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Air emission inventory - Tokoroa and Morrinsville 2016

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Air Emission Inventory – Tokoroa and Morrinsville 2016

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EXECUTIVE SUMMARY

The main air contaminant of concern in urban areas of the Waikato Region is PM_{10} (particles in the air less than 10 microns in diameter). Concentrations of PM_{10} have been measured in Tokoroa since the late 1990s but with more reliability since 2006 and in Morrinsville since 2015. The NES for PM_{10} is currently based on a 24-hour average and is set at 50 µg/m^3 with one allowable exceedance per year. Air quality monitoring data for Tokoroa indicates ongoing non-compliance with the NES but also suggests some decrease in PM_{10} emissions may have occurred since 2012 when the last inventory assessment was carried out. No previous emissions inventory has been carried out for Morrinsville. The purpose of this assessment is to evaluate changes in emissions to air in Tokoroa, establish a baseline emission for Morrinsville and estimate the contribution of different sources to these emissions.

Sources included in the 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. While the evaluation focuses on PM_{10} other contaminants also evaluated include: $PM_{2.5}$ (particles in the air less than 2.5 microns) carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds, carbon dioxide and benzo(a)pyrene.

A domestic home heating survey was undertaken to determine the proportions of households using different heating methods and fuels. The results for Tokoroa indicate wood burning continues to be the main source of home heating with just over 50% of households using solid fuel burners or open fires. In Morrinsville wood burning is less popular with just 36% of households relying on it and electricity (65%) being the predominant heating method for the main living area. Many households use more than one heating method.

In Tokoroa domestic heating is the main source of daily winter PM_{10} emissions, accounting for 87%. The other main source is outdoor burning which contributes around 10% with transport and industry contributing only 1 and 2% respectively. On an average winter's night, around 383 kilograms of PM_{10} are discharged from all sources. This compares with around 564 kg/day in Tokoroa in 2012 (after adjusting for differences in methodology) indicating a 32% reduction may have occurred. Domestic heating is also the main source of daily winter $PM_{2.5}$, carbon monoxide, sulphur oxides, volatile organic compounds, carbon dioxide and benzo(a)pyrene with transport identified as the main source of daily winter nitrogen oxides in Tokoroa.

In Morrinsville the domestic heating contribution was 53% with industry being a major contributor to PM_{10} at 42% but not to $PM_{2.5}$ as the source was non combustion. Outdoor burning and transport contributes 4% and 1% respectively to wintertime PM_{10} emissions. Around 261 kilograms per day of PM_{10} is discharged in Morrinsville on an average winter's day. Domestic heating is also the main source of daily winter $PM_{2.5}$, carbon monoxide, sulphur oxides, volatile organic compounds and benzo(a)pyrene with industry identified as the main source of daily winter nitrogen oxides and carbon dioxide in Morrinsville.

1 Introduction

The main air contaminant of concern in most urban areas of New Zealand is PM_{10}, particles in the air less than 10 microns in diameter. Concentrations of PM_{10} have been measured in Tokoroa since the late 1990s and in Morrinsville since 2015. National Environmental Standards (NES) set a limit for PM_{10} of 50 µg/m^3 (24-hour average) with one allowable exceedance per year.

Tokoroa is non-compliant with the NES for PM_{10} with around 9-10 exceedances of 50 µg/m^3 recorded per year over the past three years and 15-16 exceedances per year for the preceding three years. Tokoroa is required to comply with no more than three exceedances per year by September 2016 and no more than one exceedance by September 2020. Air quality monitoring data for Tokoroa suggests some reduction in PM_{10} concentrations although there is still some probability that the result occurs due to natural variability (Wilton, 2016).

Air quality monitoring data for Morrinsville for 2015 indicated compliance with the NES for PM_{10} with a maximum concentration of 45 µg/m^3 measured during the year. Further monitoring is required to confirm compliance as meteorological conditions vary from year to year.

The purpose of this emission inventory is to evaluate changes in emissions to air for Tokoroa and the contribution of different sources to these emissions over time to evaluate the extent of any decrease in emissions. A previous assessment of emissions to air for Tokoroa was carried out in 2012. For Morrinsville the purpose of the inventory is to establish baseline emissions and the relative contributions of sources as no historical inventory assessments have been carried out.

Sources included in the inventory are domestic heating, motor vehicle, industrial and commercial and outdoor burning. Natural source contributions (for example; sea salt and soil) are not included because methodologies are less robust. This report primarily focuses on emissions of particles (PM_{10}) from these sources. Other contaminants included in this emission inventory are $PM_{2.5}$ (particles in the air less than 2.5 microns in diameter) carbon monoxide, nitrogen oxides, sulphur oxides volatile organic compounds, carbon dioxide and benzo(a)pyrene.

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 national environmental standards exist 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 $\mu g/m^3$ 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}), fine particles ($PM_{2.5}$) carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOC), carbon dioxide (CO_2), 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 NES contaminants because of their potential for adverse health impacts. $PM_{2.5}$ has been included in the inventory because this size fraction may have significance in terms of the current review of the NES. 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 Tokoroa or Morrinsville would cause ozone problems. However, ozone formation as a result of emissions from Auckland could impact on some areas of the Waikato. 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. It is likely that the inventory does not capture a number of sources of VOCs.

2.3 Selection of areas

The Tokoroa inventory study area for 2016 is the airshed area (Figure 2.1) that is gazetted by the Ministry for the Environment. This is the same area as used for the 2012 and 2007 emission inventory. However, prior inventories were based on census area units.

The census area units used in the previous air emission inventories for Tokoroa were as follows: Paraonui, Parkdale, Matarawa, Stanley Park, Tokoroa Central, Aotea, and Strathmore.

The industrial assessment excludes emissions from Kinleith pulp and paper mill, as these are outside the Tokoroa airshed (approximately 3.5 km south of the southern boundary of the airshed).

Figure 2.2 shows the Morrinsville Airshed as gazetted which is the area used for the emission inventory assessment.

Figure 2.1: Tokoroa Airshed (source Waikato Regional Council).

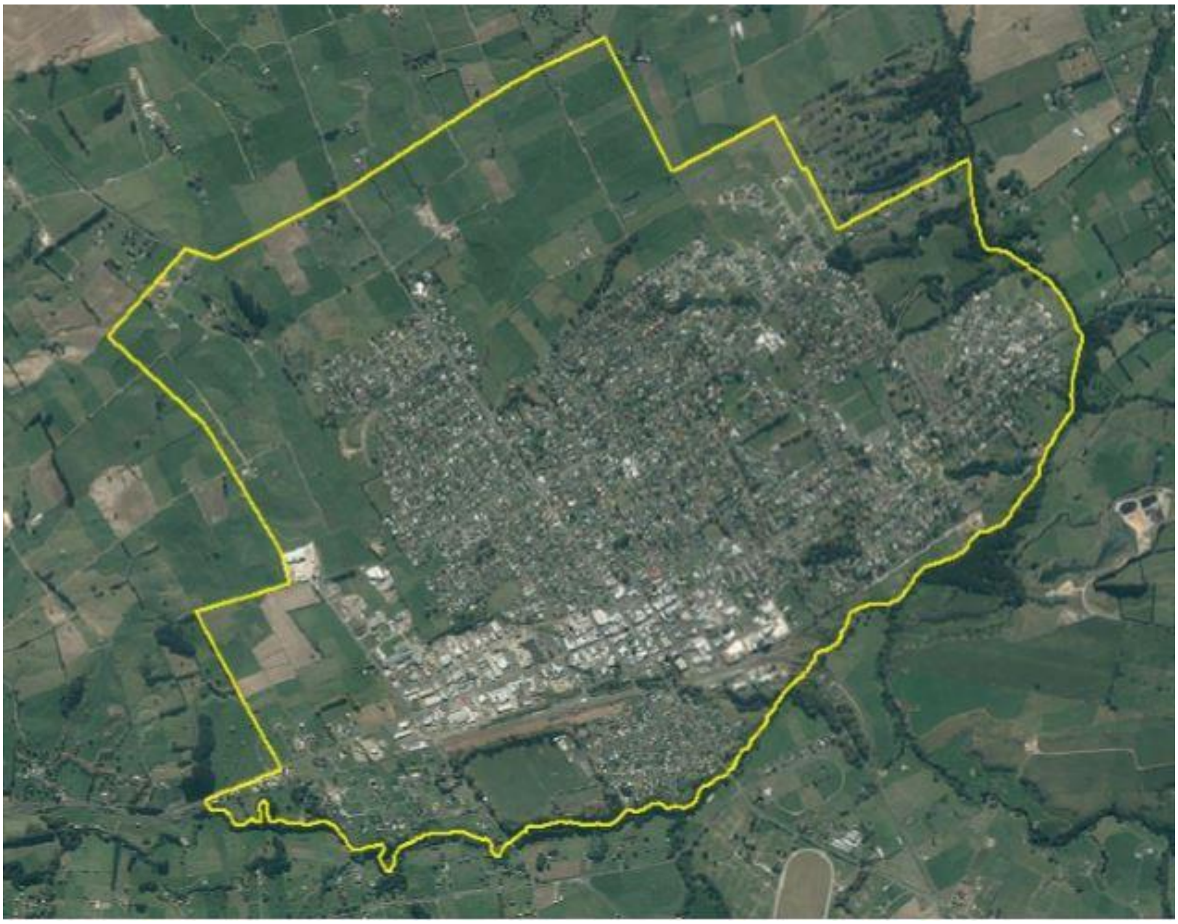
Figure 2.2: Morrinsville Airshed (source Waikato Regional Council).

2.4 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. Collection of data for time periods of less than a day were not obtained for most data.

3 Domestic heating

3.1 Methodology

Domestic heating methods and fuel used by households in Tokoroa and Morrinsville was collected using a household survey carried out by RQMS during May and June 2016 (Appendix A). Table 3.1 shows the number of households based on 2013 census data for the airshed area and survey details.

Table 3.1: Summary household, area and survey data for the Tokoroa and Morrinsville airsheds.

	Households by census area unit 2013	Sample size	Area (ha)	Sample error
Tokoroa	4605	350	1049	5%
Morrinsville	2760	340	891	5%

Home heating methods were classified as; electricity, open fires, wood burners, pellet fires, multi fuel burners, gas burners and oil burners. Wood burners were surveyed by age and then grouped into pre 2006, 2006-2011 and post 2011 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	$PM_{2.5}$ g/kg	CO g/kg	NOx g/kg	SO_2 g/kg	VOC g/kg	CO_2 g/kg	BaP g/kg
Open fire - wood	7.5	7.5	55	1.2	0.2	30	1600	0.002
Open fire - coal	21	18	70	4	8	15	2600	2.70E-06
Pre 2006 burners	10	10	140	0.5	0.2	33	1600	0.003
Post 2006 burners	4.5	4.5	45	0.5	0.2	20	1600	0.003
Pellet burners	2	2	20	0.5	0.2	20	1600	0.003
Multi-fuel[1] - wood	10	10	140	0.5	0.2	20	1600	0.002
Multi-fuel[1] – coal	19	17	110	1.6	8	15	2600	2.70E-06
Oil	0.3	0.22	0.6	2.2	3.8	0.25	3200	
Gas	0.03	0.03	0.18	1.3	7.56E-09		2500	

[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. This was converted into average daily fuel consumption based on an average log weight of 1.6 kg per piece of wood and integrating seasonal and weekly usage rates. The value of 1.6 kg/log was selected as the mid-point of the range found from different New Zealand evaluations (Wilton & Bluett, 2012, Wilton, Smith, Dey, & Webley, 2006, Metcalfe, Sridhar, & Wickham, 2013). The log weight recommended for this work (1.6 kg/piece) is the midpoint and average of the range of values.

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 in Tokoroa

The most popular form of heating the main living area of homes in Tokoroa is wood burners with 50% of households using that method. Electricity is also popular with 46% of households using that method. Around 25% of households used gas for home heating. Open fires and multi fuel burners are only used by a very small proportion of households in Tokoroa. Table 3.3 also shows that households rely on more than one method of heating their main living area during the winter months.

Around 57 tonnes of wood is burnt per typical winter's night in Tokoroa and 0.2 tonnes of coal. In 2012 the amount of wood used on average per night was around 64 tonnes[1] and around 1.5 tonnes of coal was used per night.

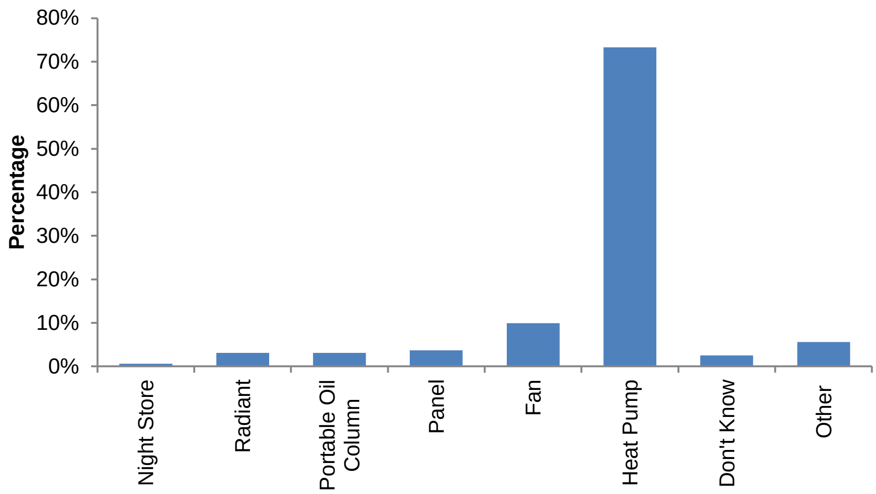

Figure 3.1: Electric heating options for Tokoroa households (main living area).

[1] Adjusting for differences in assumptions regarding the average weight of a log of wood, i.e., multiplying by 1.7/1.6.

Table 3.3: Home heating methods and fuels in Tokoroa.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	46%	2,118		
Total Gas	25%	1,158		0%
Flued gas	19%	872		
Unflued gas	6%	286		
Oil	1%	26		0%
Open fire	1%	39		
Open fire - wood	1%	39	0.5	1%
Open fire - coal	0%	13	0.1	0%
Total Wood burner	50%	2,289	55.0	96%
Pre 2006 wood burner	11%	492	11.8	21%
2006-2011 wood burner	17%	802	19.3	34%
Post-2011 wood burner	22%	995	23.9	42%
Multi-fuel burners	3.4%	158		
Multi-fuel burners-wood	1.7%	79	1.3	2%
Multi-fuel burners-coal	0%	13	0.1	0%
Pellet burners	3%	118		0%
Total wood	52%	2,408	56.8	100%
Total coal	1%	26	0.2	0%
Total		4,605	57	100%

3.3 Home heating methods in Morrinsville

Table 3.4 shows electricity is the main heating method in Morrinsville and is used by 65% of households to heat their main living area. Heat pumps were the most common type of electric heating method being used by 74% of households using electricity (Figure 3.2). Wood burners are also a popular heating method in Morrinsville with 31% of households opting for these devices. Around 18% of households used gas for home heating. Table 3.4 also shows that households rely on more than one method of heating their main living area during the winter months.

Around 18 tonnes of wood is burnt per typical winter's night in Morrinsville and around half a tonne of coal.

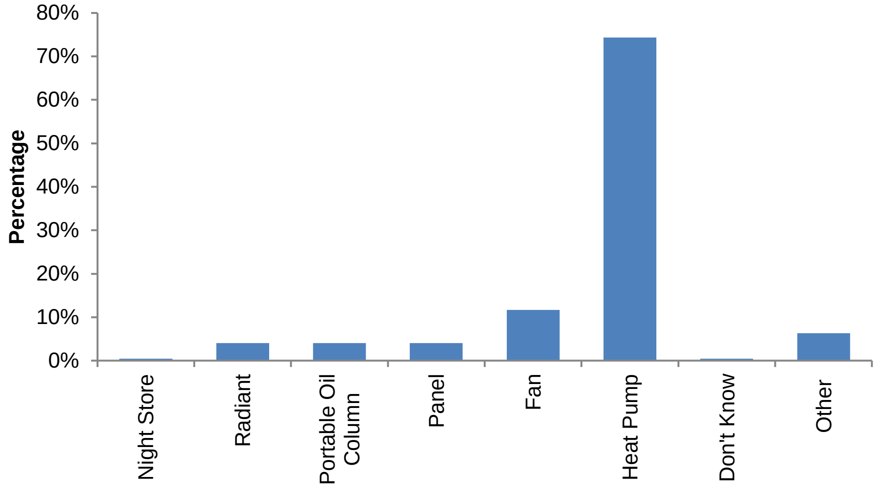

Figure 3.2: Electric heating options for Morrinsville households (main living area).

Table 3.4: Home heating methods and fuels in Morrinsville.

	Heating methods		Fuel Use	
	%	HH	t/day	%
Electricity	65%	1,802		
Total Gas	18%	487	0.0	0%
Flued gas	12%	332		
Unflued gas	6%	155		
Oil	1%	41	0.0	0%
Open fire	2%	65		
Open fire - wood	2%	65	1.0	5%
Open fire - coal	0%	0	0.0	0%
Total Wood burner	31%	852	16.3	86%
Pre 2006 wood burner	12%	337	6.5	34%
2006-2011 wood burner	11%	307	5.9	31%
Post-2011 wood burner	8%	208	4.0	21%
Multi-fuel burners	4%	122		
Multi-fuel burners-wood	2%	65	1.2	6%
Multi-fuel burners-coal	2%	57	0.5	3%
Pellet burners	0%	8	0.0	0.0%
Total wood	36%	982	18	97%
Total coal	2%	57	0.5	3%
Total		2,760	19	

3.4 Emissions from domestic heating in Tokoroa

Around 334 kilograms of PM_{10} is discharged on a typical winter's day from domestic home heating in Tokoroa. Around 35% of the PM_{10} emissions are from pre 2006 wood burners (Figure 3.3). The NES design criteria for wood burners was mandatory for new installations on properties less than 2 hectares from September 2005. Wood burners installed during the years 2006 to 2011 contribute to 26% of domestic heating PM_{10} emissions and burners less than five years old contribute 32%. Open fires contribute 2% and multi fuel burners less than 5%.

Tables 3.5 and 3.6 show the estimates of emissions for different heating methods under average and worst-case scenarios respectively. Days when households may not be using specific home heating methods are accounted for in the daily winter average emissions[2]. Under the worst-case scenario that all households are using a burner on any given night around 388 kilograms of PM_{10} is likely to be emitted.

Figures 3.4 and 3.5 show the monthly variation in appliance use for those that use a particular appliance type and the average days per week used for those that use an appliance type for the month indicated. Figure 3.4 shows that all households that use open fires use them during the winter months. Figure 3.5 shows that all households that use a multi fuel burner during December use it 7 days a week (most probably for water heating purposes). The seasonal variation in contaminant emissions is shown in Table 3.7. Figure 3.6 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

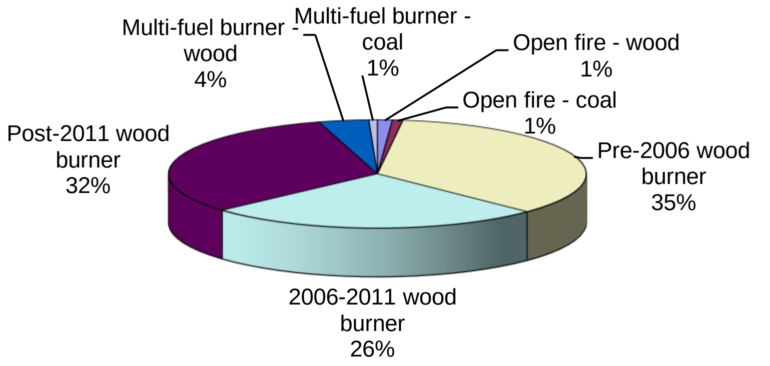

Figure 3.3: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Tokoroa.

[2] Total fuel use per day is adjusted by the average number of days per week wood burners are used (e.g.,6/7) and the proportion of wood burners that are used during July (e.g.,95%).

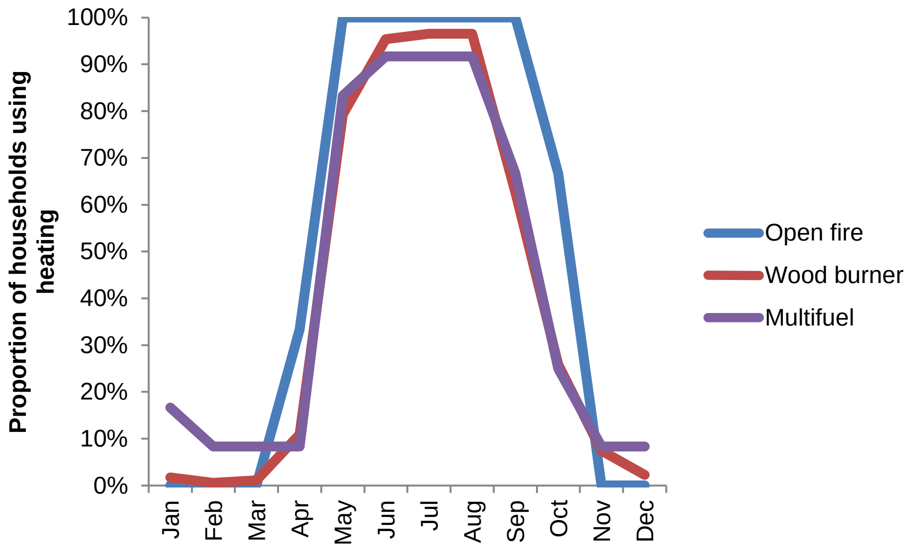

Figure 3.4: Monthly variations in appliance use in Tokoroa.

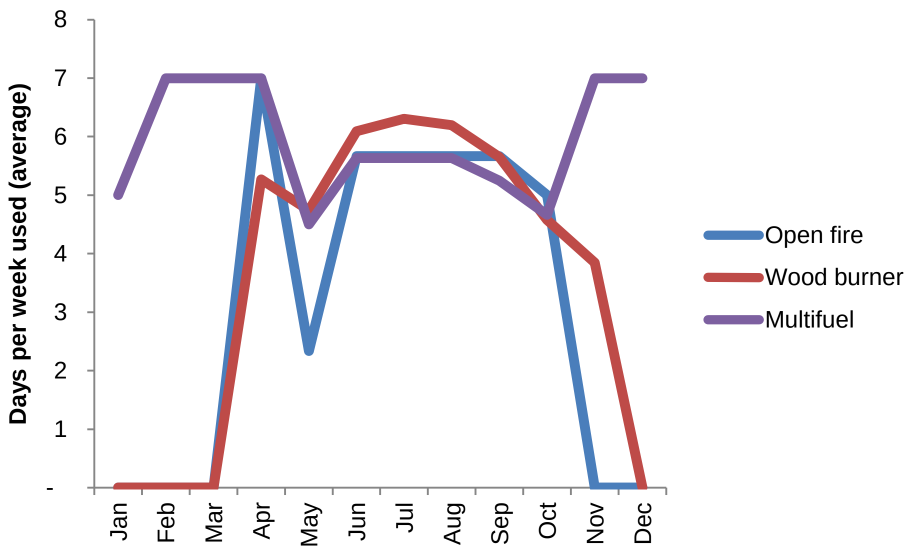

Figure 3.5: Average number of days per week appliances are used in Tokoroa.

Table 3.5: Tokoroa winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			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	0.5	1%	4	4	1%	28	27	1%	1	1	2%	0	0	1%	15	15	1%	1	1	1%	4	4	1%	0.00	0.00	1%
Open fire - coal	0.1	0%	3	3	1%	9	9	0%	1	0	2%	1	1	8%	2	2	0%	0	0	0%	2	2	1%	0.00	0.00	0%
Wood burner	55.0																									
Pre 2006 wood burner	11.8	21%	118	113	35%	1655	1578	43%	6	6	20%	2	2	18%	390	372	30%	19	18	21%	118	113	35%	0.04	0.03	21%
2006-2011 wood burner	19.3	34%	87	83	26%	867	827	23%	10	9	33%	4	4	29%	385	367	30%	31	29	34%	87	83	26%	0.06	0.06	34%
Post 2011 wood burner	23.9	42%	108	103	32%	1076	1026	28%	12	11	41%	5	5	36%	478	456	37%	38	36	42%	108	103	32%	0.07	0.07	43%
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	1.3	2%	13	12	4%	181	172	5%	1	1	2%	0	0	2%	26	25	2%	2	2	2%	13	12	4%	0.00	0.00	2%
Multi fuel – coal	0.1	0%	2	2	1%	13	12	0%	0	0	1%	1	1	7%	2	2	0%	0	0	0%	2	2	1%	0.00	0.00	0%
Gas	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%
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	56.8	100%	329	314	99%	3807	3630	99%	29	27	98%	11	11	85%	1295	1235	100%	91	87	99%	329	314	99%	0.17	0.16	100%
Total Coal	0.2	0%	5	5	1%	22	21	1%	1	1	2%	2	2	15%	4	3	0%	1	1	1%	4	4	1%	0.0	0.0	0%
Total	57		334	319		3829	3650		29	28		13	13		1299	1238		92	87		334	318		0.2	0.2	

Table 3.6: Tokoroa winter daily domestic heating emissions by appliance type (worst case).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			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	0.6	1%	5	5	1%	35	33	1%	1	1	2%	0	0	1%	19	18	1%	1	1	1%	5	5	1%	0.0	0.0	1%
Open fire - coal	0.2	0%	3	3	1%	11	11	0%	1	1	2%	1	1	8%	2	2	0%	0	0	0%	3	3	1%	0.0	0.0	0%
Wood burner	63.3																									
Pre 2006 wood burner	13.6	21%	136	130	35%	1903	1815	43%	7	6	20%	3	3	17%	449	428	30%	22	21	21%	136	130	35%	0.0	0.0	21%
2006-2011wood burner	22.2	34%	100	95	26%	997	951	22%	11	11	32%	4	4	28%	443	423	30%	35	34	33%	100	95	26%	0.1	0.1	34%
Post 2011 wood burner	27.5	42%	124	118	32%	1238	1180	28%	14	13	40%	6	5	35%	550	524	37%	44	42	42%	124	118	32%	0.1	0.1	42%
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%
Multi fuel burner																										
Multi fuel– wood	1.7	3%	17	17	5%	245	233	6%	1	1	3%	0	0	2%	35	33	2%	3	3	3%	17	17	5%	0.0	0.0	2%
Multi fuel – coal	0.2	0%	3	3	1%	17	17	0%	0	0	1%	1	1	8%	2	2	0%	0	0	0%	3	3	1%	0.0	0.0	0%
Gas	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%
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	66	100%	382	364	98%	4418	4212	99%	33	32	97%	13	13	84%	1496	1426	100%	105	100	99%	382	364	99%	0.2	0.2	100%
Total Coal	0	0%	6	6	2%	28	27	1%	1	1	3%	3	2	16%	5	5	0%	1	1	1%	6	5	1%	0.0	0.0	0%
Total	66		388	370		4446	4239		34	33		16	15		1501	1431		106	101		387	369		0.2	0.2	

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

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	$PM_{2.5}$ kg/day	BaP kg/day
January	0	6	0	0	1	0	0	0.0
February	0	4	0	0	1	0	0	0.0
March	0	4	0	0	1	0	0	0.0
April	8	91	1	0	31	2	8	0.0
May	207	2378	18	8	801	57	206	0.1
June	320	3665	28	13	1242	88	319	0.2
July	334	3829	29	13	1299	92	334	0.2
August	329	3767	29	13	1277	90	328	0.2
September	48	562	4	2	190	13	48	0.0
October	16	188	1	1	64	4	16	0.0
November	4	48	0	0	16	1	4	0.0
December	0	4	0	0	1	0	0	0.0
Total (kg/year)	38912	446578	3420	1537	151104	10653	38848	20

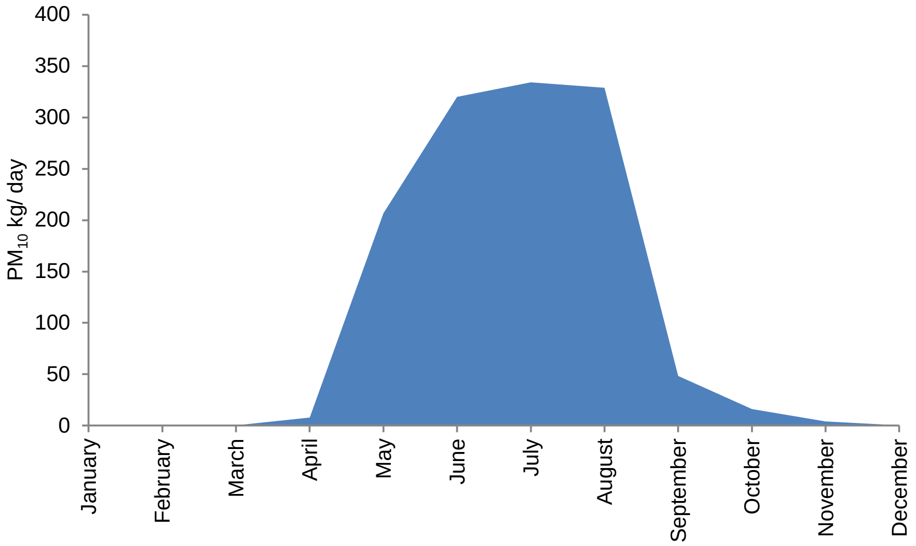

Figure 3.6: Monthly variations in PM_{10} emissions from domestic heating in Tokoroa.

3.5 Emissions from domestic heating in Morrinsville

Around half of the daily PM_{10} emissions from domestic heating in Morrinsville during the winter are from pre 2006 wood burners (Figure 3.7). Wood burners meeting the NES design criteria for burners contribute 32% of domestic heating daily winter PM_{10} emissions. Open fires contribute 5% and multi fuel burners 17% of winter time PM_{10} from domestic heating.

Figures 3.8 and 3.9 show the monthly variation in appliance use for those that use a particular appliance type and the average days per week used for those that use an appliance type for the month indicated. Average daily wintertime PM_{10} emissions are around 137 kilograms per day. Days when households may not be using specific home heating methods are accounted for in this method[3]. Under the worst-case scenario around 171 kilograms of PM_{10} are discharged from all households using solid fuel burners on a particular night.

Figures 3.8 and 3.9 show the monthly variation in appliance use and average days per week used. The seasonal variation in contaminant emissions is shown in Table 3.10. Figure 3.10 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

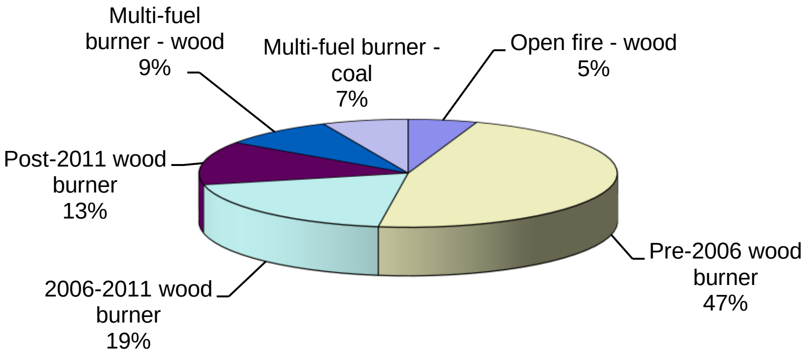

Figure 3.7: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Morrinsville.

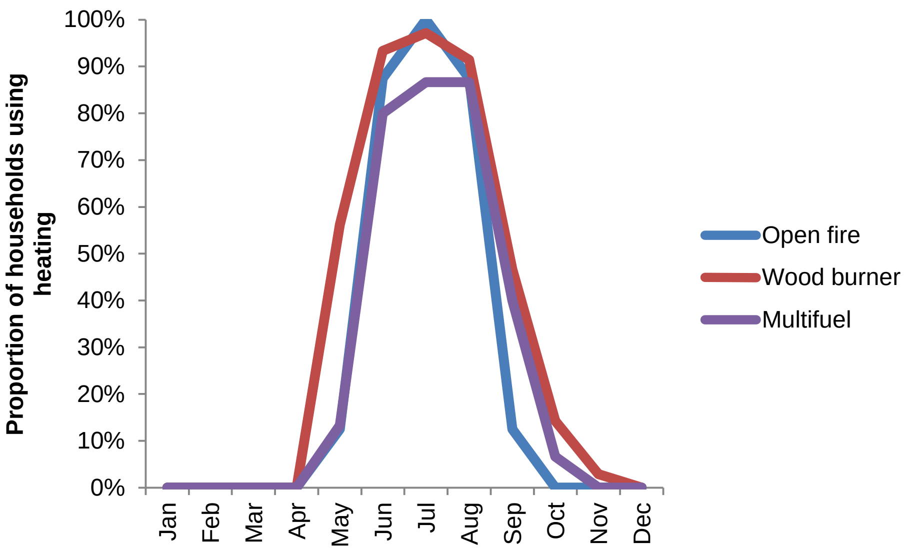

Figure 3.8: Monthly variations in appliance use in Morrinsville.

[3] Total fuel use per day is adjusted by the average number of days per week wood burners are used (e.g.,6/7) and the proportion of wood burners that are used during July (e.g.,95%).

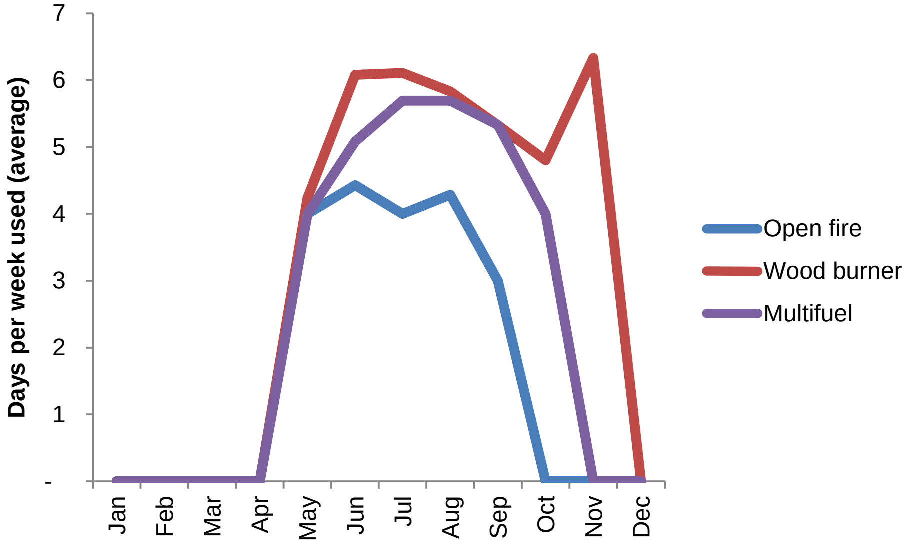

Figure 3.9: Average number of days per week appliances are used in Morrinsville.

Table 3.8: Morrinsville winter daily domestic heating emissions by appliance type (winter average).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$			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	1.0	5%	7	8	5%	54	60	3%	1	1	11%	0	0	3%	29	33	6%	2	2	5%	7	8	5%	0.0	0.0	4%
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	16.3	86%																								
Pre 2006 wood burner	6.5	34%	65	72	47%	903	1014	56%	3	4	30%	1	1	17%	213	239	45%	10	12	33%	65	72	47%	0.0	0.0	36%
2006-2011 wood burner	5.9	31%	26	30	19%	264	297	16%	3	3	27%	1	1	16%	117	132	25%	9	11	30%	26	30	19%	0.0	0.0	33%
Post 2011 wood burner	4.0	21%	18	20	13%	179	201	11%	2	2	19%	1	1	11%	80	90	17%	6	7	21%	18	20	13%	0.0	0.0	22%
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	1.2	6%	12	14	9%	169	190	10%	1	1	6%	0	0	3%	24	27	5%	2	2	6%	12	14	9%	0.0	0.0	5%
Multi fuel – coal	0.5	3%	9	10	7%	53	59	3%	1	1	7%	4	4	51%	7	8	2%	1	1	4%	8	9	6%	0.0	0.0	0%
Gas	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%
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	18.5	97%	128	144	93%	1570	1763	97%	10	11	93%	4	4	49%	464	521	98%	30	33	96%	128	144	94%	0.1	0.1	100%
Total Coal	0.5	3%	9	10	7%	53	59	3%	1	1	7%	4	4	51%	7	8	2%	1	1	4%	8	9	6%	0.0	0.0	0%
Total	19		137	154		1623	1822		11	12		8	8		471	529		31	35		136	153		0.1	0.1	

Table 3.9: Morrinsville winter daily domestic heating emissions by appliance type (worst case).

	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	1.7	7%	13	14	7%	94	105	5%	2	2	15%	0	0	3%	51	57	9%	3	3	7%	13	14	8%	0.00	0.00	5%
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%	0.00	0.00	0%
Wood burner	19.2	82%																								
Pre 2006 wood burner	7.6	33%	76	85	44%	1066	1197	53%	4	4	28%	2	2	15%	251	282	43%	12	14	32%	76	85	45%	0.02	0.03	35%
2006-2011wood burner	6.9	30%	31	35	18%	312	350	16%	3	4	25%	1	2	14%	139	156	24%	11	12	29%	31	35	18%	0.02	0.02	32%
Post 2011 wood burner	4.7	20%	21	24	12%	212	238	11%	2	3	17%	1	1	9%	94	106	16%	8	8	20%	21	24	12%	0.01	0.02	22%
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%	0.00	0.00	0%
Multi fuel burner																										
Multi fuel– wood	1.7	7%	17	19	10%	240	269	12%	1	1	6%	0	0	3%	34	38	6%	3	3	7%	17	19	10%	0.00	0.00	5%
Multi fuel – coal	0.7	3%	13	15	8%	75	84	4%	1	1	8%	5	6	55%	10	11	2%	2	2	5%	11	13	7%	0.00	0.00	0%
Gas	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%
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	23	97%	158	178	92%	1923	2159	96%	13	14	92%	5	5	45%	569	639	98%	36	41	95%	158	178	93%	0.06	0.07	100%
Total Coal	1	3%	13	15	8%	75	84	4%	1	1	8%	5	6	55%	10	11	2%	2	2	5%	11	13	7%	0.00	0.00	0%
Total	23		171	192		1998	2244		14	15		10	11		580	651		38	43		170	191		0.1	0.1	

Table 3.10: Monthly variations in contaminant emissions from domestic heating in Morrinsville.

	PM_{10} kg/day	CO kg/day	NOx kg/day	SOx kg/day	VOC kg/day	CO_2 t/day	$PM_{2.5}$ kg/day	BaP kg/day
January	0	0	0	0	0	0	0	0.00
February	0	0	0	0	0	0	0	0.00
March	0	0	0	0	0	0	0	0.00
April	0	0	0	0	0	0	0	0.00
May	47	571	4	2	172	11	47	0.02
June	129	1524	10	7	447	29	128	0.05
July	137	1623	11	8	471	31	136	0.05
August	126	1483	10	7	428	28	125	0.05
September	7	88	1	0	27	2	7	0.00
October	2	24	0	0	7	0	2	0.00
November	1	6	0	0	2	0	1	0.00
December	0	0	0	0	0	0	0	0.00
Total (kg/year)	13774	163315	1070	721	47663	3112	13675	5

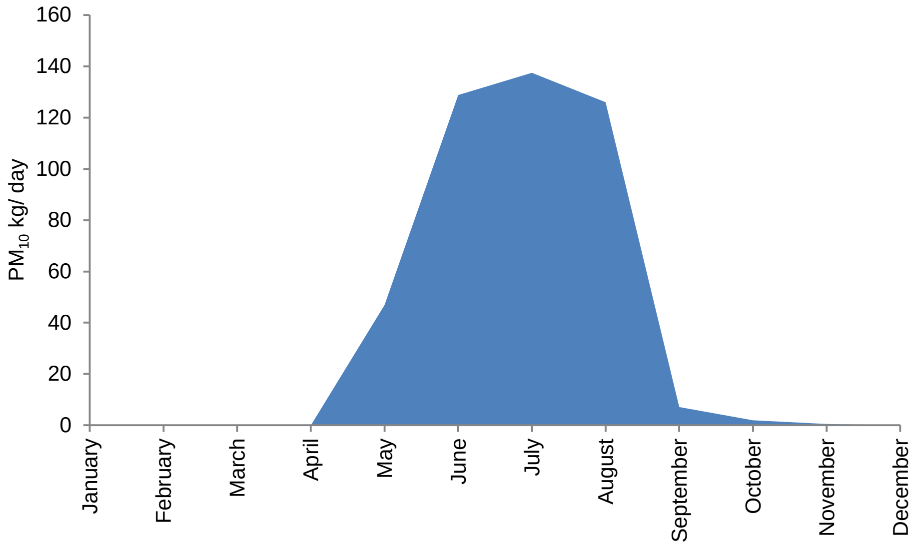

Figure 3.10: Monthly variations in PM_{10} emissions from domestic heating in Morrinsville.

4 Motor vehicles

4.1 Methodology

Motor vehicle emissions to air include tailpipe emissions of a range of 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 emission 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 5.1). Emission factors for PM_{10}, $PM_{2.5}$, CO, NOx, VOCs and CO_2 for this study have been based on VEPM 5.1. Default settings were used for all variables except for the temperature data and the vehicle fleet profile which was based on South Waikato District and Matamata Piako District vehicle registration data for the year ending 30 June 2016 (Table 4.1). Temperature data for both towns were based on a 2015 annual average temperature of 11 degrees for Tokoroa. Resulting emission factors are shown in Table 4.2.

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.

No emission factor data for BaP are available for motor vehicle emissions in New Zealand.

The number of vehicle kilometres travelled (VKT) for the airshed was estimated using the New Zealand Transport Authority VKT data for 2013 available at the census area unit level. No CAU data for VKT were available for more recent years. Table 4.3 shows the estimated VKTs distributed by time of day splits from the Taupo transport model as no road network models were available for Tokoroa or Morrinsville.

Table 4.1: Vehicle registrations for the year ending March 2016.

South Waikato	Petrol	Diesel	LPG	Other	Total
Cars	12,712	1,174	7	0	13,893
LCV	975	1,976	4	0	2,955
Bus	31	57			88
HCV		1,433			1,433
Miscellaneous	207	416	2	0	625
Motorcycle	823				823
Total	14748	5056	13	0	19,817
Matamata Piako	**Petrol**	**Diesel**	**LPG**	**Other**	**Total**
Cars	21,506	2,106	12	4	23,628
LCV	1,481	3,814	2	0	5,297
Bus	25	159			184
HCV		2,572			2,572
Miscellaneous	371	1454	8	0	1,833
Motorcycle	1,009				1,009
Total	24392	10105	22	4	34,523

Table 4.2: Emission factors for Tokoroa and Morrinsville vehicle fleet (2016).

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
Tokoroa	3.69	237	0.23	0.62	0.026	0.01	0.01
Morrinsville	3.30	237	0.20	0.60	0.025	0.01	0.01

Table 4.3: VKT by time of day for Tokoroa and Morrinsville.

	Total VKT	Time of day			
		6am-10am	10am-4pm	4pm-10pm	10pm-6am
Tokoroa	89321	17319	36830	29805	5367
Morrinsville	54188	10507	22343	18082	3256

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) = Emission Rate (g/VKT) * VKT

4.2 Motor vehicle emissions

Around three kilograms per day of PM_{10} are estimated to be emitted from motor vehicles daily in Tokoroa and 2 kg/day in Morrinsville. The analysis found that around 28% of the PM_{10} from motor vehicles is estimated to occur as a result of the wearing of brakes and tyres. Table 4.4 shows the daily estimates of emissions of other contaminants in Tokoroa and Morrinsville.

Table 4.4: Summary of daily motor vehicle emissions

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Tokoroa	1049	3.2	3.0	330	314	56	53	0.3	0.3
Morrinsville	891	1.9	2.1	179	201	33	37	0.2	0.2
		VOC		CO_2		Benzene		$PM_{2.5}$	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha	kg	g/ha
Tokoroa	1049	20	19	21	20	1.0	1	2.7	2.6
Morrinsville	891	11	12	13	14	0.6	1	1.7	1.6

5 Industrial and Commercial

5.1 Methodology

Information on activities discharging to air in Tokoroa and Morrinsville were provided by the Waikato Regional Council. Two industrial discharges were included in the assessments for each of Morrinsville and Tokoroa.

Only one school in Morrinsville used a coal fired boiler and one in Tokoroa used a pellet fire. Other school heating systems were typically gas or heat pumps. Emissions from gas and diesel boilers were not included in the inventory as the PM_{10} emissions from them are negligible for small to medium size boilers.

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 (for example for contaminants other than PM_{10}), 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 data provided by Waikato Regional Council staff.

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[4].

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	Benzene g/kg	$PM_{2.5}$ g/kg
Coal underfeed	2	5.5	4.8	18 x S*	0.1	2400	0.00	1.2
Grain handling	0.017							0.0028
Pellet boiler	0.8	6.8	0.8	0.0	0.1	1069		0.7

* where S is the sulphur content of the fuel

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

5.2 Industrial and commercial emissions

Table 5.2 shows the estimated emissions to air from industrial and commercial activities in Tokoroa and Morrinsville. Around six kilograms is estimated to be discharged to air per winter's day in Tokoroa compared with 110 kg/day in Morrinsville (Table 5.2). The main source of industrial PM_{10} in Morrinsville is Fonterra. The Tokoroa PM_{10} emissions have reduced since the 2012 emissions assessment as a result of the hospital converting from coal burning to gas.

Table 5.2: Summary of industrial emissions (daily winter) in Tokoroa and Morrinsville.

		PM_{10}		CO		NOx		SOx	
	Hectares	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Tokoroa	1049	6	6	7	7	8	7	0	0
Morrinsville	891	110	124	25	28	182	205	0	0
		VOC		CO_2		Benzene		$PM_{2.5}$	
	Hectares	kg	g/ha	t	kg/ha	kg	g/ha	kg	g/ha
Tokoroa	1049	1	1	12	12	12.20	12	0.9	0.8
Morrinsville	891	4	5	88	99	0.09	0	11	12.7

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 Tokoroa and Morrinsville were estimated for the winter months based on data collected during the 2016 domestic home heating survey. The survey showed 10% of households in Tokoroa and 11% in Morrinsville burnt rubbish in the outdoors during the winter. For Tokoroa this is the same proportion that burnt outdoors during winter in 2012.

On average there are around 10 fires per day during winter in both Tokoroa and Morrinsville. Emissions were calculated based on the assumption of an average weight of material per burn of 159 kilograms per cubic metre of material[5] and using the emission factors in Table 6.1 with an average fire size of 1.9 m3 in Tokoroa and 0.6 m^3 in Morrinsville (size based on survey responses). The assumption of material density is higher than for previous inventories. Emission factors for 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 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 on days more suitable for burning[6]. 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. Outdoor burning emissions include a higher degree of uncertainty relative to domestic heating, motor vehicles and industry owing to uncertainties in the distribution of burning and potential variabilities in material density.

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

[5] Based on the average of low and medium densities for garden vegetation from (Victorian EPA, 2016)
[6] The fire service in Tokoroa indicate more complaints regarding burning occur on weekdays as opposed to weekends.

6.2 Outdoor burning emissions

Around 40 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average in Tokoroa and around 12 kilograms per day in Morrinsville.

Table 6.2: Outdoor burning emission estimates for Tokoroa.

	PM10 kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO2 t/ day	$PM_{2.5}$ kg/day	BaP kg/day
Summer (Dec-Feb)	32	106	8	1	11	4	30	0.005
Autumn (Mar-May)	34	115	8	1	12	4	32	0.005
Winter (June-Aug)	40	133	9	2	14	5	37	0.006
Spring (Sept-Nov)	32	108	8	1	11	4	30	0.005

Table 6.3: Outdoor burning emission estimates for Morrinsville.

	PM_{10} kg/ day	CO kg/ day	NOx kg/ day	SOx kg/ day	VOC kg/ day	CO_2 t/ day	$PM_{2.5}$ kg/day	BaP kg/day
Summer (Dec-Feb)	7	23	2	0	2	1	6	0.001
Autumn (Mar-May)	11	37	3	0	4	1	10	0.002
Winter (June-Aug)	12	39	3	0	4	1	11	0.002
Spring (Sept-Nov)	10	34	2	0	4	1	10	0.002

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. These sources are not typically included because the methodology used to estimate the emissions is less robust.

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[7].

[7] 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 Tokoroa

Around 383 kilograms of PM_{10} is discharged to air in Tokoroa on an average winter's day. This compares with an estimated 564 kilograms per day for 2012 (after taking into account differences in methods) indicating a reduction in emissions of around 32% since 2012. The majority of the reduction is estimated to occur as a result of the replacement of older burners with those meeting the NES design criteria. Tampering with these burners to allow shutting down of the oxygen supply will compromise this improvement and has been identified as an issue in some areas of New Zealand. If tampering occurs in the Waikato the actual emission reductions will be less than those estimated. This could be a reason why reductions in monitored concentrations do not always reflect the estimated emission reductions.

Figure 8.1 shows that domestic home heating is the main source of PM_{10} emissions contributing 87% of the daily wintertime emissions. Outdoor burning contributes 10%, industry 2% and transport around 1% of the total wintertime PM_{10} emissions.

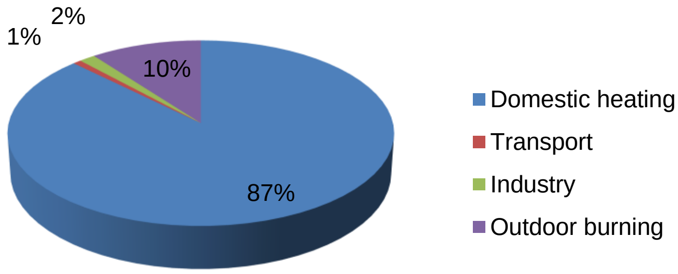

Figure 8.1: Relative contribution of sources to daily winter PM_{10} emissions in Tokoroa.

The estimated reduction in PM_{10} emissions in Tokoroa from 2012 to 2016 is illustrated in Figure 8.2.

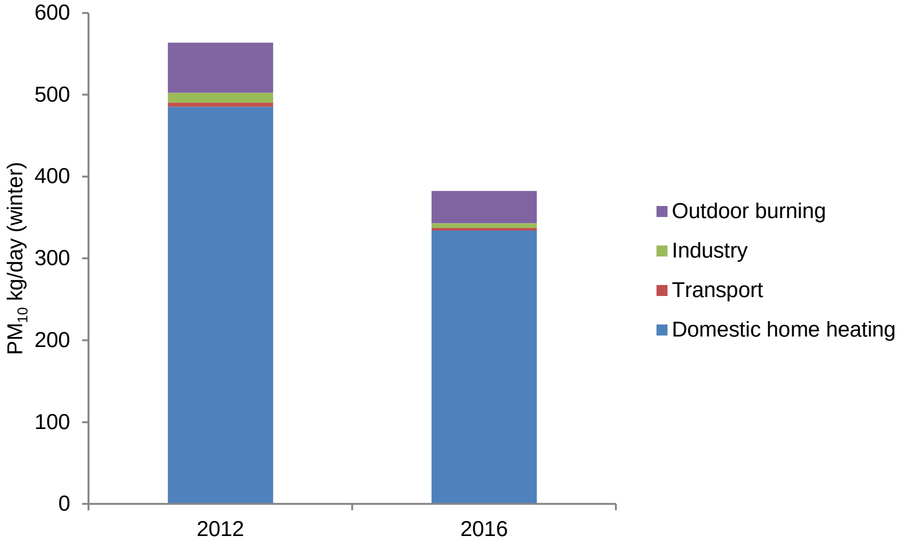

Figure 8.2: Comparison of estimated changes in daily winter PM_{10} emissions in Tokoroa from 2012 to 2016.

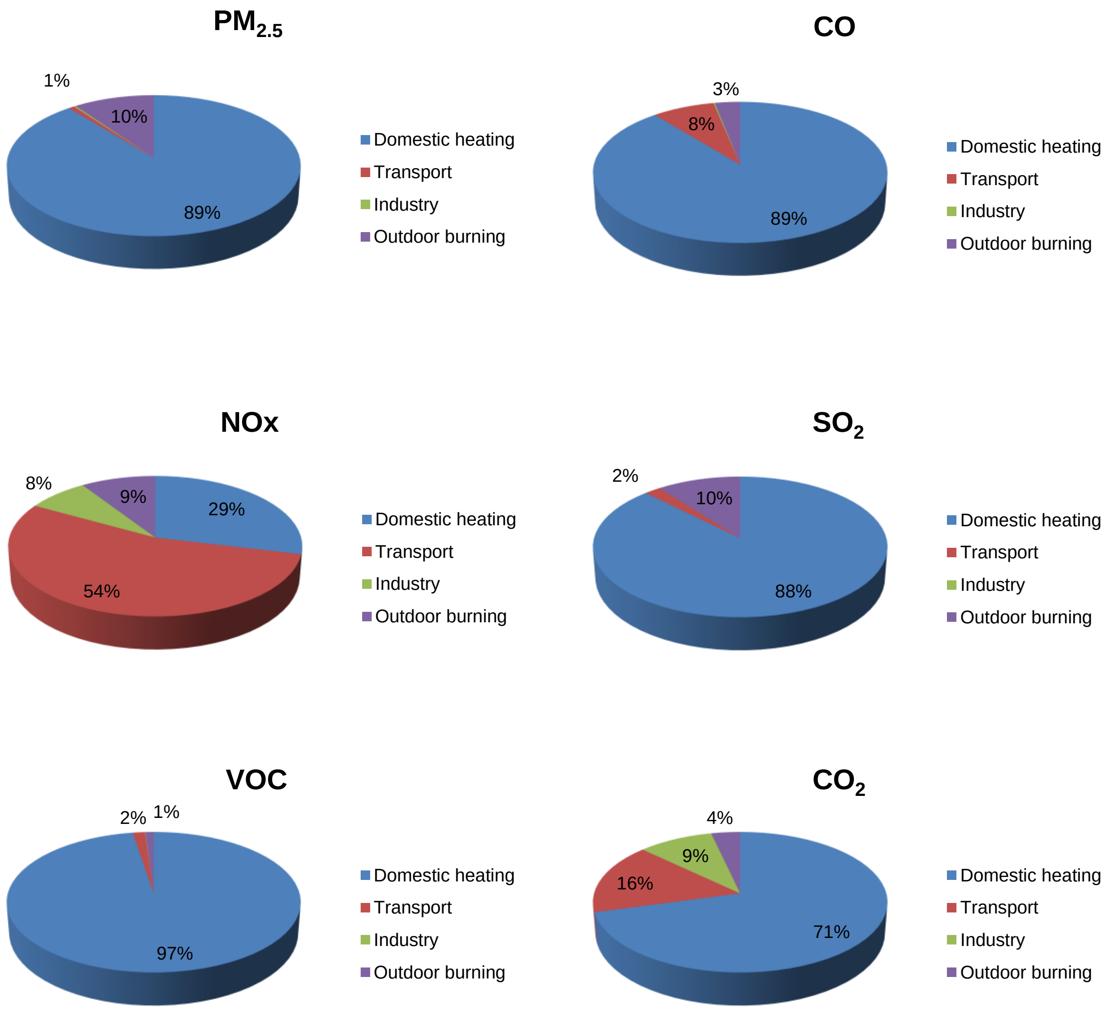

Figure 8.3: Relative contribution of sources to daily winter contaminant emissions in Tokoroa

Domestic home heating is also the main source of daily winter $PM_{2.5}$, CO, SOx, VOCs and CO_2 and motor vehicles are the main source of daily winter NOx in Tokoroa (Figure 8.3).

Table 8.1 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 main source of PM_{10} emissions. Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 8.2.

Figure 8.4 shows the spatial distribution in PM_{10} emissions (by meshblock) across Tokoroa.

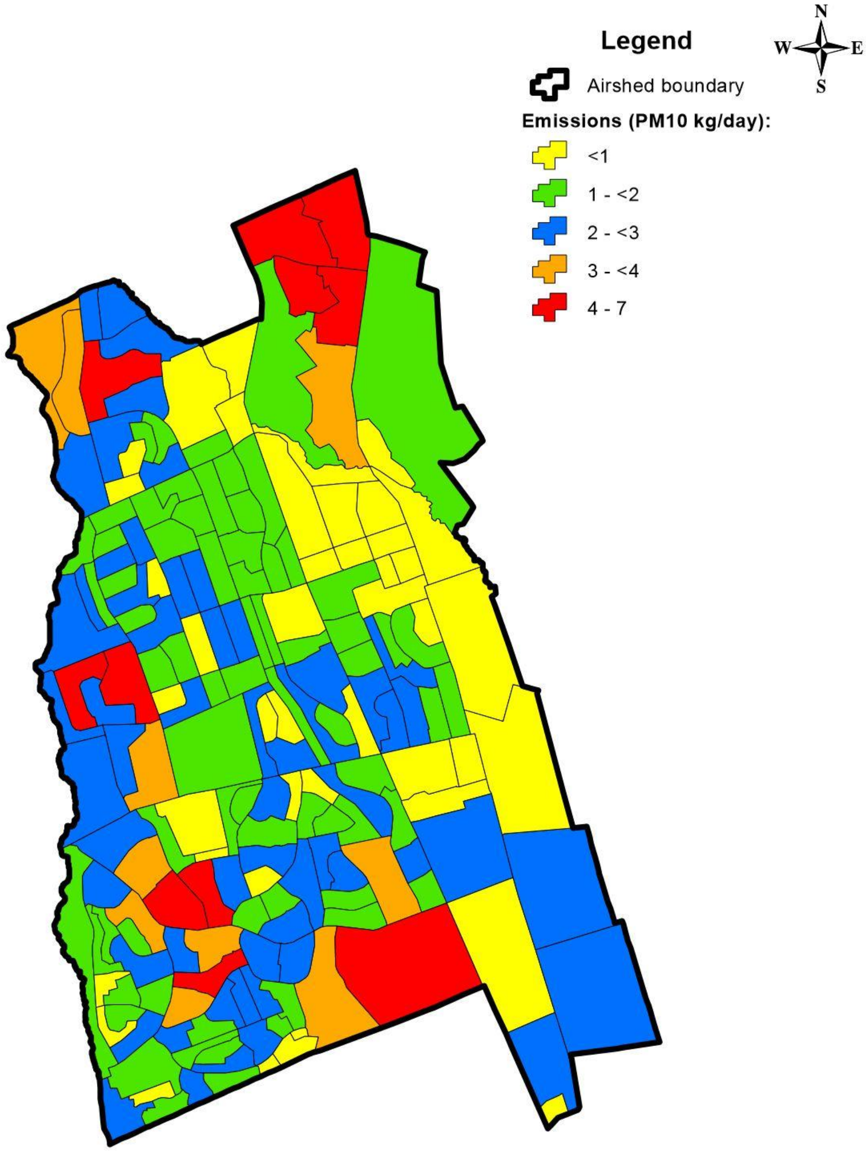

Figure 8.4: Spatial distribution in PM_{10} emissions across Tokoroa

Table 8.1: Monthly variations in daily PM_{10} emissions in Tokoroa.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	1%	32	78%	5	14%	3	7%	40
February	0	1%	32	78%	5	14%	3	7%	40
March	0	1%	34	80%	5	13%	3	7%	43
April	8	16%	34	68%	5	11%	3	6%	50
May	207	83%	34	14%	5	2%	3	1%	249
June	320	87%	40	11%	6	2%	3	1%	368
July	334	87%	40	10%	6	2%	3	1%	382
August	329	87%	40	10%	6	2%	3	1%	377
September	48	54%	32	36%	5	6%	3	3%	89
October	16	29%	32	57%	5	9%	3	5%	57
November	4	9%	32	72%	5	12%	3	7%	44
December	0	1%	32	78%	5	14%	3	7%	40
Total kg year	38912		12555		2017		1060		

Table 8.2: Daily contaminant emissions from all sources in Tokoroa (winter average).

	PM_{10}		CO		NOx		SOx	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	334.2	319	3829	3650	29	28	13	13
Transport	3.2	3	330	314	56	53	0	0
Industry	5.8	6	7	7	8	7	0	0
Outdoor burning	39.5	38	133	127	9	9	2	2
Total	382.7	365	4298	4098	102	98	15	14
	VOC		CO_2		$PM_{2.5}$		BaP	
	kg	g/ha	tonnes	kg/ha	kg	g/ha	kg	g/ha
Domestic home heating	1299	1238	92	87	334	318	0.2	0.2
Transport	20	19	21	20	3	3		
Industry	1	1	12	12	1	1	0.000	0.0
Outdoor burning	14	13	5	4	37	35	0	0.0
Total	1333	1271	129	123	374	357	0	0.2

8.2 Morrinsville

Around 261 kilograms of PM_{10} is discharged to air in Morrinsville on an average winter's day. Domestic home heating and industry are the main sources of PM_{10} emissions contributing 53% and 42% of the daily wintertime emissions respectively (Figure 8.5). Outdoor burning contributes 4% and motor vehicles 1%.

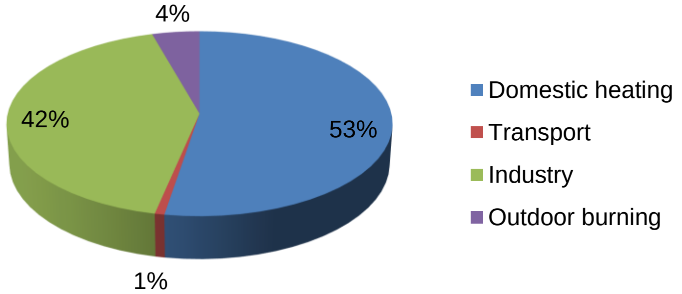

Figure 8.5: Relative contribution of sources to daily winter PM_{10} emissions in Morrinsville.

Domestic home heating is also the main source of $PM_{2.5}$, CO, SO_x and VOCs and industry is the main source of NO_x and CO_2 (Figure 8.6).

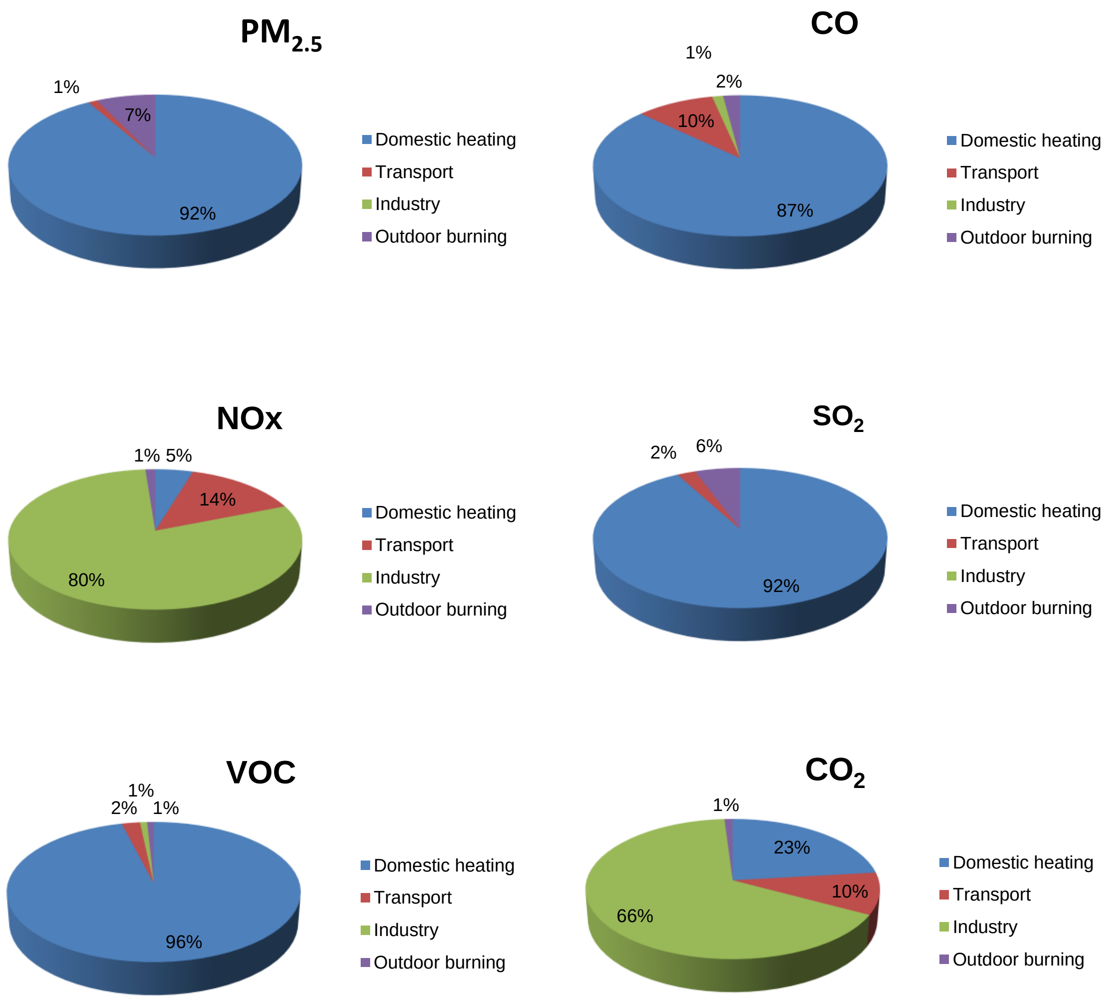

Figure 8.6: Relative contribution of sources to contaminant emissions in Morrinsville

Table 8.3 shows seasonal variations in PM_{10} emissions. During the summer months industry is the dominant contributor to PM_{10} emissions in Morrinsville. Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 8.4.

Figure 8.7 shows the spatial distribution in PM_{10} emissions (by meshblock) across Morrinsville. Note that the red cross-hatched meshblock to the south of Morrinsville represents a very high emission rate of 105 kg/day of PM_{10} compared to all other meshblocks. The source of this elevated emission rate is the Fonterra dairy factory. Previous air dispersion modelling[8] in support of the air discharge consent that authorises the emissions from the milk powder driers on site predicts only a very small contribution to ambient PM_{10} concentrations at ground level within the airshed due to the high efflux velocity and elevated stack heights. Because the source of this PM_{10} is from milk powder driers and is therefore non-combustion related, the proportion of $PM_{2.5}$ associated with this $PM1_0$ emission is expected to be insignificant.

[8] Waikato Regional Council evaluation report for resource consent application 121458 (Doc# 1715598).

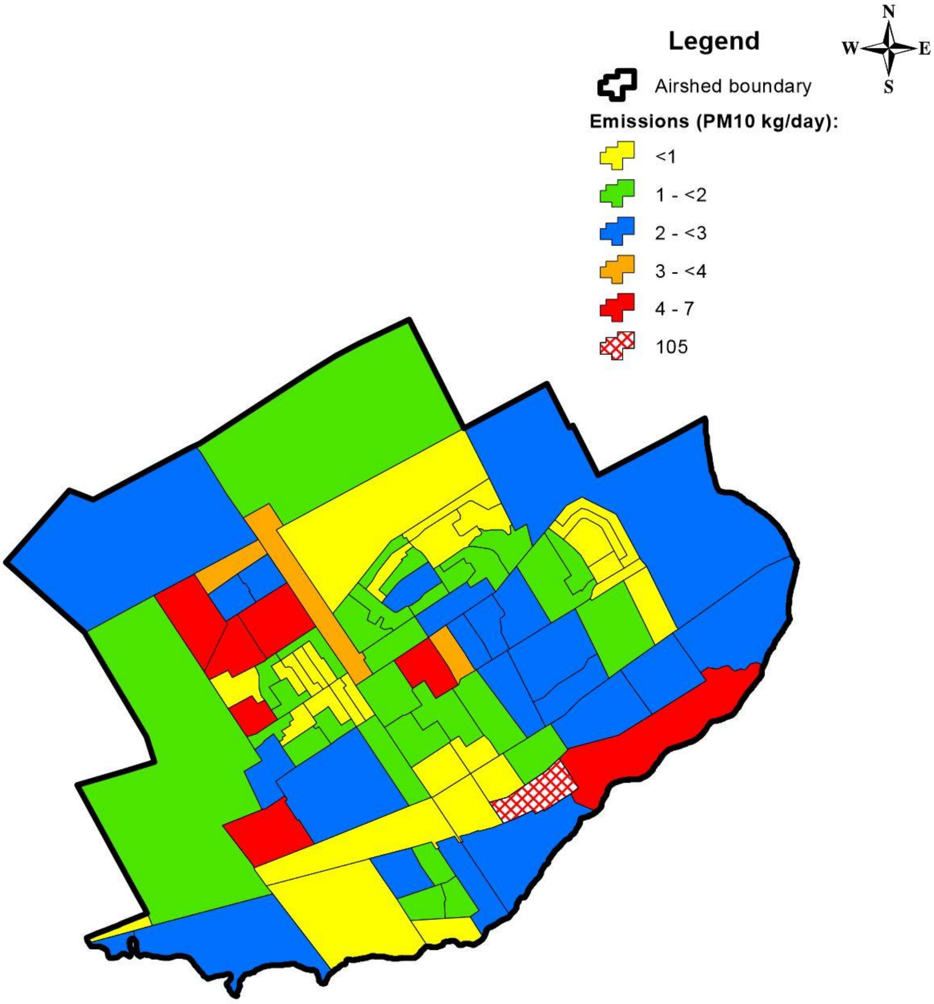

Figure 8.7: Spatial distribution in PM_{10} emissions across Morrinsville

Table 8.3: Monthly variations in daily PM_{10} emissions in Morrinsville.

	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	7	6%	105	92%	2	2%	114
February	0	0%	7	6%	105	92%	2	2%	114
March	0	0%	11	9%	110	89%	2	2%	123
April	0	0%	11	9%	110	90%	2	2%	123
May	47	28%	11	6%	110	65%	2	1%	170
June	129	51%	12	5%	111	44%	2	1%	253
July	137	53%	12	4%	110	42%	2	1%	261
August	126	50%	12	5%	110	44%	2	1%	250
September	7	6%	10	8%	110	85%	2	1%	130
October	2	2%	10	8%	110	89%	2	2%	124
November	1	0%	10	8%	110	90%	2	2%	123
December	0	0%	7	6%	105	92%	2	2%	114
Total kg year	13774		3617		39818		694		

Table 8.4: Daily contaminant emissions from all sources in Morrinsville (winter average).

	PM_{10}		CO		NOx		SOx	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	137	154	1623	1822	11	12	8	8
Transport	2	2	179	201	33	37	0	0
Industry	110	124	25	28	182	205	0	0
Outdoor burning	12	13	39	43	3	3	0	1
Total	261	293	1866	2095	229	257	8	9
	VOC		CO_2		$PM_{2.5}$		BaP	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	471	529	31	35	136	153	0.05	0.1
Transport	11	12	13	14	1.7	1.9		
Industry	4	5	88	99	0.0	0.0	0.0	0.0
Outdoor burning	4	4	1	2	10.8	12.1	0.0	0.0
Total	490	550	133	149	138	155	0.05	0.1

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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 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 your 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 were based on the review of New Zealand emission rates carried out by Wilton et al., (2015) for the Ministry for the Environments air quality indicators programme. This review evaluated emission factors used by different agencies in New Zealand and where relevant compared these to overseas emission factors and information. Preference was given to New Zealand based data where available including real life testing of pre 1994 and NES compliant wood burners (Wilton & Smith, 2006; Smith, et. al., 2008) and burners meeting the NES design criteria for wood burners (Bluett, Smith, Wilton, & Mallet, 2009; Smith, Bluett, Wilton, & Mallet, 2009).

The PM_{10} open fire emission factor was reduced in the review relative to previous factors. Some very limited New Zealand testing was done on open fires during the late 1990s. Two tests gave emissions of around 7.2 and 7.6 g/kg which at the time was a lot lower than the proposed AP42 emission factors (http://www.rumford.com/ap42firepl.pdf) for open fires and the factors used in New Zealand at the time (15 g/kg). An evaluation of emission factors for the 1999 Christchurch emission inventory revised the open fire emission factor down from 15 g/kg to 10 g/kg based on the testing of Stern, Jaasma, Shelton, & Satterfield, (1992) in conjunction with the results observed for New Zealand (as reported in Wilton, 2014). The proposed AP42 emission factors (11.1 g/kg dry) now suggest that the open fire emission factor may be lower still and closer to the result of the limited testing carried out in New Zealand. Consequently a factor of 7.5 g/kg for PM_{10} (wet weight) is proposed to be used for open fires in New Zealand based on the likelihood of the Stern et al., (1992) data being dry weight (indicating a lower emission factor), the data supporting a proposed revised AP 42 factor and the results of the New Zealand testing being around this value. It is proposed that other contaminant emissions for open fires be based on the proposed AP42 emission factors adjusted for wet weight.

The emission factor for wood use on a multi fuel burner was also reduced from 13 g/kg (used in down to the same value as the pre 2004 wood burner emission factor (10 g/kg). The basis for this was that there was no evidence to suggest that multi fuel burners burning wood will produce more emissions than an older wood burner burning wood.

Emission factors for coal use on a multi fuel burner are based on limited data, mostly local testing. Smithson, (2011) combines these data with some further local testing to give a lower emission factor for coal use on multi fuel burners. While these additional data have not been viewed, and it uncertain whether bituminous and subbituminous coals are considered, the value used by Smithson has been selected. The Smithson, (2011) values for coal burning on a multi fuel burner have also been used for PM_{10}, CO and NOx as it is our view that many of the more polluting older coal burner (such as the Juno) will have been replaced over time with more modern coal burners.

No revision to the coal open fire particulate emission factor was proposed as two evaluations (Smithson, (2011) and Wilton 2002) resulted in the same emission factor using different studies. Emissions of sulphur oxides will vary depending on the sulphur content of the fuel, which will vary by location. A value of 8 g/kg is proposed for SOx based on an assumed average sulphur content of 0.5 g/kg and relationships described in AP42 for handfed coal fired boilers (15.5 x sulphur content).

An emission factor of 0.5 g/kg was proposed for NOx from wood burners based on the AP42 data because the non-catalytic burner measurements were below the detection limit but the catalytic converter estimates (and conventional burner estimates) weren't. This value is half of the catalytic burner NOx estimate.

A ratio of 14 x PM_{10} values was used for CO emission estimates as per the AP42 emissions table for wood stoves. This is selected without reference to any New Zealand data owing to the latter not being in any publically available form.