0	0%	1	0	2%	0	0	0%	0	0	0%	1	1	2%	0	0	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	0.0	0%
Total Wood	28.4	92%	228	186	79%	2280	1863	90%	19	15	82%	6	5	44%	683	558	95%	45	37	87%	28	23	100%	0.1	0.1	100%
Total Coal	2.2	7%	60	49	21%	254	207	10%	4	3	16%	7	6	56%	33	27	5%	6	5	11%	0	0	0%	0.0	0.0	0%
Total	31		288	235		2534	2070		23	18		13	11		716	585		52	43		28	23		0.1	0.1	

Table 3.10: Thames worst-case winter daily domestic heating emissions by appliance type.

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	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	4.9	12%	49	40	11%	486	397	14%	8	6	25%	1	1	4%	146	119	16%	8	6	11%	5	4	14%	0.01	0.01	10%
Open fire - coal	0.6	2%	13	11	3%	49	40	1%	2	2	8%	3	3	13%	9	8	1%	2	1	2%	0	0	0%	0.00	0.00	0%
Wood burner	25.3																									
Pre 1999 wood burner	11.7	29%	113	93	27%	1132	925	33%	6	5	19%	2	2	10%	339	277	37%	19	15	27%	11	9	34%	0.04	0.03	37%
1999-2004 wood burner	7.0	17%	42	35	10%	423	346	12%	4	3	11%	1	1	6%	127	104	14%	11	9	16%	7	6	20%	0.02	0.02	22%
Post 2004 wood burner	6.6	16%	20	16	5%	198	162	6%	3	3	11%	1	1	6%	59	49	6%	11	9	15%	6	5	19%	0.02	0.02	21%
Pellet Burner		0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.00	0.00	0%
Multi fuel burner																										
Multi fuel– wood	4.4	11%	57	47	14%	574	469	17%	2	2	7%	1	1	4%	172	141	19%	7	6	10%	4	4	13%	0.01	0.01	9%
Multi fuel– coal	4.6	11%	128	105	30%	550	450	16%	6	4	18%	14	11	58%	69	56	7%	12	10	17%	0	0	0%	0.00	0.00	0%
Gas	0.6	1%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0.00	0.00	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%	0.00	0.00	0%
Total Wood	35	86%	281	230	67%	2814	2299	82%	23	19	72%	7	6	29%	843	689	92%	55	45	79%	34	27	100%	0.09	0.08	100%
Total Coal	5	13%	141	115	33%	599	490	18%	8	6	25%	17	14	71%	78	64	8%	14	11	19%	0	0	0%	0.00	0.00	0%
Total	40		423	345		3413	2789		31	26		24	19		921	753		70	57		34	27		0.09	0.08	

Table 3.11: Monthly variations in contaminant emissions from domestic heating in Thames.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	0	1	0	0	0	0	0	0.0
February	0	1	0	0	0	0	0	0.0
March	0	1	0	0	0	0	0	0.0
April	7	68	0	0	20	1	1	0.0
May	93	923	8	3	275	20	12	0.0
June	234	2095	18	9	596	44	24	0.1
July	288	2534	23	13	716	52	28	0.1
August	214	1914	17	9	544	41	22	0.1
September	53	526	3	1	158	10	6	0.0
October	4	42	0	0	12	1	0	0.0
November	0	5	0	0	1	0	0	0.0
December	0	2	0	0	1	0	0	0.0
Total annual (kg/y except CO_2 in t/y)	27418	248761	2114	1100	71297	5200	2851	8.2

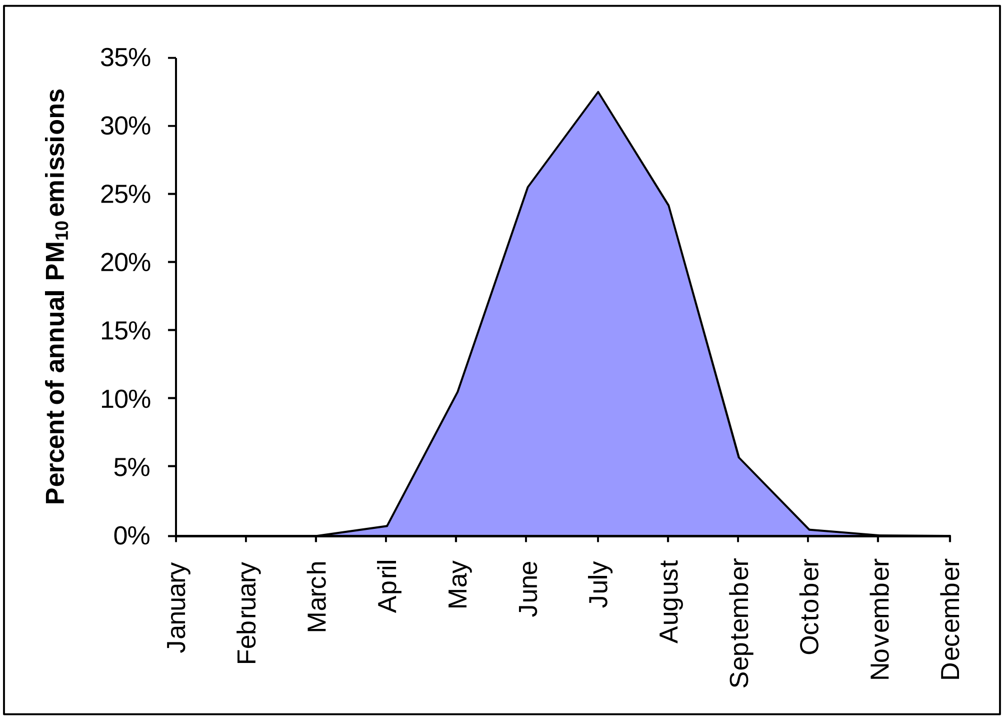


Figure 3.8: Monthly variations in PM_{10} emissions from domestic heating in Thames as a proportion of annual emissions.

3.3.3 Huntly

Multi fuel burners produce 55% of PM_{10} from domestic heating during the winter in Huntly, with multi fuel burners burning coal contributing 35% and multi fuel burners burning wood contributing to 20% of PM_{10} from domestic heating during winter.

Pre 1999 wood burners contribute to around 19% of the daily average wintertime PM_{10} in Huntly. Open fires contribute to 17% of the PM_{10} and wood burners installed between 1999 and 2004 and post 2004 contributed to six and three percent of domestic wintertime PM_{10} emissions respectively (Figure 3.9).

Estimates of wintertime contaminant emissions for different heating methods under average and worst-case scenarios are shown in Tables 3.12 and 3.13. Tables 3.12 and 3.13 indicate that from June to August, average daily wintertime PM_{10} emissions from inside the Huntly airshed (Figure 2.3) are around 468 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method. Under the worst-case scenario around 638 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night. From June to August, on an average winter's night, 56% of domestic PM_{10} emissions come from the burning of wood, and 44% from the burning of coal.

Figures 3.10 and 3.11 show the monthly variations in appliance use and average days per week used. The seasonal variation in contaminant emissions is shown in Table 3.14. Figure 3.12 indicates that the majority of the annual PM_{10} from domestic home heating occurs during June, July and August.

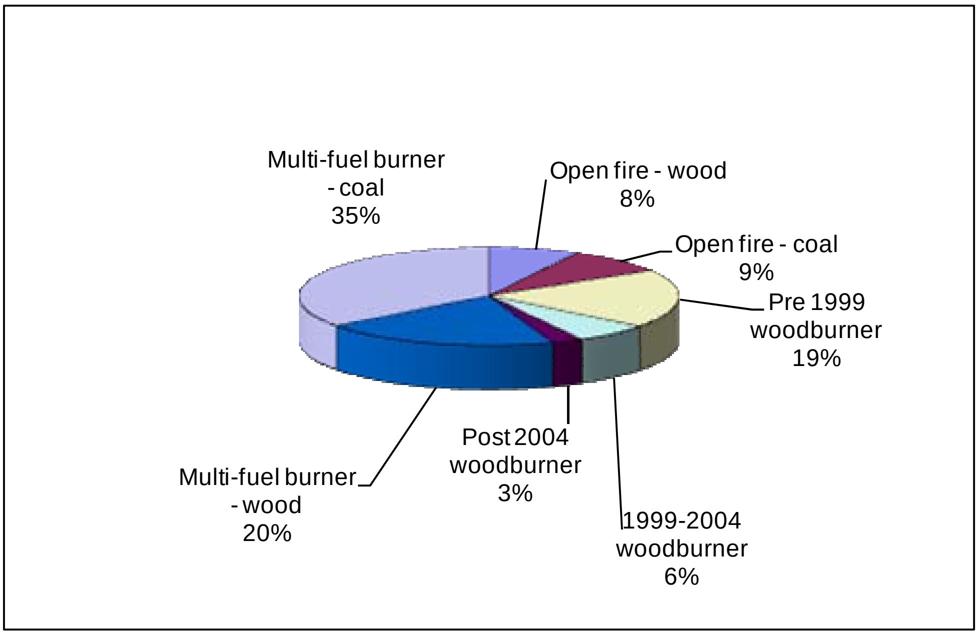


Figure 3.9: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Huntly.

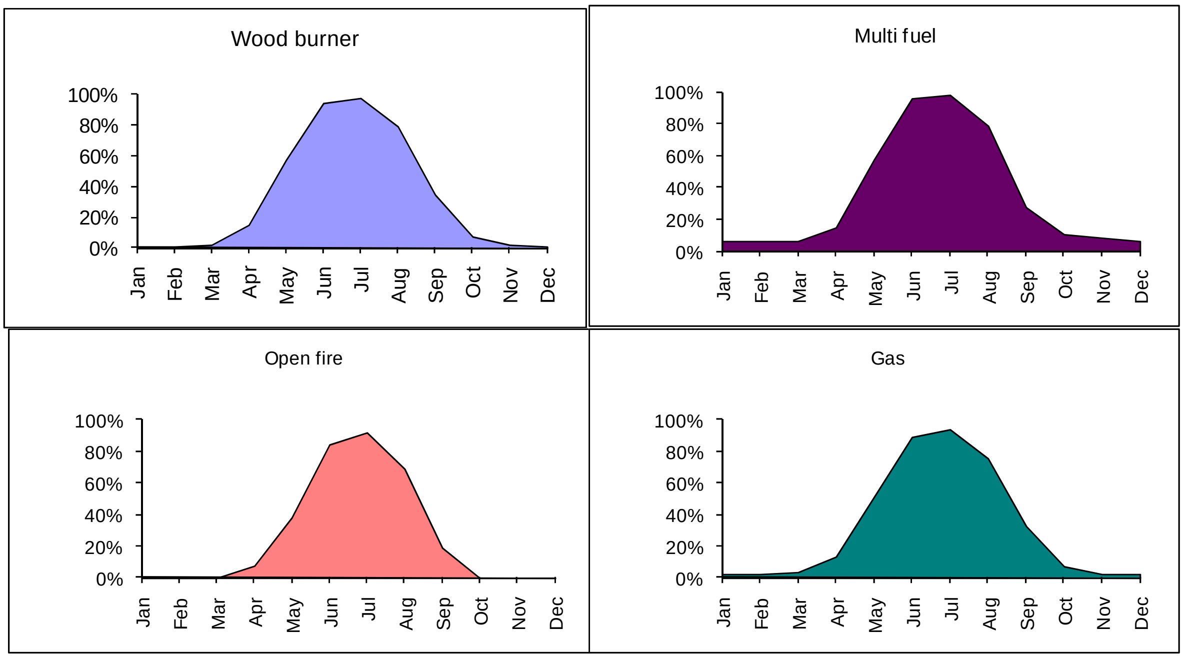


Figure 3.10: Monthly variations in appliance use in Huntly.

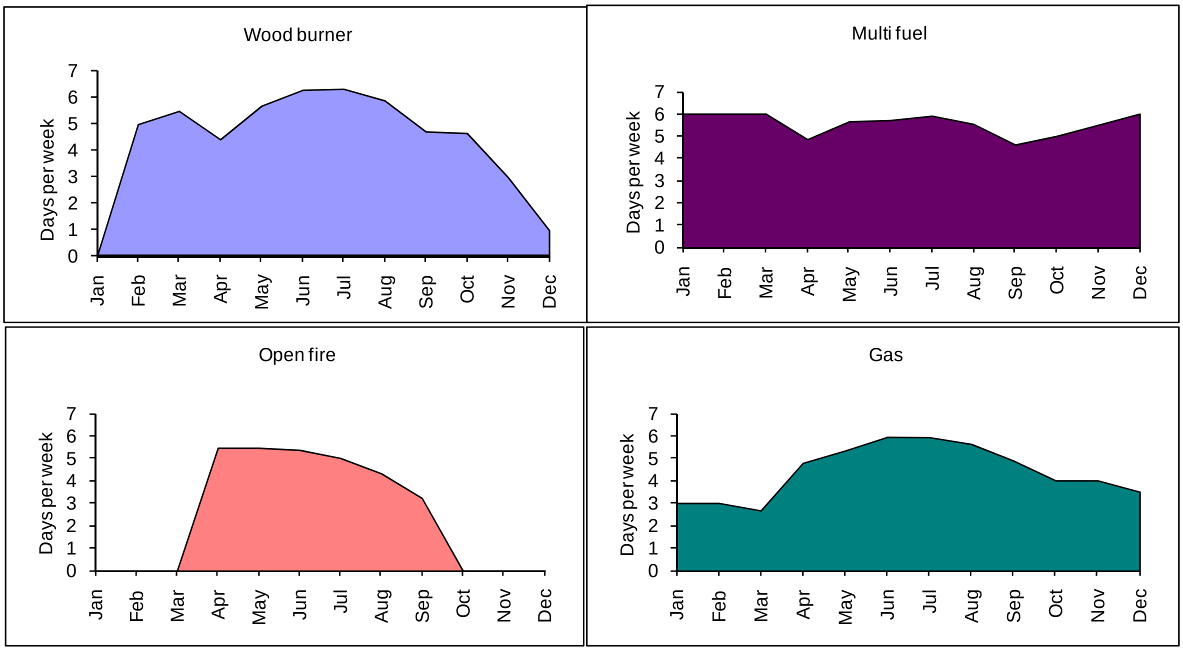


Figure 3.11: Average number of days per week appliances are used in Huntly.

Table 3.12: Huntly winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	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	3.6	10%	36	36	8%	364	358	10%	6	6	17%	1	1	2%	109	107	12%	6	6	8%	4	3	12%	0.01	0.01	9%
Open fire - coal	1.9	5%	40	39	8%	152	149	4%	8	7	22%	9	9	29%	28	28	3%	5	5	7%	0	0	0%	0.00	0.00	0%
Wood burner	18.4																									
Pre 1999 wood burner	9.3	25%	90	89	19%	902	886	26%	5	5	14%	2	2	6%	270	265	30%	15	15	22%	9	9	32%	0.03	0.03	36%
1999-2004 wood burner	5.0	13%	30	29	6%	299	294	9%	2	2	7%	1	1	3%	90	88	10%	8	8	12%	5	5	17%	0.01	0.01	19%
Post 2004 wood burner	4.1	11%	12	12	3%	122	120	4%	2	2	6%	1	1	2%	37	36	4%	7	6	9%	4	4	14%	0.01	0.01	16%
Pellet Burner	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%	0.00	0.00	0%
Multi fuel burner																										
Multi fuel– wood	7.3	19%	94	93	20%	945	928	27%	4	4	11%	1	1	4%	283	279	31%	12	11	17%	7	7	25%	0.01	0.01	19%
Multi fuel– coal	5.9	16%	165	163	35%	709	697	20%	7	7	21%	18	17	53%	89	87	10%	15	15	22%	0	0	0%	0.00	0.00	0%
Gas	0.7	2%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0	0	0%	2	2	2%	0	0	0%	0.00	0.00	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%	0.00	0.00	0%
Total Wood	29.3	78%	263	259	56%	2632	2587	75%	19	18	54%	6	6	18%	789	775	87%	47	46	68%	28	28	100%	0.08	0.08	100%
Total Coal	7.8	21%	205	202	44%	861	846	25%	15	14	43%	27	27	82%	117	115	13%	20	20	29%	0	0	0%	0.00	0.00	0%
Total	38		468	460		3493	3433		34	34		33	33		906	890		69	68		28	28		0.08	0.08	

Table 3.13: Huntly worst-case winter daily domestic heating emissions by appliance type.

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			Benzene			BaP		
	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	6.0	12%	60	59	9%	597	587	13%	10	9	19%	1	1	2%	179	176	15%	10	9	11%	6	6	17%	0.01	0.01	13%
Open fire - coal	3.9	8%	82	81	13%	314	309	7%	16	15	31%	20	19	38%	59	58	5%	10	10	11%	0	0	0%	0.00	0.00	0%
Wood burner	20.8																									
Pre 1999 wood burner	10.5	22%	102	100	16%	1019	1001	22%	5	5	10%	2	2	4%	305	299	26%	17	17	19%	10	10	29%	0.03	0.03	34%
1999-2004 wood burner	5.6	12%	34	33	5%	338	332	7%	3	3	6%	1	1	2%	101	100	9%	9	9	10%	5	5	16%	0.02	0.02	18%
Post 2004 wood burner	4.6	9%	14	14	2%	138	136	3%	2	2	5%	1	1	2%	42	41	4%	7	7	8%	4	4	13%	0.01	0.01	15%
Pellet Burner		0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0.00	0.00	0%
Multi fuel burner																										
Multi fuel– wood	9.0	18%	117	115	18%	1167	1147	26%	4	4	9%	2	2	3%	350	344	30%	14	14	16%	9	9	25%	0.02	0.02	19%
Multi fuel– coal	8.2	17%	230	226	36%	985	968	22%	10	10	19%	25	24	48%	123	121	11%	21	21	24%	0	0	0%	0.00	0.00	0%
Gas	0.8	2%	0	0	0%	0	0	0%	1	1	2%	0	0	0%	0	0	0%	2	2	2%	0	0	0%	0.00	0.00	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%	0.00	0.00	0%
Total Wood	36	73%	326	320	51%	3259	3204	72%	24	24	48%	7	7	14%	977	960	84%	57	56	63%	35	34	100%	0.09	0.09	100%
Total Coal	12	25%	312	307	49%	1299	1277	28%	26	25	50%	44	43	86%	182	179	16%	32	31	35%	0	0	0%	0.00	0.00	0%
Total	49		638	627		4558	4481		51	50		51	51		1159	1139		91	89		35	34		0.09	0.09	

Table 3.14: Monthly variations in contaminant emissions from domestic heating in Huntly.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	Benzene kg/day	BaP kg/day
January	4	21	0	0	4	0	0	0.0
February	4	21	0	0	4	0	0	0.0
March	4	21	0	0	4	0	0	0.0
April	23	143	2	2	33	3	1	0.0
May	162	1237	11	11	324	26	11	0.0
June	418	3138	31	29	816	62	26	0.1
July	468	3493	34	33	906	69	28	0.1
August	288	2193	19	19	573	44	19	0.1
September	60	444	4	4	114	9	4	0.0
October	8	47	0	1	9	1	0	0.0
November	6	31	0	1	6	1	0	0.0
December	4	21	0	0	4	0	0	0.0
Total annual (kg/y except CO_2 in t/y	44434	331308	3109	3069	85644	6616	2772	8

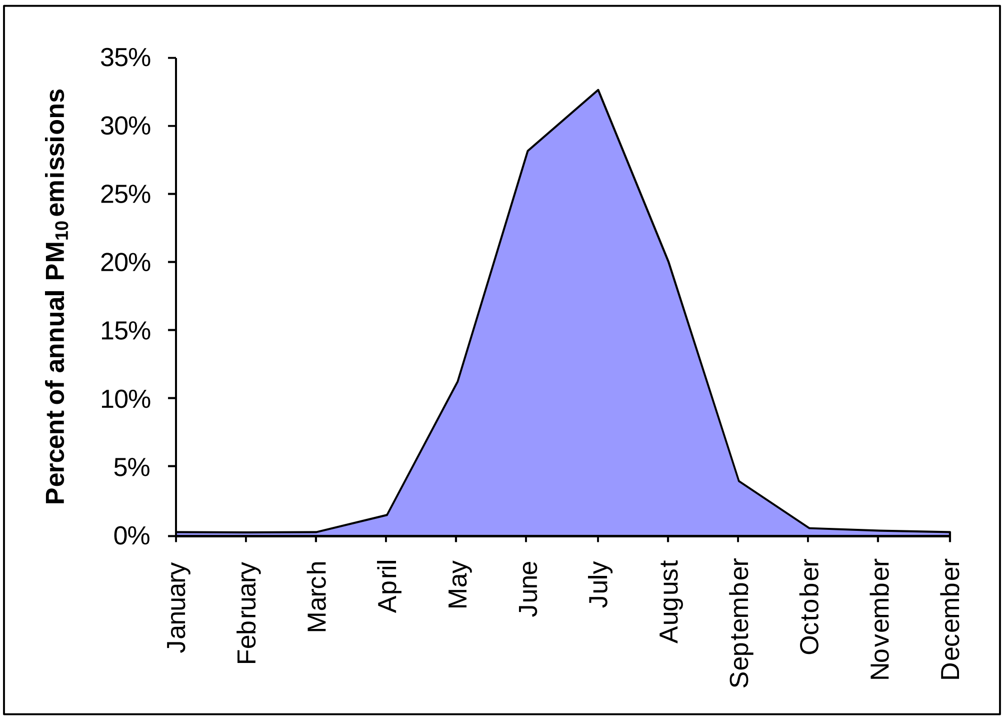


Figure 3.12: Monthly variations in PM_{10} emissions from domestic heating in Huntly as a proportion of annual emissions.

4 Motor vehicles

Motor vehicle emissions to air include tailpipe emissions 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 3.0. Default settings were used for all variables except:

- Vehicle fleet profile
    - Taupo - based on vehicle registrations for Taupo for year ending 30 June 2009
    - Huntly and Thames – based on vehicle registrations for Hamilton for year ending 30 June 2009
- Annual average temperature
    - Taupo – based on annual average temperature for Taupo for 2008
    - Huntly and Thames – based on annual average temperature for Hamilton for 2008

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.

The scope of the inventory was extended over previous inventories for the Waikato to include BaP emission estimates because of the potential for this contaminant to be of concern. No emission factor data for BaP are available for motor vehicle emissions in New Zealand. Emission factors for BaP used here have been taken from USEPA - emission factors for estimating mobile source PAH emissions in the National Toxics Inventory (www.epa.gov/ttn/chief/nti/index.html#info). These are based on a proportion of the PM and was estimated at 0.0008 x PM for this study based on the proportion of heavy versus light vehicles. This estimate will be highly approximate because of differences in fuel composition and should therefore be treated with caution.

Table 4.1: Vehicle registrations in Taupo and Hamilton for the year ending June 2009.

Taupo	Petrol	Diesel	LPG	Other	Total
Cars	15360	2169	2		17531
LCV	1185	2341	3		3529
Bus	33	161			194
HCV		1713			1713
Miscellaneous	240	265	2	3	510
Motorcycle	459				459
Total	17277	6649	7	3	23936
Hamilton	**Petrol**	**Diesel**	**LPG**	**Other**	**Total**
Cars	69033	4603	17		73653
LCV	2558	4413	7		6978
Bus	85	720			805
HCV		3386			3386
Miscellaneous	1173	555	43	11	1782
Motorcycle	1548				1548
Total	74397	13677	67	11	88152

Historically VKTs were differentiated into three different driving conditions called Levels Of Service (LOS) and a fourth category representing emissions under cold running conditions. Estimates of VKTs based on road network models use these classifications which represent free flow conditions (LOS category A-B), interrupted flow conditions (LOS category C-D) and congested flow conditions (LOS category E-F). Estimates of the LOS are based on number of vehicles on a particular road relative to the capacity of the road.

Estimates of VKT for different LOS for 2009 were based on road network model projections made for the Taupo 2004 inventory. No road network model exists for Huntly or Thames so total VKTs for these areas were based on the average number of VKTs per household for Hamilton and Napier respectively, which were obtained from previous road network modelling. Because of the relatively uncongested nature of vehicle movements in Huntly and Thames, all VKTs were assumed to occur under free flowing conditions.

Table 4.2 shows the estimated number of VKTs for Taupo, Huntly and Thames for 2009.

Table 4.2: VKT by time of day for Taupo, Thames, and Huntly for 2009.

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Taupo					
A-B	491008	92393	205503	160206	32906
C-D	35567	7719	14149	13699	0
E-F	652	652	0	0	0
Total	527227	100764	219652	173905	32906
Thames (A-B)	171540	32279	71795	55970	11496
Huntly (A-B)	143640	27029	60118	46867	9626

The VFEM uses an average vehicle speed as opposed to LOS for differentiating emissions. In this study the average speeds used to derive emission factors for different LOS were 15 km/hr, 25 km/hr and 50 km/hr for congested, interrupted and free flow conditions. The average emission factor for each LOS for each contaminant for Taupo (based on Taupo vehicle fleet), and Huntly and Thames (based on Hamilton vehicle fleet) is shown in Table 4.3.

Table 4.3: Emission factors for 2009 for Taupo vehicle fleet and Hamilton vehicle fleet – used in Huntly and Thames estimates.

Driving Conditions	CO g/VKT	CO_2 g/VKT	VOC g/VKT	NOx g/VKT	PM_{10} g/VKT	PM brake & tyre g/VKT	Benzene g/VKT
Taupo A-B	4.47	230.71	0.34	0.87	0.06	0.01	0.02
Taupo C-D	6.50	307.66	0.50	0.95	0.09	0.01	0.02
Taupo E-F	10.21	393.36	0.71	1.10	0.12	0.01	0.04
Hamilton - A-B	4.06	209.67	0.30	0.79	0.04	0.01	0.02

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.

Emissions (g) = A-B Emission Rate (g/VKT) * VKT (A-B) + C-D Emission Rate (g/VKT) * VKT (C-D) + E-F Emission Rate (g/VKT) * VKT (E-F)

4.1 Motor vehicle emissions

4.2 Taupo

The projections of motor vehicle VKTs made for the 2004 inventory were around 633000 VKTs per day for 2021 for a “do minimum” scenario. This compares with an estimated 482000 for 2004. The projected 2009 total VKT is based on an extrapolation of these projections and an adjustment for an inventory study area with more households is 642000 per day.

Around 49 kilograms per day of PM_{10} are estimated to occur from motor vehicle emissions in Taupo. Around 17% of this is estimated to occur as a result of the wearing of brakes and tyres.

Other contaminant emissions from motor vehicles in Taupo include around 2966 kilograms of CO, 465 kilograms of NOx and three kilograms of SOx (Table 4.4). In comparison, in Christchurch, where CO concentrations exceed ambient air quality guidelines at least once during most winters, motor vehicles emit around 109 tonnes of CO within the main urban area.

4.3 Thames

In Thames around 129000 VKTs are estimated per day on average in Thames based on a VKT per household ratio of 45 (similar to Napier and Timaru). This is based on a lower VKT per household ratio because through traffic in Thames is likely to be less than Huntly (based on Hamilton). All VKT are assumed to occur under free flowing conditions.

Estimated emissions to air include six kilograms per day of PM_{10}. Around 27% of this is estimated to occur as a result of the wearing of brakes and tyres. Other contaminant emissions from motor vehicles in Thames include around 523 kilograms of CO and 102 kilograms of NOx.

4.4 Huntly

Around 144,000 VKTs are estimated per day on average in Huntly based on an average VKT per household ratio of 60 (similar to Hamilton). All VKT are assumed to occur under free flowing conditions.

Around seven kilograms per day of PM_{10} are estimated for Huntly and 27% of this is estimated to occur as a result of the wearing of brakes and tyres. Other contaminant emissions from motor vehicles in Huntly include around 583 kilograms of CO and 103 kilograms of NOx.

Table 4.4 shows emissions from motor vehicles in Taupo, Thames and Huntly by weight and grams per hectare.

Table 4.4: Summary of daily motor vehicle emissions in Taupo Thames and Huntly.

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Taupo	1669	49	30	2966	1777	565	338	3	2
Thames	1224	6	5	466	381	91	74	0	0
Huntly	1017	8	8	662	651	129	127	0	0
		VOC		**CO_2**		**Benzene**		**BaP**	
	Hectares	**kg**	**g/ha**	**t**	**kg/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Taupo	1669	228	136	152	91	12	7	0.003	0
Thames	1224	35	29	24	20	2	2	0.000	0
Huntly	1017	50	49	34	34	3	3	0.000	0

5 Industrial and Commercial

5.1 Methodology

An evaluation of potential discharges to air from industrial and commercial sources in Taupo, Thames and Huntly was undertaken to identify activities that discharge PM_{10}. Environment Waikato staff provided information on consented activities.

All schools in Taupo, Thames and Huntly were also surveyed by phone to determine the source of their heating. The results showed that only three schools (Kimihia School, Thames South School and Taupo Intermediate School) use coal boilers. Thames High School changed from a coal fired boiler to a wood chip burner in early 2009. The remaining schools use natural gas, electricity or geothermal power for heating. Emissions from gas boilers were not included in the inventory as the PM_{10} emissions from them are negligible for small to medium size boilers. Two schools have replaced coal boilers with heat pumps over the past three years. Eleven industrial and commercial premises were included in the inventory.

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.

For most industries included in the assessment, site specific emissions data was available from the resource consent application. Emissions were estimated based on equation 5.1.

Equation 5.1 Emissions (kg/day) = Emission rate (kg/hr) x hrs per day (hrs)

Where 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 Environment Waikato 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[2].

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

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

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	BaP g/kg
Underfeed stokers	2.0	5.5	4.8	13.5	0.1	2400	0.00002
Pellet boiler	0.83	6.8	0.8	0.0	0.1	1069	0.03
	kg/m^3	**kg/m^3**	**kg/m^3**	**kg/m^3**	**kg/m^3**	**kg/m^3**	**kg/m^3**
Natural gas AP42	0.00012	0.00134	0.00160	0.00001	0.00009	1.92000	1.9E-11

5.2 Industrial and commercial emissions

5.3 Taupo

5.3.1 Urban part of the airshed

No industrial activities with discharges to air significant enough to require resource consent were found in the Taupo urban area. Emission estimates were made based on school boilers in the area for which there was only one that used solid fuel. Less than 1 kilogram of PM_{10} is estimated to be discharged to air from industrial and commercial activities in the Taupo urban airshed.

5.3.2 Industrial part of the airshed

An estimate of PM_{10} emissions was made for the industrial airshed area of Taupo and was based on activities hold discharge to air resource consents. It is noted, that other sources, for example, domestic heating and motor vehicles in that airshed have not been examined. Results indicate that around 380 kilograms of PM_{10} per day could be expected from the five industries in the area that are operational during 2009. Note that one activity with consent was not due to be operational until 2010 and was therefore not included. The Laminex Group contributes to over half of the industrial PM_{10} emissions in the industrial Taupo airshed.

5.4 Thames

Discharges from three industrial and commercial activities were included in the assessment. An additional industrial activity was located around one kilometer to the south of Thames but outside of the inventory area. While concentrations of PM_{10} from this source may contribute to PM_{10} within the airshed, the extent of contribution is unknown and the inventory includes only discharges from within the airshed area. Air dispersion modelling would be an appropriate tool for determining the contribution of this industry to PM_{10} concentrations.

Around 13 kilograms of PM_{10} are discharged to air from industrial and commercial activities in Thames.

5.5 Huntly

Discharges from two industrial and commercial activities were included in the assessment. These included a brickworks and a local school using coal for winter time heating. A number of additional industries with air discharges were identified in the Huntly area but were outside of the airshed area defining the emission inventory study area. The Huntly power station was one of the industries excluded because it was outside of the study area (see Section 2.3), and potential air quality impacts on the town of Huntly are addressed as part of the resource consent process an conditions of operation. Around three kilograms of PM_{10} are discharged to air from industrial and commercial activities in Huntly.

Table 5.2: Summary of industrial emissions (daily winter) in Taupo, Thames and Huntly.

		PM_{10}		CO		NOx		SOx	
	Hectares	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Taupo	1669	0.7	0.4	1.3	0.8	1.1	0.6	3.1	1.8
Thames	1224	13	10	0	0	0	0	0.0	0.0
Huntly	1017	3	3	414	407	48	48	1.0	1.0
		VOC		CO_2		**BaP**			
	Hectares	**kg**	**g/ha**	**t**	**kg/ha**	**kg**	**g/ha**		
Taupo	1669	0.0	0.0	0.5	0.3	0.0	0.0		
Thames	1224	0.0	0.0	0.0	0.0	0.0	0.0		
Huntly	1017	0.0	0.0	74	73	0.0	0.0		

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 Waikato Regional Plan permits outdoor burning of specified materials including untreated wood, vegetative matter, paper and cardboard and other similar materials subject to a number of conditions (Rule 6.1.13.1). The conditions include ensuring that the effects of the discharge do not go beyond the boundary of the property and are sourced from the property where the burning occurs.

6.1 Methodology

Outdoor burning emissions for Taupo, Thames and Huntly were estimated for the winter months based on data collected during the 2009 domestic home heating survey. The survey showed 5% of households in Taupo and 14% in Thames and 12% in Huntly burnt rubbish in the outdoors during the winter. The average number of fires per day during winter was 11, 17 and 27 in Taupo, Thames and Huntly respectively. Emissions were calculated based on the assumption of an average weight of material per burn of 150 kilograms and using the emission factors in Table 6.1. This was based on an average fires size of 2 m^3 across the two areas and an estimated average weight of 75 kg/m^3. Emission factors of benzene and BaP were based on wood burning for domestic heating and are indicative only. Emissions of these contaminants will be largely influenced by the material burnt, in particular the inclusion of household rubbish and plastics.

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	BaP g/kg
Outdoor burning	8	42	3	0.5	4	1470	0.97	0.003

6.2 Taupo

Around 14 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average in Taupo. Outdoor burning also produces around 72 kilograms of carbon monoxide and around three tonnes of carbon dioxide on average per day during winter.

Table 6.2: Outdoor burning emission estimates for Taupo.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 t/ day	Benzene kg/day	BaP kg/day
Summer (Dec-Feb)	14	73	5	1	7	3	2	0.003
Autumn (Mar-May)	13	70	5	1	7	2	2	0.003
Winter (June-Aug)	14	72	5	1	7	3	2	0.003
Spring (Sept-Nov)	16	84	6	1	8	3	2	0.004

6.3 Thames

Table 6.3 shows an average of around 20 kilograms of PM_{10} per day from outdoor burning in Thames during the winter months. Outdoor burning also produces around 105 kilograms of carbon monoxide per day during the winter.

Table 6.3: Outdoor burning emission estimates for Thames.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 t/ day	Benzene kg/day	BaP kg/day
Summer (Dec-Feb)	12	62	4	1	6	2	1	0.003
Autumn (Mar-May)	18	95	7	1	9	3	2	0.005
Winter (June-Aug)	20	105	7	1	10	4	2	0.005
Spring (Sept-Nov)	20	104	7	1	10	4	2	0.005

6.4 Huntly

Outdoor burning emission estimates for Huntly (Table 6.4) indicate that around 33 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months, on average. Outdoor burning also produces around 172 kilograms of CO.

Table 6.4: Outdoor burning emission estimates for Huntly.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 t/ day	Benzene kg/day	BaP kg/day
Summer (Dec-Feb)	28	145	10	2	14	5	3	0.007
Autumn (Mar-May)	35	182	13	2	17	6	4	0.009
Winter (June-Aug)	33	172	12	2	16	6	4	0.008
Spring (Sept-Nov)	31	162	12	2	15	6	4	0.008

7 Other sources of emissions

This inventory includes all likely major sources of PM_{10} 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[3].

[3] 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

8.1 Taupo

8.1.1 Taupo urban area

It has been noted that the Taupo airshed (Figure 2.1) is unusual in having two distinct areas, one being predominantly urban and the other, to the northeast, being mainly industrial. Under most circumstances, contributions from one area to the other are expected to be minimal.

In the urban area of the Taupo airshed around 747 kilograms of PM_{10} is discharged to air on an average winter's day. Figure 8.1 shows that domestic home heating is the main source of PM_{10} emissions contributing 91% of the daily wintertime emissions. Transport contributes to seven percent, outdoor burning contributes to two percent and industry has a negligible contribution to total wintertime PM_{10} emissions.

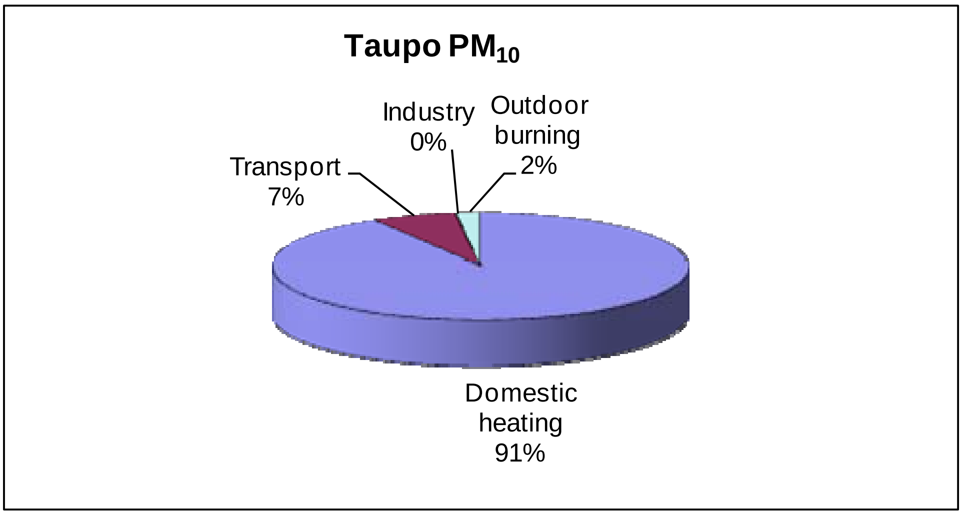


Figure 8.1: Relative contribution of sources to daily winter PM_{10} emissions in urban Taupo.

An estimate of the spatial distribution of PM_{10} emissions from all sources in urban Taupo are shown in Figure 8.2 and Appendix C. The estimate of spatial distribution is based on the location of households burning wood and coal from the 2006 census combined with the 2009 emission inventory estimates for domestic heating. Emissions from other sources are included but are assumed to be spatially uniform across the study area.

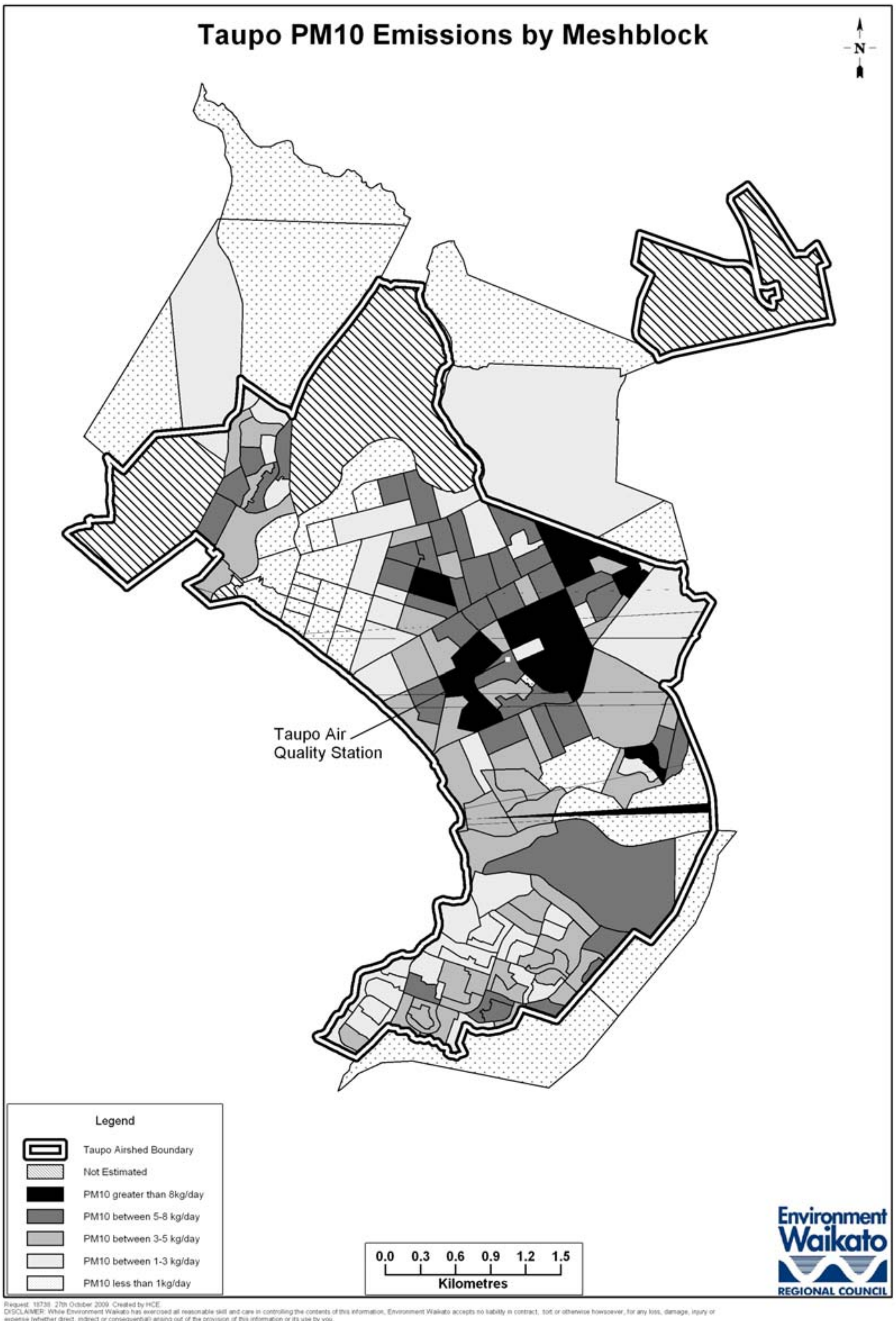


Figure 8.2: Estimate of the spatial distribution of PM_{10} emissions from all sources in the urban Taupo airshed. (See Appendix C for raw data and a version of this map with some roads identified.)

Domestic home heating is also the main source of BaP, CO, SOx, VOCs and CO_2 in Taupo. Motor vehicles are the main source of NOx (Figure 8.3).

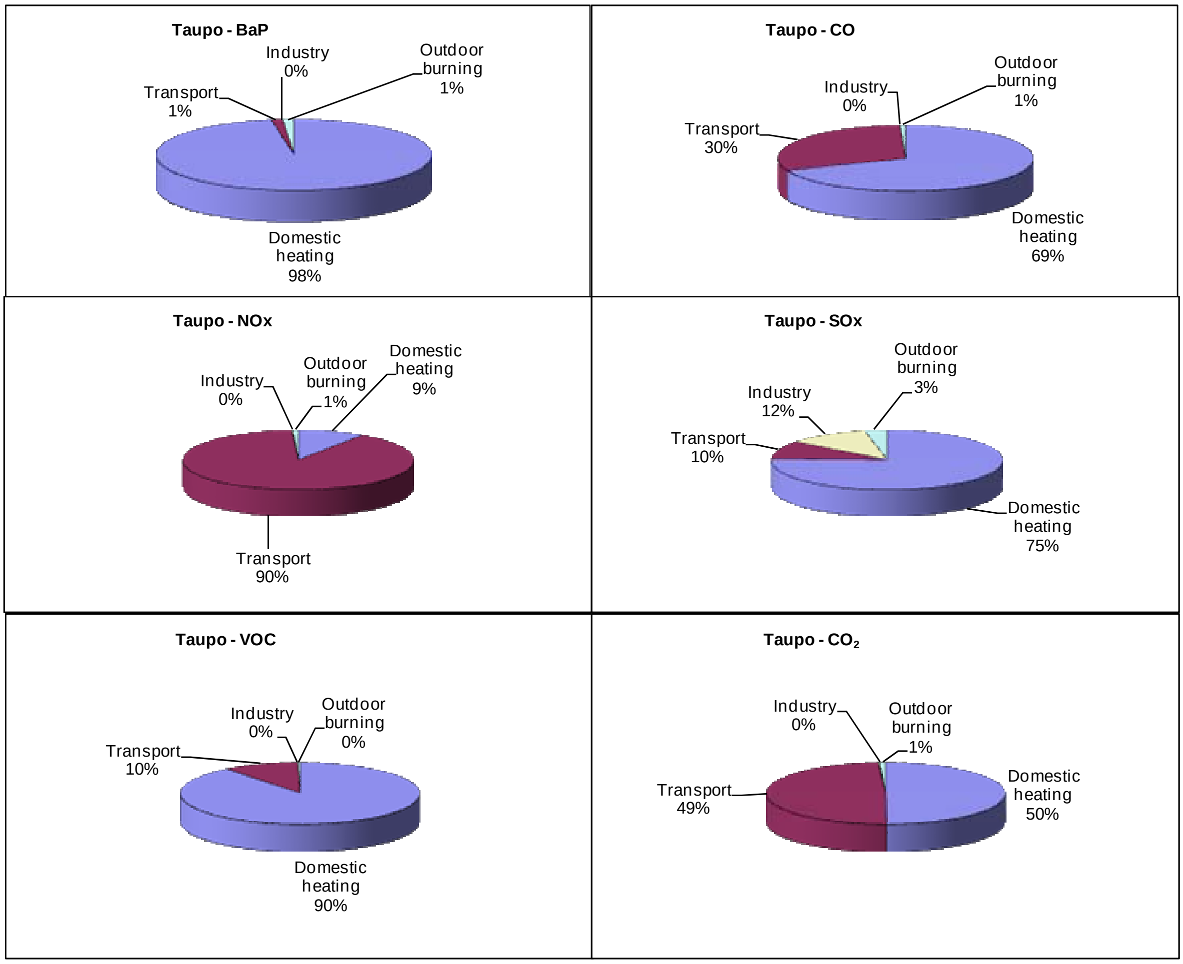


Figure 8.3: Relative contribution of sources to contaminant emissions in Taupo.

Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 8.1. 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, motor vehicles and outdoor burning are the dominant contributors to PM_{10} emissions.

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

	PM_{10}		CO		NOx		SOx	
	Kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	683	409	6686	4006	59	35	20	12
Transport	49	30	2966	1777	565	338	3	2
Industry	1	0	1	1	1	1	3	2
Outdoor burning	14	8	72	43	5	3	1	1
Total	747	448	9725	5826	630	377	27	16
	VOC		CO_2		BaP		Benzene	
	kg	g/ha	t	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	1983	1188	154	92	0.3	0.1	33	19.8
Transport	228	136	152	91	0.0	0.0	12	6.9
Industry	0	0	1	0	0.0	0.0	0	0.0
Outdoor burning	7	4	3	2	0.0	0.0	2	1.0
Total	2217	1328	309	185	0.3	0.2	0	27.7

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

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	14	22%	1	1%	49	77%	64
February	0	0%	14	22%	1	1%	49	77%	64
March	0	1%	13	21%	1	1%	49	77%	64
April	39	38%	13	13%	1	1%	49	48%	102
May	382	86%	13	3%	1	0%	49	11%	445
June	614	91%	14	2%	1	0%	49	7%	678
July	683	91%	14	2%	1	0%	49	7%	747
August	610	91%	14	2%	1	0%	49	7%	673
September	280	81%	16	5%	1	0%	49	14%	346
October	76	53%	16	11%	1	0%	49	35%	142
November	4	6%	16	23%	1	1%	49	70%	70
December	0	0%	14	22%	1	1%	49	77%	64
Total kg year	82396		5185		258		18014		

8.1.2 Industrial Airshed

For the industrial part of the Taupo airshed (the area to the northeast in Figure 2.1) PM_{10} emissions from the five significant industries operational during 2009 were estimated. These total about 380 kilograms of PM_{10} per day (Section 5.3.2). Emissions from other sources to this part of the airshed (for example, domestic heating and motor vehicles) have not been quantified. Under New Zealand legislation, industrial operations with significant emissions to air require resource consent. Detailed air-dispersion modelling of emissions and potential impacts from such sources is carried out as part of the resource consent application process.

8.2 Thames

Around 326 kilograms of PM_{10} is discharged to air in the Thames airshed (Figure 2.2) on an average winter's day. The main source of PM_{10} emissions is domestic home heating that contributes to 88% of the daily wintertime PM_{10} (Figure 8.4). Outdoor burning contributes six percent to total PM_{10} emissions, while the transport and industry sector contribute two and four percent respectively.

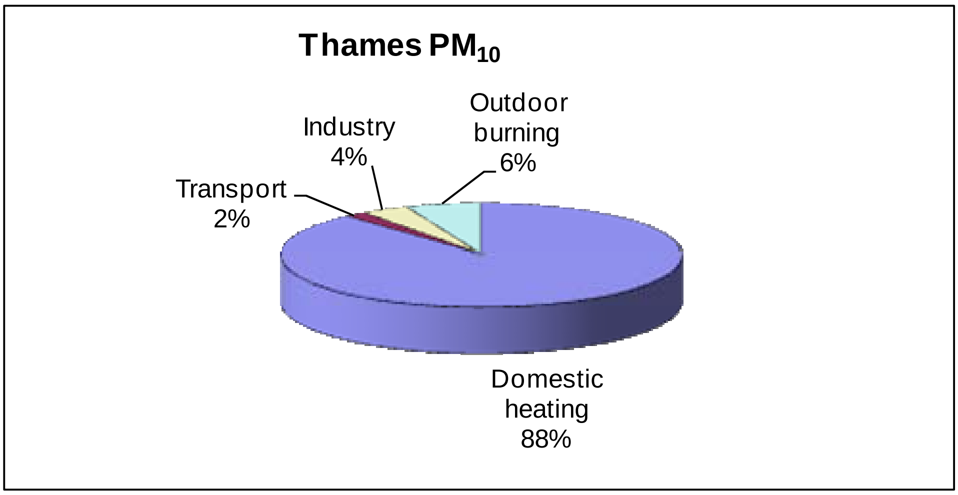


Figure 8.4: Relative contribution of sources to daily winter PM_{10} emissions in Thames

Domestic home heating is also the main source of BaP, CO, SOx and VOCs and contributes around two thirds of the CO_2. Motor vehicles are the main source of NOx, and contribute to around a third of CO_2 emissions (Figure 8.5).

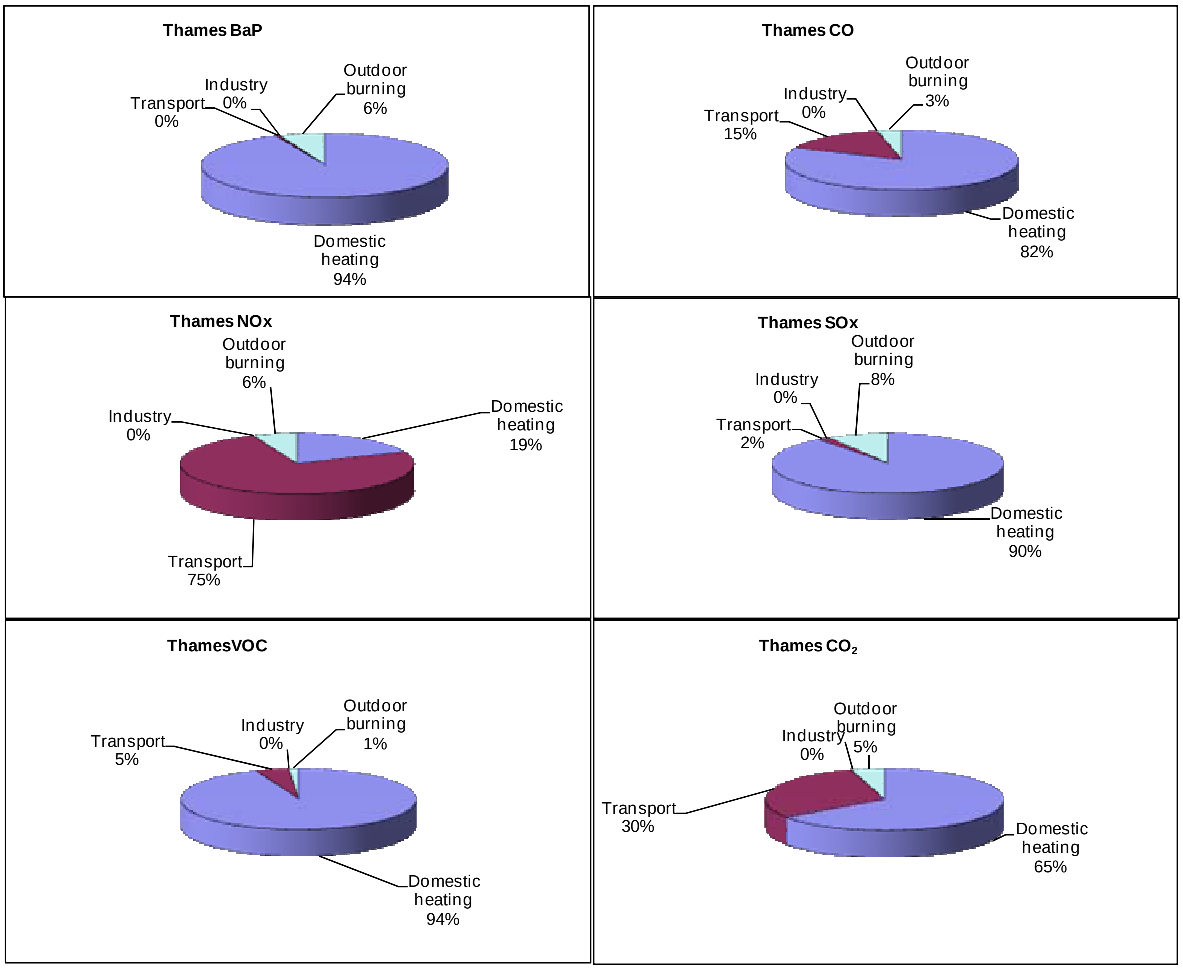


Figure 8.5: Relative contribution of sources to contaminant emissions in Thames

Table 8.3 shows the daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha). Table 8.4 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, outdoor burning is the dominant contributor to PM_{10} emissions.

Table 8.3: Daily contaminant emissions from all sources in Thames (winter average).

	PM_{10}		CO		NOx		SOx	
	Kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	288	235	2534	2070	23	18	33	27
Transport	6	5	466	381	91	74	0	0
Industry	13	10	0	0	0	0	1	1
Outdoor burning	20	16	105	86	7	6	2	2
Total	326	267	3105	2537	121	99	37	30
	VOC		CO_2		BaP		Benzene	
	Kg	g/ha	t	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	716	585	52	43	0.08	0.06	11	8.76
Transport	35	29	24	20	0.00	0.00	2	1.64
Industry	0	0	0	0	0.00	0.00	0	0.00
Outdoor burning	10	8	4	3	0.00	0.00	2	1.98
Total	761	622	80	65	0.08	0.07	0	12.37

Table 8.4: Monthly variations in daily PM_{10} emissions in Thames.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	12	39%	13	42%	6	18%	30
February	0	0%	12	39%	13	42%	6	18%	30
March	0	0%	18	50%	13	35%	6	15%	37
April	7	16%	18	42%	13	29%	6	13%	43
May	93	72%	18	14%	13	10%	6	4%	130
June	234	86%	20	7%	13	5%	6	2%	272
July	288	88%	20	6%	13	4%	6	2%	326
August	214	85%	20	8%	13	5%	6	2%	253
September	53	58%	20	22%	13	14%	6	6%	91
October	4	10%	20	47%	13	30%	6	13%	42
November	0	1%	20	51%	13	33%	6	14%	38
December	0	1%	12	39%	13	42%	6	18%	30
Total kg year	27418		6370		4637		2033		

8.3 Huntly

The boundaries of the Huntly airshed are shown in Figure 2.3. Around 512 kilograms of PM_{10} is discharged to air on an average winter's day from inside this airshed. The main source of PM_{10} is domestic home heating which contributes 91% of the daily wintertime PM_{10} (Figure 8.6). Outdoor burning contributes around six percent of total PM_{10} emissions with industry contributing one percent and transport contributing two percent.

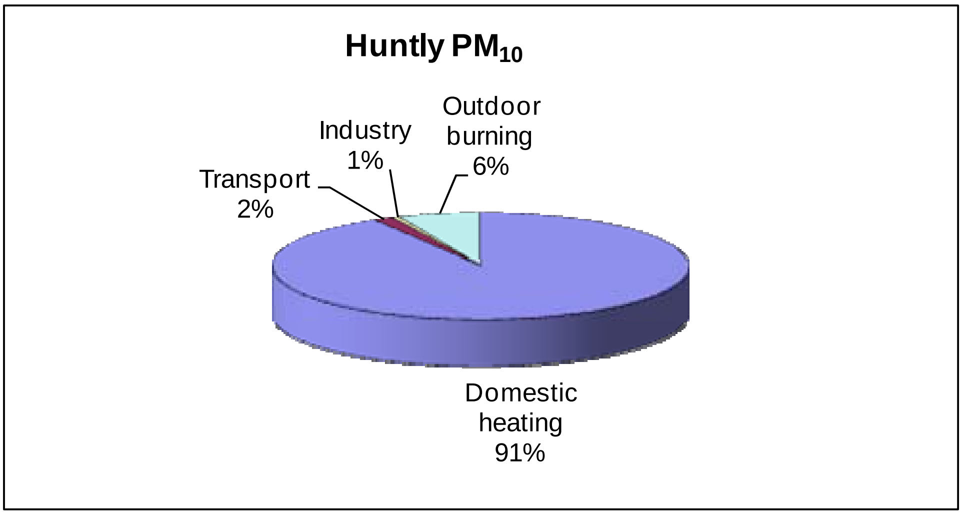


Figure 8.6: Relative contribution of sources to daily winter PM_{10} emissions in Huntly.

In regards to other contaminants, domestic home heating is the main source of BaP, CO, SOx, and VOC in Huntly (Figure 8.7). Transport is the main source of NOx emissions and contributes to around a quarter of CO_2 emissions.

It should be noted that this inventory is not intended to cover emissions from the Huntly Power Station operated by Genesis Energy, which is located outside the Huntly airshed boundary. Potential impacts of the power station to ambient air quality in the town of Huntly are addressed as part of the resource consent process and reflected in this operation's resource consent conditions.

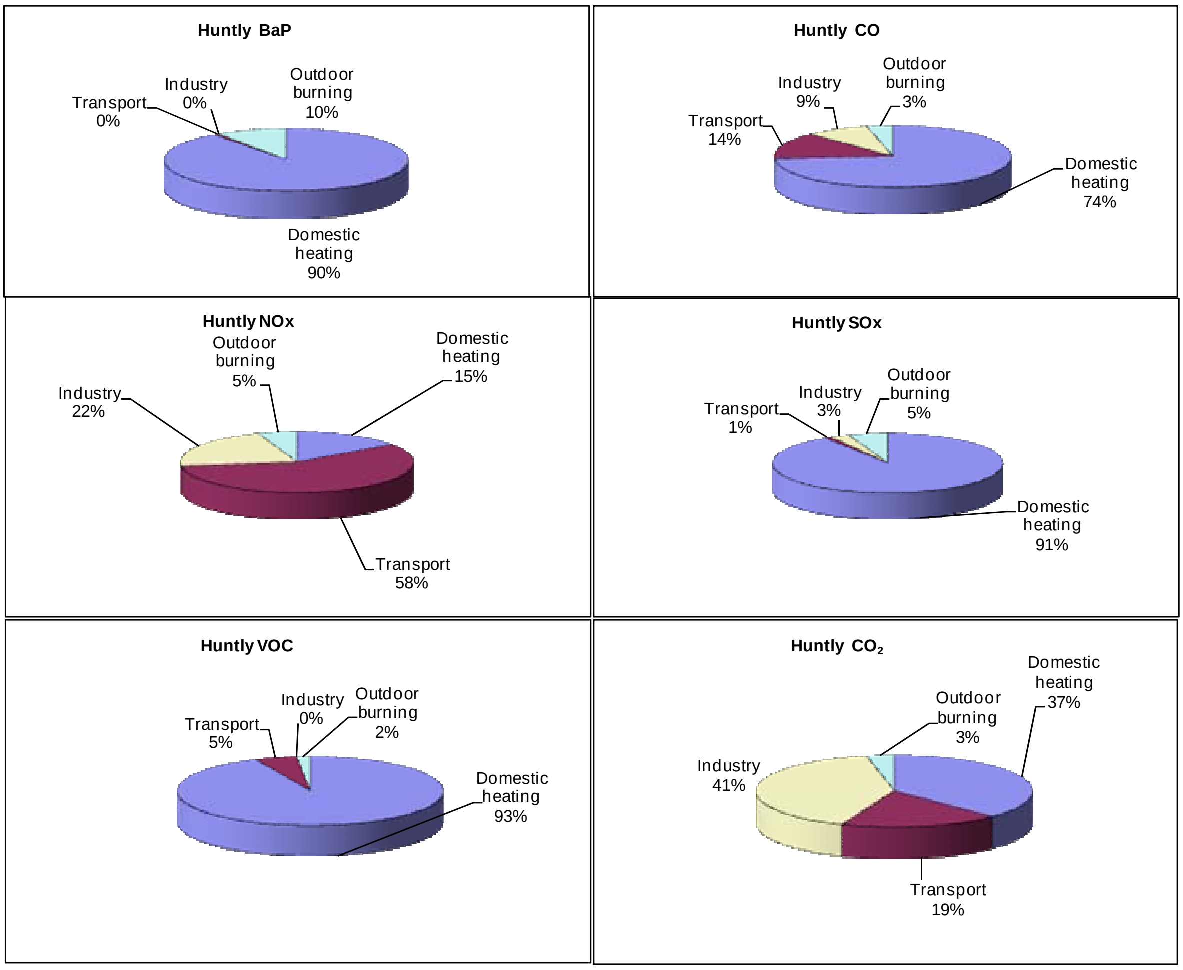


Figure 8.7: Relative contribution of sources to contaminant emissions in Huntly.

Table 8.5 shows daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) inside the Huntly airshed. Seasonal variations in PM_{10} emissions are shown in Table 8.6. Table 8.5 indicates that domestic home heating is the dominant source of PM_{10} emissions during the winter months, but during the summer, outdoor burning is the dominant contributor to PM_{10} emissions.

Table 8.5: Daily contaminant emissions from all sources in Huntly (winter average).

	PM_{10}		CO		NOx		SOx	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	468	460	3493	3433	34	34	33	33
Transport	8	8	662	651	129	127	0	0
Industry	3	3	414	407	48	48	1	1
Outdoor burning	33	32	172	169	12	12	2	2
Total	512	503	4741	4660	224	220	37	36
	VOC		**CO_2**		**BaP**		**Benzene**	
	kg	**g/ha**	**t**	**g/ha**	**kg**	**g/ha**	**kg**	**g/ha**
Domestic home heating	906	890	69	68	0.08	0.08	11	10.86
Transport	50	49	34	34	0.00	0.00	3	2.79
Industry	0	0	74	73	0.00	0.00	0	0.00
Outdoor burning	16	16	6	6	0.01	0.01	4	3.90
Total	972	955	183	180	0.09	0.08	0	17.56

Table 8.6: Monthly variations in daily PM_{10} emissions in Huntly.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	4	10%	28	65%	3	7%	8	18%	43
February	4	10%	28	65%	3	7%	8	18%	43
March	4	9%	35	70%	3	6%	8	16%	50
April	23	34%	35	51%	3	4%	8	12%	68
May	162	78%	35	17%	3	1%	8	4%	207
June	418	91%	33	7%	3	1%	8	2%	462
July	468	91%	33	6%	3	1%	8	2%	512
August	288	87%	33	10%	3	1%	8	2%	332
September	60	59%	31	30%	3	3%	8	8%	101
October	8	17%	31	62%	3	6%	8	16%	50
November	6	13%	31	65%	3	6%	8	17%	48
December	4	10%	28	65%	3	7%	8	18%	43
Total kg year	44434		11498		1083		2886		

References

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

Hennessy, W., 1999, Statement of evidence – Hearing on proposed coal ban for Christchurch. Environment Canterbury unpublished.

Kim, N., 2007, Meeting the Air NES – general methodology and reappraisal for Tokoroa following 2007 instrument calibration. Unpublished Environment Waikato Memo dated 3 September 2007.

McCauley, M., 2005, Ambient concentrations of polycyclic aromatic hydrocarbons and dioxins/furans in Christchurch - 2003/2004, Report No. 05/14, Environment Canterbury.

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

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

Scott, A., 2004, Impact of strategies to reduce residential heating emissions in Christchurch - an update, Unpublished, draft Environment Canterbury Report.

Smith, J., Bluett, J., Wilton, E., Mallett, T., 2008, *'In home testing of particulate emissions from NES compliant woodburners: Nelson, Rotorua and Taumaranui 2007'*, NIWA Project: PCCA085 Prepared for Foundation for Science, Research and Technology

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/

Wilton, E. and Smith J., 2006, Real Life Emissions Testing of Pre 1994 Woodburners in New Zealand. Environment Waikato Report No. TR2006/05.

Wilton, E., 2001, Taupo, Huntly, Putaruru and Matamata, Domestic Heating Emissions Inventory. Unpublished report prepared for Environment Waikato.

Wilton. E., 2004,Taupo Emission Inventory 2004, Environment Waikato report number 963048.

Wilton. E., Anderson B., and Iseli.J., 2007, Cost effectiveness of policy options for boilers – Rangiora. Unpublished report prepared for Environment Canterbury.

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 Environment Waikato

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).

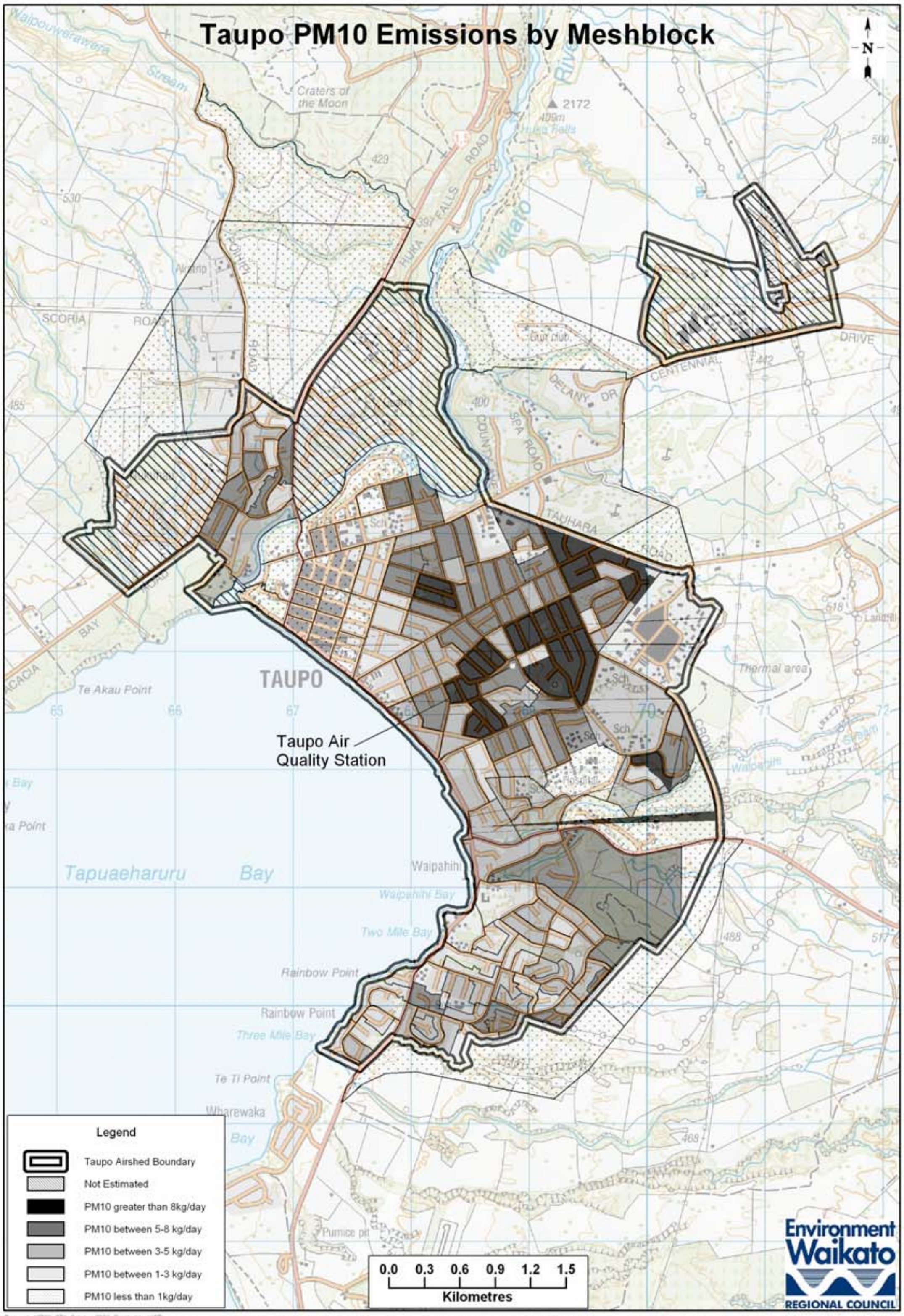
Domestic heating emission factors for CO, NOx, SOx and CO_2 were also based on the Christchurch 1999 emission factor revisions with adjustments made for relationships with PM_{10} where appropriate.

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.

Appendix C: Estimate of the spatial distribution of PM_{10} emissions from all sources in the urban Taupo airshed.

Meshblock (2006 areas)	PM_{10} (kg/day)	Meshblock (2006 areas)	PM_{10} (kg/day)	Meshblock (2006 areas)	PM_{10} (kg/day)	Meshblock (2006 areas)	PM_{10} (kg/day)
MB 1279004	0.4	MB 1273900	0.9	MB 1271900	2.1	MB 1267011	6.1
MB 1279006	0.4	MB 1274000	0.4	MB 1272100	7.3	MB 1267101	4.6
MB 1279023	2.3	MB 1274100	0.4	MB 1272200	6.7	MB 1267102	6.5
MB 1279024	0.4	MB 1274200	0.4	MB 1278802	0.4	MB 1267200	3.3
MB 1275105	5.3	MB 1274300	0.6	MB 1267400	3.1	MB 1267301	4.1
MB 1275108	1.8	MB 1274400	0.9	MB 1267500	3.8	MB 1267302	1.8
MB 1275109	4.3	MB 1274500	0.8	MB 1267600	3.8	MB 1267303	3.6
MB 1275110	2.3	MB 1274600	0.6	MB 1267701	3.8	MB 1267304	1.8
MB 1275111	4.8	MB 1274700	6.5	MB 1267703	3.3	MB 1280002	0.4
MB 1275112	1.8	MB 1274800	6.5	MB 1267704	3.3	MB 1266403	2.8
MB 1275113	5.1	MB 1274900	1.4	MB 1267705	0.6	MB 1266404	3.3
MB 1275114	5.3	MB 1275000	0.6	MB 1267800	2.8	MB 1266405	3.3
MB 1275115	2.8	MB 1275400	0.8	MB 1267900	5.8	MB 1266406	2.2
MB 1275116	3.3	MB 1275500	0.4	MB 1268000	4.8	MB 1266407	2.8
MB 1275117	5.3	MB 1275600	0.9	MB 1268100	5.6	MB 1266501	1.0
MB 1275200	7.7	MB 1269500	2.8	MB 1268205	6.2	MB 1266502	1.8
MB 1275301	4.8	MB 1269600	8.0	MB 1268206	0.9	MB 1266503	2.3
MB 1279602	3.3	MB 1269701	9.7	MB 1268207	8.0	MB 1266609	5.3
MB 1268300	2.8	MB 1269702	8.7	MB 1268208	2.8	MB 1266610	0.4
MB 1268400	4.8	MB 1269800	7.2	MB 1268209	4.6	MB 1266611	5.6
MB 1269000	4.8	MB 1269900	4.3	MB 1268210	3.3	MB 1266612	1.3
MB 1269100	5.6	MB 1270000	7.2	MB 1268211	4.1	MB 1266613	4.3
MB 1269200	5.8	MB 1270100	9.5	MB 1268212	6.1	MB 1266614	3.6
MB 1269300	4.8	MB 1270200	12.4	MB 1268501	4.1	MB 1266615	4.8
MB 1269400	9.0	MB 1270300	6.1	MB 1268502	6.5	MB 1266616	4.1
MB 1272000	5.3	MB 1270400	7.7	MB 1268600	4.3	MB 1266617	3.8
MB 1272300	5.1	MB 1270501	3.8	MB 1268700	8.0	MB 1266618	2.8
MB 1272400	4.8	MB 1270503	1.2	MB 1268801	6.7	MB 1266619	3.8

MB 1272500	3.8	MB 1270504	8.0	MB 1268803	0.6	MB 1266620	5.8
MB 1272600	6.4	MB 1270600	1.2	MB 1268804	3.6	MB 1266621	6.1
MB 1272700	5.1	MB 1270700	2.8	MB 1268900	5.6	MB 1266701	2.3
MB 1272800	9.3	MB 1270800	1.2	MB 1279908	7.5	MB 1266702	2.0
MB 1272900	5.6	MB 1270900	0.4	MB 1266801	2.6	MB 1266703	3.3
MB 1273000	1.8	MB 1271000	8.0	MB 1266803	2.8	MB 1266704	1.6
MB 1273100	5.1	MB 1271100	9.5	MB 1266805	2.8	MB 1267004	3.3
MB 1273200	2.8	MB 1271200	8.5	MB 1266806	2.8	MB 1267005	2.8
MB 1273300	4.3	MB 1271300	4.3	MB 1266903	1.8	MB 1267006	4.8
MB 1273400	2.8	MB 1271400	1.5	MB 1266904	2.8	MB 1267007	1.8
MB 1273500	0.8	MB 1271500	2.8	MB 1266905	3.8	MB 1267008	4.6
MB 1273600	2.3	MB 1271600	7.0	MB 1266906	3.3	MB 1267009	3.3
MB 1273700	0.9	MB 1271700	7.8	MB 1266907	3.3		
MB 1273800	0.4	MB 1271800	6.5	MB 1267010	4.3		



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