Environment Committee Meeting

2 May 2023

This Report relates to Item **9** in the Agenda

"Picton Air Emission Inventory 2022 and Update on Picton Air Quality Monitoring"

JULY 2022

PREPARED FOR

Marlborough District Council

PREPARED BY

Emily Wilton, Environet Ltd

www.environet.co.nz

Picton Air Emission Inventory - 2022

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EXECUTIVE SUMMARY

Picton is a small waterfront town in the Marlborough District located on the Queen Charlotte Sound. It is a popular holiday destination and serves as a hub for recreation and transportation marine vessels for the area as well as the south island base to the interisland ferry systems. Picton has a normally resident population of around 4300 people.

The main air contaminants of concern in most urban areas of New Zealand are PM_{10} (particles in the air less than 10 microns in diameter) and $PM_{2.5}$ (particles in the air less than 2.5 microns in diameter). The National Environmental Standard (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 but is currently under review and a new standard including annual and daily $PM_{2.5}$ limits are proposed.

The purpose of an emission inventory is to estimate the contribution of different sources to emissions to air and evaluate changes over time. Previous inventory assessments have not been carried out in Picton so trend evaluations are limited.

Sources included in the emission inventory are domestic heating, motor vehicles, port activities including shipping and cargo handling, 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} and $PM_{2.5}$ other contaminants also evaluated include: carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds and carbon dioxide.

Domestic heating was found to be the main source of daily winter PM_{10} emissions, accounting for 75% of the daily winter PM_{10} and 79% of the daily winter $PM_{2.5}$. On an average winter's night, around 100 kilograms of PM_{10} are discharged from all sources. The main contributor to annual PM_{10} and $PM_{2.5}$ is domestic heating (around 53% and 60% for PM_{10} and $PM_{2.5}$ respectively) with outdoor burning and industry being the next most significant contributors.

1 INTRODUCTION

Picton is a small waterfront town in the Marlborough District located on the Queen Charlotte Sound. It is a popular holiday destination and serves as a hub for recreation and transportation marine vessels for the area as well as the south island base to the interisland ferry system. Picton has a normally resident population of around 4300 people and is located approximately 30 kilometers from the Regions main urban centre, Blenheim.

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. National Environmental Standards (NES) set a limit for PM_{10} of 50 µg/m^3 (24-hour average) with one allowable exceedance per year.

The purpose of an emission inventory is to estimate the contribution of different sources to emissions to air and evaluate changes over time. Previous inventory assessments have not been carried out in Picton so trend evaluations are limited. Other air quality studies carried out in Picton include a 2021 spatial air quality monitoring assessment as well as some short term investigative monitoring of PM_{10} concentrations.

Sources included in the emission inventory are domestic heating, motor vehicles, port activities including shipping and cargo handling, 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} and $PM_{2.5}$ other contaminants also evaluated include: carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds and carbon dioxide.

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2 INVENTORY DESIGN

This emission inventory focuses on particulate (PM_{10}) emissions as this, in conjunction with the finer size fraction 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).

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), and carbon dioxide (CO_2).

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 is known to be the best indicator of health impacts of particulate pollution and was a key focus of the proposed amendments to the NES (Ministry for the Environment, 2020). Carbon dioxide has been typically included in emission inventory investigations in New Zealand to allow for the assessment of regional greenhouse gas CO_2 emissions. However, these data are now generally collected nationally and for a broader range of greenhouse gases. Estimates of CO_2 have been retained in the inventory but readers should be directed to national statistics (e.g., www.climatechange.govt.nz.) should detailed data on this source be required. Volatile organic compounds are typically included in emission inventory investigations because of their potential contribution to the formation of photochemical pollution. It is unlikely that ozone formation from emissions within Blenheim would cause ozone problems. In this report, VOC emissions have been estimated for existing sources but data on emissions from VOC specific sources (e.g., spray painting) has not been included. It is likely that the inventory does not capture a number of sources of VOCs.

2.3 Selection of areas

The Picton inventory study area for 2022 is the inventory area defined by the Waitohi and Waikawa SA2 (2018) boundaries as shown in Figure 2.1.

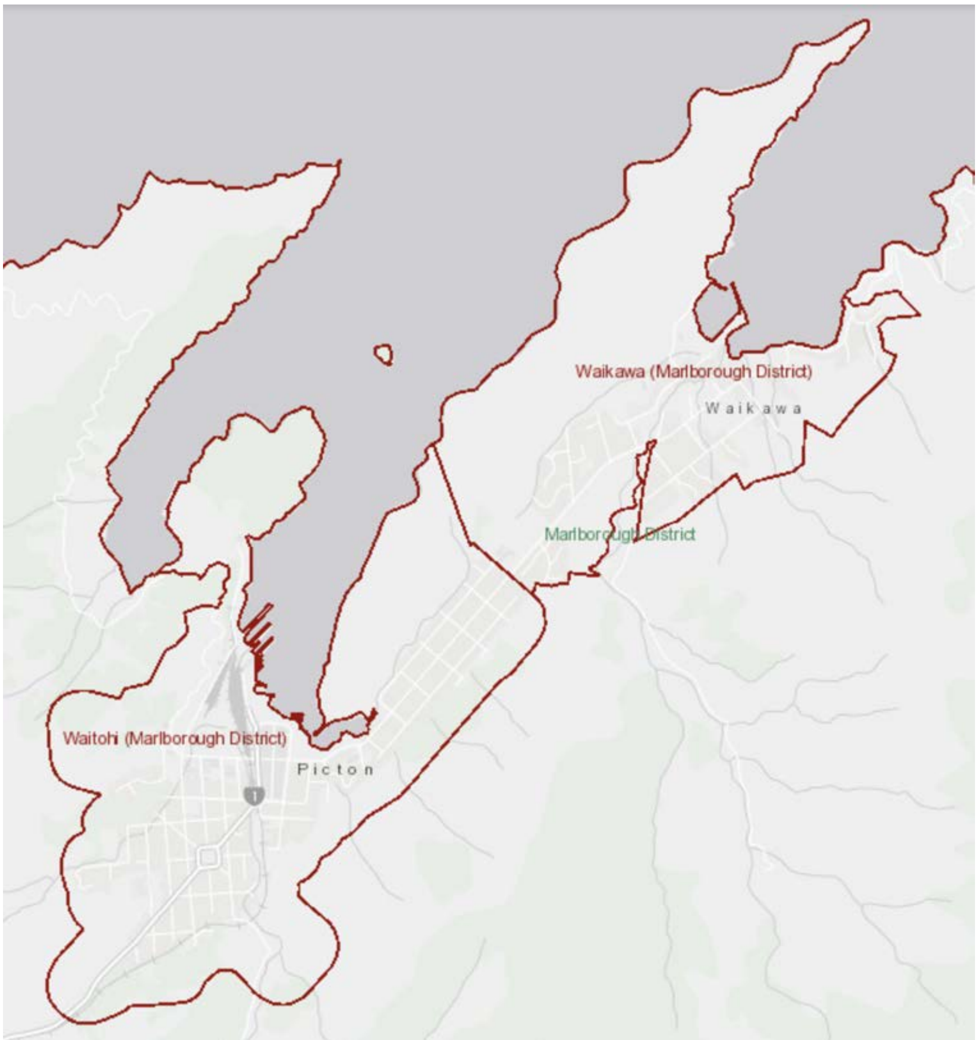

Figure 2.1: Picton inventory area comprising Waitohi and Waikawa SA2 areas.

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 and data 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

Information on domestic heating methods and fuel used by households in Picton was collected using a combination of household survey (winter 2022) and 2018 census data for heating methods (Table 3.1). The latter data were extrapolated for 2022 Picton household numbers based on Statistics New Zealand population projections. Table 3.1 shows the estimated number of households (occupied private dwellings) based on 2018 census data and the 2022 estimates for the inventory area described in section 2.3.

Table 3.1: Summary household data

	Dwellings	Heat pump	Electric heater	Fixed gas heater	Portable gas heater	Wood burner	Pellet fire	Coal burner	Other types of heating
2018 SA2 (census)	1974	1092	591	75	102	912	15	15	27
2022 SA2 (projected)	2069	1144	619	79	107	956	16	16	28

Responses from the sample surveyed were extrapolated to the wood burning households in Picton to estimate the burner age distributions and fuels quantities used. Home heating methods were classified as; electricity, open fires, wood burners (differentiated by age), pellet fires, multi fuel burners, gas burners and oil burners. Emission factors were applied to these data 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
Open fire - wood	7.5	7.5	55	1.2	0.2	30	1600
Open fire - coal	21	18	70	4	8	15	2600
Pre 2006 burners	10	10	140	0.5	0.2	33	1600
Post 2006 burners	4.5	4.5	45	0.5	0.2	20	1600
Pellet burners	2	2	20	0.5	0.2	20	1600
Multi-fuel[1] - wood	10	10	140	0.5	0.2	20	1600
Multi-fuel[1] – coal	19	17	110	1.6	8	15	2600
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

Fuel use data were taken from the 2022 Picton household survey. 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 et al., 2006) (Metcalfe et al., 2013). The log weight recommended for this work (1.6 kg/ piece) is the midpoint and average of the range of values. Seasonal distribution data for solid fuel burners in Picton was taken from the 2022 Blenheim Air Emission 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.

3.2 Home heating methods in Picton

The most popular form of heating the main living area of homes in Picton is electricity with around 71% of households using that method. Of households using electricity, 78% use heat pumps. Wood burners are the next most common at 47% of households.

Trends in heating fuels from 2006 to 2018 were examined to assess trends in solid fuel burner use for home heating. Figure 3.1 shows that the proportion of households using wood burning for home heating has not changed significantly over the past 15 years. Coal use has been low historically with a further decrease in households relying on this method from 2006 to 2018.

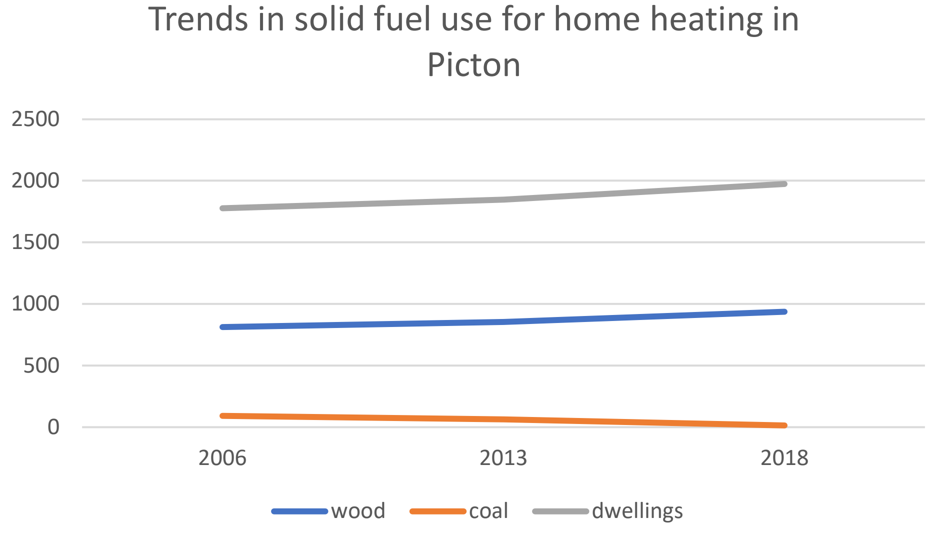

Figure 3.1: Trends in home heating fuels in Picton from 2006 to 2018 (NZ Stats, 2021)

Table 3.3 combines survey data with census data to provide a more detailed breakdown of heating methods.

Around 12 tonnes of wood is estimated to be burnt per typical winter's night in Picton for 2022.

Table 3.3: Home heating methods and fuels.

	Heating methods		Fuel Use	
	%	Households	t/day	%
Electricity	71%	1,471		
Total Gas	9%	182	0	1%
Flued gas	0%			
Unflued gas	0%			
Oil	0%	0	0.0	0%
Open fire	1%	25		
Open fire - wood	1%	25	0	2%
Open fire - coal	0%	0	0	0%
Total Wood burner	46%	956	12	95%
Pre 2006 wood burner	15%	306	4	31%
2006-2016 wood burner	21%	440	5	44%
Post-2016 wood burner	10%	210	3	21%
Multi-fuel burners	1%	16		
Multi-fuel burners-wood	0%	0	0	0%
Multi-fuel burners-coal	1%	16	0	1%
Pellet burners	1%	16		0%
Total wood	47%	981	12	97%
Total coal	1%	16	0	1%
Total		2,069	12	99%

3.3 Emissions from domestic heating.

Around 77 kilograms of PM_{10} is discharged on a typical winter's day from domestic home heating in Picton.

Figure 3.2 shows that older wood burners installed prior to 2006 contribute the majority of the PM_{10} from domestic heating. The NES design criteria for wood burners was mandatory for new installations on properties less than 2 hectares from September 2005. Wood burners installed from 2006 to 2016 contribute 31% of domestic heating PM_{10} emissions and post 2016 burners contribute 8%.

Tables 3.4 and 3.5 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[1]. Under the worst-case scenario that all households are using a burner on any given night around 91 kilograms of PM_{10} is likely to be emitted.

The seasonal variation in contaminant emissions is shown in Table 3.6. Figure 3.3 indicates that the majority of the annual PM_{10} emissions from domestic home heating occur during June, July and August.

[1] 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%).

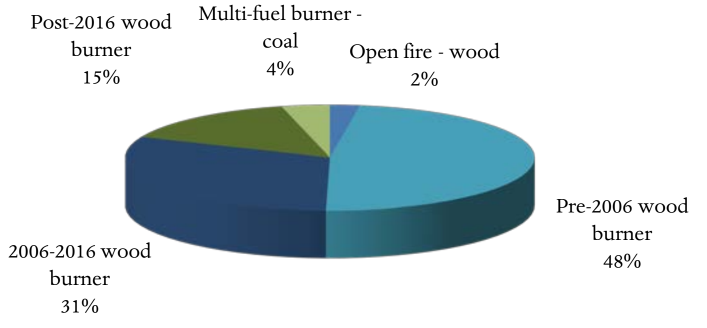

Figure 3.2: Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating.

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

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	0.2	2%	2	2	2%	13	14	1%	0	0	4%	0	0	1%	7	8	3%	0	0	2%	2	2	2%
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%
Wood burner	11.6																						
Pre 2006 wood burner	3.7	31%	37	40	48%	518	565	57%	2	2	28%	1	1	21%	122	133	42%	6	6	30%	37	40	48%
2006-2016 wood burner	5.3	44%	24	26	31%	239	261	27%	3	3	41%	1	1	30%	106	116	37%	9	9	43%	24	26	31%
Post 2016 wood burner	2.5	21%	11	12	15%	114	125	13%	1	1	19%	1	1	14%	51	55	18%	4	4	21%	11	12	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	0	0%
Multi fuel burner																							
Multi fuel– wood	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 – coal	0.2	1%	3	3	4%	17	19	2%	0	0	4%	1	1	34%	2	3	1%	0	0	2%	3	3	3%
Gas	0.2	1%	0.01	0	0%	0	0	0%	0	0	3%	0	0	0%	0	0	0%	0	0	2%	0	0	0%
Oil	0.0	0%	0.00	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total Wood	11.8	97%	74.15	81	96%	885	965	98%	6	7	93%	2	3	66%	286	312	99%	19	21	96%	74	81	97%
Total Coal	0.2	1%	2.94	3	4%	17	19	2%	0	0	4%	1	1	34%	2	3	1%	0	0	2%	3	3	3%
Total	12		77	84		902	984		7	7		4	4		289	315		20	21		77	84	

Table 3.5: Picton winter daily domestic heating emissions by appliance type (worst case).

	Fuel Use		PM_{10}			CO			NO_x			SO_x			VOC			CO_2			$PM_{2.5}$		
	t/day	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	kg	g/ha	%	T	kg/ha	%	kg	g/ha	%
Open fire																							
Open fire - wood	0.4	3%	3	3	3%	23	25	2%	1	1	7%	0	0	2%	13	14	4%	1	1	3%	3	3	3%
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%
Wood burner	13.5																						
Pre 2006 wood burner	4.3	30%	43	47	47%	604	659	57%	2	2	28%	1	1	20%	142	155	41%	7	8	30%	43	47	47%
2006-2011wood burner	6.2	44%	28	30	31%	279	304	26%	3	3	41%	1	1	29%	124	135	36%	10	11	43%	28	30	31%
Post 2011 wood burner	3.0	21%	13	15	15%	133	146	13%	1	2	19%	1	1	14%	59	65	17%	5	5	21%	13	15	15%
Pellet Burner	0.1	1%	0	0	0%	3	3	0%	0	0	1%	0	0	1%	3	3	1%	0	0	1%	0	0	0%
Multi fuel burner																							
Multi fuel– wood	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 – coal	0.2	1%	4	4	4%	21	23	2%	0	0	4%	2	2	35%	3	3	1%	0	1	2%	3	3	3%
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%
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%
Total Wood	14	99%	88	96	96%	1042	1136	98%	7	8	96%	3	3	65%	341	372	99%	22	24	98%	88	96	97%
Total Coal	0	1%	4	4	4%	21	23	2%	0	0	4%	2	2	35%	3	3	1%	0	1	2%	3	3	3%
Total	14		91	100		1063	1159		8	8		4	5		344	375		23	25		91	99	

Table 3.6: Monthly variations in contaminant emissions from domestic heating in Picton.

	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
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	6	73	0	0	23	2	6
April	17	197	2	1	63	5	17
May	34	387	3	2	126	9	34
June	73	853	6	3	277	18	73
July	77	904	7	4	291	20	77
August	62	738	5	3	235	16	62
September	35	410	3	2	130	9	35
October	11	134	1	0	43	3	11
November	1	18	0	0	6	0	1
December	0	0	0	0	0	0	0
Total (kg/year)	9703	113650	830	447	36548	2507	9661

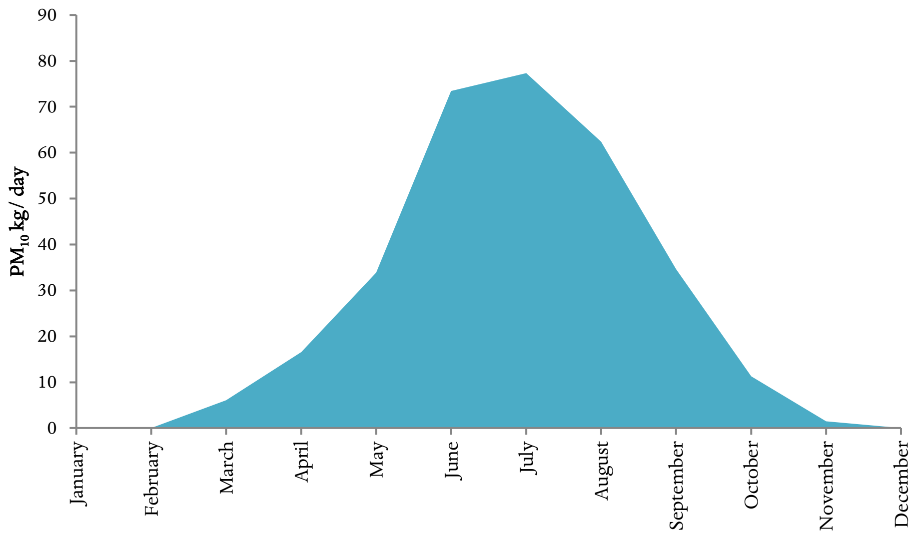

Figure 3.3: Monthly variations in PM_{10} emissions from domestic heating.

4 TRANSPORT EMISSIONS

4.1 Motor vehicles

4.1.1 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.

Emission factors for motor vehicles are determined using the Vehicle Emission Prediction Model (VEPM 6.0) developed by Auckland Council. Emission factors for PM_{10}, $PM_{2.5}$, CO, NOx, VOCs and CO_2 for this study have been based on VEPM 6.0. Default settings were used for all variables except for the temperature data and the vehicle fleet profile which was based on Marlborough vehicle registration data for 2021 (Table 4.1). Temperature data were based on a winter average temperature for Picton of seven degrees. 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.

In addition to estimates of tailpipe emissions and brake and tyre emissions using VEPM an estimate of re-suspended road dust was made using the emissions factors in the EMEP/EEA air pollutant emission inventory guidebook (Table 4.3). This is a source of vehicle related emissions that wasn't included in previous inventories.

The number of vehicle kilometres travelled (VKT) for the airshed was estimated using the Blenheim 2022 inventory VKT estimate adjusted based on the proportion of VKT in Picton relative to Blenheim for 2013[2]. This suggested daily VKT of around 33,557 for Picton.

Table 4.1: Vehicle registrations (Marlborough) for the year ending December 2021.

Picton	Petrol	Diesel	Hybrid	Plug in hybrid	Electric	LPG	Other	Total
Cars	30,110	4,201	420	78	169	3	0	34,981
LCV	2,165	12,442	0	0	3	4	0	14,614
Bus	84	378	0	0	0	0	0	462
HCV		5,516			33			5,549
Miscellaneous	850	2126	1	0	50	18	0	3,045
Motorcycle	2,690							2,690
Total	35899	24663	421	78	255	25	0	61,341

Table 4.2: Emission factors (2022) for Picton vehicle fleet.

	CO g/VKT	CO_2 g/VKT	VOC g/VKT	NOx g/VKT	PM_{10} g/VKT	PM_{10} brake & tyre g/VKT	$PM_{2.5}$ (tailpipe and brake and tyre) g/VKT
Picton	1.5	0.028	0.023	0.836	0.175	0.028	0.012

[2] Most recent year data were available at this spatial resolution

Table 4.3: Road dust TSP emissions (from EMEP/EEA guidebook, EEA, 2016).

	TSP g/VKT
Two wheeled vehicles	0.01
Passenger car	0.02
Light duty trucks	0.02
Heavy duty trucks	0.08
Weighted vehicle fleet factor	0.02
PM_{10} size fraction	0.5
$PM_{2.5}$ size fraction	0.27

Emissions 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

4.1.2 Motor vehicle emissions

Around two kilograms per day of PM_{10} are estimated to be emitted from motor vehicles daily in Picton. Around 45% of the PM_{10} from motor vehicles is estimated to occur as a result of tailpipe emissions with 38% from the wearing of brakes and tyres. Tables 4.4 and 4.5 show the daily and annual estimates of motor vehicle emissions in Picton.

Table 4.4: Summary of daily motor vehicle emissions

	PM_{10}		CO		NOx		SOx	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Tailpipe	0.9	1.0	50	55	28	31	0.0	0.03
Brake and tyre	0.8	0.8						
Road dust	0.3	0.4						
Total	2.1	2.2	50	54.5	28	30.6	0	0.03
	VOC		CO_2		$PM_{2.5}$			
	kg	g/ha	t	kg/ha	kg	g/ha	kg	g/ha
Tailpipe	5	5	8	9	0.9	1		
Brake and tyre					0.4	0		
Road dust					0.2	0		
Total	5	8	8	14	1.5	2		

Table 4.5: Summary of annual motor vehicle emissions

PM_{10} tonnes/year	CO tonnes/year	NOx tonnes/year	SOx tonnes/year	VOC tonnes/year	CO_2 tonnes/year	$PM_{2.5}$ tonnes/year
0.7	18.3	10	0.01	1.6	2977	0.6

4.2 Shipping and port emissions

Shipping emissions within the inventory area occur as a result of vessels approaching and leaving the Port facilities including the Shakespare Bay dock, manoeuvring whilst berthing and as a result of the use of auxiliary engines and boilers whilst docking. Harbour vessels including tugs, coast guard and recreational boats also contribute to shipping emissions, but to a lesser extent (e.g., Peeters, 2018).

In addition, Port emissions occur as a result of the loading and unloading of cargo at the Port. In particular, PM_{10} and $PM_{2.5}$ discharges occur as a result of the handling of materials that generate fine dusts. The latter are included in the industrial emissions assessment however. Cargo handling equipment and trucks visiting the Port emit products of combustion including all contaminants considered in this inventory (PM_{10}, CO, NOx, SOx, VOCs, CO_2 and $PM_{2.5}$). Other sources of PM_{10} and $PM_{2.5}$ include open storage of material, brake and tyre wear and use of paved and unpaved roads.

4.2.1 Shipping methodology

The methodology for assessing emissions from shipping was taken from the USEPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories (ICF International, 2009). That report details three approaches for ocean going vessels: a detailed inventory, a mid tier assessment and a port matching process.

Emissions from ocean going vessels that call at a Port vary depending on vessel size and the time spent at different speeds. A call refers to one entrance and one clearance of a vessel from the Port Authority area. A shift refers to a movement within the Port Authority Area as vessels may move from berth to berth during a call. Hotelling is the time spent stationary at Port during which it uses its auxiliary engine for power. Activity data for shipping includes the number of calls for different vessel sizes, the average number of shifts and the time spent in Port. Speeds are broken down into cruise speed (94% of maximum speed), reduced speed (harbour reduced speed zone – 9-12 knots in most areas) and manoeuvre speed (typically 3-8 knots).

For the purposes of assessing the contribution of shipping and port activities to the Picton air emission inventory the shipping discharge was limited to emissions assessed at a reduced speed within the harbour area as well as a three kilometre radius from the harbour entry.

Emissions from ocean going vessels were calculated using equation 4.1 which was applied to both the main propulsion engine and the auxiliary engine using the load factor assumptions from Table 4.2.

Equation 4.1 $E = P \times LF \times A \times EF$

Where:

E = Emissions (grams)

P = Maximum continuous rating power (kW)

LF = Load Factor (percent of vessels total power)

A = Activity (hours)

EF = Emission Factor (g/kWh)

A mid-tier assessment approach was undertaken using information on the number of calls by ship type and using the average power rating and load factors for the vessel type.

Recreational vessels are typically much lesser contributors to shipping emissions (e.g., Peeters, 2018). Consequently these are often excluded from of Port emissions assessments in New Zealand (e.g., Wilton, 2019). However, the number of ocean going vessels comparatively for Picton is low and estimates have therefore been included for both recreational and passenger vessels.

Data on the number of calls for different vessel types and the time in Port was obtained from the Port of Marlborough (pers comm, Rose Prendeville, 2022). Vessels classified as miscellaneous were assumed to have the same average rating and loadings as the general cargo vessels.

Emission factors for shipping were taken from ICF International, (2009) and are shown in Table 4.8. Emission factors are considered constant down to loads of 20% and increase for lower loads. Low load adjustment factors from ICF International (Table 2-15, 2009) were used when loads were estimated at less than 20%. ICF

International, (2009) indicated that most ocean-going vessels operate their main propulsion engines on residual oil (RO)/ heavy fuel oil (HFO). However, emission factors for MGO 0.5% have been used for this assessment because vessels are already complying with Marpol Annex VI (pers comm Rose Prendeville, 2022). Load factors are 83% for ships at cruise speed and for lower speeds are calculated using propeller law as per Equation 4.2. The maximum speed per vessel type was calculated using equations developed for the Port of Auckland Inventory (Peeters, 2018).

Equation 4.2: Load Factor = $(\text{Average speed}/\text{Maximum speed})^3$

Emissions from vessels whilst stationary at Port also need to be assessed as the auxiliary engines are used during this time to provide power to the ship unless shore power (connection of ships to land based power) is adopted. No Ports in New Zealand currently offer shore power. The load factors used to assess auxiliary emissions whilst stationary at Port (referred to as hoteling) are shown in Table 4.9 along with the average power rating of auxiliary engines for different vessels. Time spent hoteling was calculated using the average time in Port less the approach and manoeuvring times.

Table 4.6: Emission factors for shipping (ICF International, 2009)

	Fuel + S content	PM_{10} g/kWh	CO g/kWh	SOx g/kWh	NOx* g/kWh	$PM_{2.5}$ g/kWh
Slow speed diesel	RO 2.7%	1.42	1.4	10.29	18.1	1.31
	MDO 1%	0.45	1.4	3.62	17	0.42
	MGO 0.5%	0.31	1.4	1.81	17	0.28
	MGO 0.1%	0.19	1.4	0.36	17	0.17
Medium speed diesel	RO 2.7%	1.43	1.1	11.24	14	1.32
	MDO 1%	0.47	1.1	3.97	13.2	0.43
	MGO 0.5%	0.31	1.1	1.98	13.2	0.29
	MGO 0.1%	0.19	1.1	0.40	13.2	0.17
Gas turbine	RO 2.7%	1.47	0.2	16.1	6.1	1.35
	MDO 1%	0.58	0.2	5.67	5.7	0.53
	MGO 0.5%	0.35	0.2	2.83	5.7	0.32
	MGO 0.1%	0.17	0.2	0.57	5.7	0.15
Steam turbine	RO 2.7%	1.47	0.2	16.1	2.1	1.35
	MDO 1%	0.58	0.2	5.67	2.0	0.53
	MGO 0.5%	0.35	0.2	2.83	2.0	0.32
	MGO 0.1%	0.17	0.2	0.57	2.0	0.15
Auxiliary Engine	RO 2.7%	1.44	1.1	11.98	14.7	1.32
	MDO 1%	0.49	1.1	4.24	13.9	0.45
	MGO 0.5%	0.32	1.1	2.12	13.9	0.29
	MGO 0.1%	0.18	1.1	0.42	13.9	0.17

* ICF International, (2009) indicates that an adjustment factor of 0.8 can be applied to NOx emissions for a 2015 assessment to take into account international standards relating to NOx emissions from shipping.

RO = residual oil, MGO = marine gas oil, MDO marine diesel oil

Table 4.7: Average engine power, speeds, load factors and boiler energy defaults (ICF International, 2009)

Ship Type	Average propulsion engine (kW)	Average Auxiliary Engines No.	Power each (kW)	Total Power	Boiler Energy default – hotel (kW)	LF (Aux hoteling)	LF (Aux reduced speed)	LF (Aux cruise)	LF (Aux manoeuvre)	Cruise speed (knots)
Bulk carrier	8000	2.9	612	1776	371	0.1	0.30	0.15	0.45	14.5
Container ship	30900	3.6	1889	6800	109	0.19	0.27	0.17	0.45	21.6
Cruise ship	39600	4.7	2340	11000	506	0.64	0.25	0.13	0.48	20.9
General cargo	9300	2.9	612	1776	1000	0.22	0.80	0.80	0.80	15.2
Roll on roll off	11000	2.9	983	2850	106	0.26	0.27	0.17	0.45	16.8
Reefer	9600	4	975	3900	109	0.32	0.30	0.15	0.45	19.5
Tanker	9400	2.7	735	1985	464	0.26	0.34	0.20	0.67	14.8
	Average propulsion engine (kW)						**LF Main**			
Ferry	857 x 1.9	1.2	81.9	98			0.42			

Table 4.8: Activity data for shipping (pers comm, Rose Prendeville, Port of Marlborough, email 17 July 2022)

Classification	No of calls call/year	Time in Port hours/year
Bulk carrier	2706	2736
Ferries	57	5412
Other vessels	55	1320
Small commercial	1100	n/a
Recreational vessel	31000	n/a

4.2.2 Shipping

Table 4.9 shows the estimated emissions from shipping, harbour and recreational vessels at the Port by ship type. This indicates less than one tonne of PM_{10} and $PM_{2.5}$ per year from shipping and recreational vessels in the Picton airshed (including a three kilometre harbour entry passage).

Table 4.9: Shipping and recreational vessel emissions

	PM_{10} tonnes/year	CO tonnes/year	NOx tonnes/year	SOx tonnes/year	$PM_{2.5}$ tonnes/year
Recreational vessels	0.28	1.13	13.59	1.92	0.28
Bulk carrier	0.19	0.64	8.06	1.22	0.17
Small commercial	0.02	0.07	0.80	0.12	0.02
Ferry	0.31	1.12	13.59	1.95	0.28
Miscellaneous	0.21	0.16	9.04	0.27	0.19
Total	1.0	3.1	45.1	5.5	0.9

Additionally, the prevalence of cruise ships has the potential to increase shipping emissions in the airshed. No cruise ships were present or anticipated during 2022) but of interest is the potential for increases in emissions associated with this source. Historical cruise ship numbers and hotelling time were provided by the Port of Marlborough (pers comm, Rose Prendeville, 2022) for the purpose of assessing future potential emissions. For 2022, a total of 51 cruise ships with an average of 10 hours docking per ship was recorded. This source would add an additional 0.1 tonnes per year of PM_{10} and $PM_{2.5}$, 4.4 tonnes of NOx and 0.7 tonnes of SOx using MARPOL (Annex VI) compliant fuels.

4.3 Rail

KiwiRail operates New Zealand DL class (diesel-electric) locomotives with the network extending for around four kilometers into the Picton airshed and culminating at the Port of Marlborough terminal. The location of the rail network within the airshed can be seen in Figure 2.1.

Emissions from rail are calculated using emission factors and fuel consumption as follows:

Emissions = fuel consumption (tonnes of diesel per day) x emission factor (kg pollutant/ tonne of diesel)

The fuel consumption was estimated using data on the gross tonne kilometres (GTK) within the Picton inventory area. Diesel consumption was estimated by multiplying the GTK by the average diesel consumption rate per GTK across the national rail network (litres per GTK).

Data provided by KiwiRail indicates around 5,855,255 Gross Tonne kilometres (GTKs) occur in Picton (Table 7.7) assuming around 17.5% of the GTKs the Spring Creek - Picton segment occur within the Picton Airshed. The diesel consumption rate per GTK was provided by KiwiRail (pers com J, Jones, 2018) as 5.7 litres per 1000 GTK (average for New Zealand rail fleet).

Emission factors for rail are shown in Table 7.8 and are from the European Inventory Guidebook (EEA/EMEP, 2016).

Table 7.10: Gross Tonne Kilometers (GTKs) for Rail Links - Picton.

Train Segment Name	Distance (km)	2021 GTK's
Picton - Spring Creek	22.85	33,448,142

Table 7.11: Emission factors for rail (source EEA, 2016).

	PM_{10}	CO	SOx*	NOx	$PM_{2.5}$
	kg/tonne fuel	kg/tonne fuel	kg/tonne fuel	kg/tonne fuel	kg/tonne fuel
Line-haul rail	1.2	18	0.02	63	1.1
Upper CI (95%)	3	21		93	3
Lower CI (95%)	0.45	5		29	0.42

*SOx emissions calculated based on the sulphur content of diesel in New Zealand

5 INDUSTRIAL AND COMMERCIAL ACTIVITIES

5.1 Methodology

Information on industrial activities with resource consents for air discharges in Picton were provided by the Marlborough District Council. Additional activities with smaller scale discharges to air were identified though a web based search.

The selection of industries for inclusion in this inventory was based on potential for PM_{10} and $PM_{2.5}$ emissions. Industrial activities such as spray painting or dry cleaning operations, which discharge primarily VOCs were not included in the assessment.

Emissions were estimated using activity data and emission factor information, as indicated in Equation 5.1. 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 typically collected using data contained on resource consent applications or by direct contact with industry.

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 pellet fired boiler emission factors for PM_{10} are based on New Zealand specific emission factors as described in Wilton & Baynes (2010). Other emission factors are from the USEPA AP42 database[3] with the exception of pizza ovens which is from EEA, (2019).

Emissions from log loading and unloading and storage were estimated using product quantities provided by the Port of Marlborough (pers comm, Rose Prendeville, email 27 July 2022) and AP42 emission factors (Table 5.2).

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	CO2 g/kg	$PM_{2.5}$ g/kg
Abrasive blasting	0.69						
Diesel boiler	0.3	0.67	3.2	0.1	0.2	3194	0.2
Pellet boiler	0.8	6.8	0.8	0.0	0.1	1069	0.7
Wood fired pizza oven	13.6	72	0.9	0.20	10.8	1500	13.2

Table 5.2: Activity data and emission factors for cargo handling.

Product	Quantity Tonnes*	AP42 description	SIC	PM_{10} kg/tonne product	$PM_{2.5}$ kg/tonne product
Logs	941670	AP42 memorandum		0.000145 /drop	0.000044 /drop
				Tonne/ha/year	
Log storage	8 hectares	AP 42 memorandum		0.04	

Based on a conversion of JAS/m³ of 0.95 and a m³/tonne conversion of 0.9 (pinus radiatus – 12 years aged) (Ellis, 2016).

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

5.2 Industrial and commercial emissions

Tables 5.2 and 5.3 show the estimated emissions to air from industrial and commercial activities in Picton. Around nine kilograms is estimated to be discharged to air per winter's day and just over three tonnes per year.

Table 5.3: Summary of industrial emissions (daily winter).

PM_{10}		CO		NOx		SOx	
kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
9	10	1	2	0	0	0	0
VOC		**CO_2**		**$PM_{2.5}$**			
kg	g/ha	t	kg/ha	kg	g/ha		
0	0	221	241	4	5		

Table 5.4: Summary of annual industrial emissions

PM_{10}	CO	NOx	SOx	VOC	CO_2	$PM_{2.5}$
tonnes/year	tonnes/year	tonnes/year	tonnes/year	tonnes/year	tonnes/year	tonnes/year
3.3	0.4	0.0	0.0	0.1	29	1.6

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 notified Marlborough Plan prohibits outdoor burning in Picton during the winter months. The plan is not yet operative. However, because outdoor burning is prohibited in a notified plan a resource consent would be required for outdoor rubbish burning until such time as the plan became operative.

6.1 Methodology

Outdoor burning emissions for Picton were estimated for the winter months based on data collected during the 2022 domestic home heating survey. The survey showed 12% of households in Picton burnt rubbish in the outdoors during the winter. It is noted that the survey has a sample error of 9.5% and t

Emissions were calculated based on the assumption of an average weight of material per burn of 159 kilograms per cubic metre of material[4] and using the emission factors in Table 6.1 with an average fire size of 2.25 m3 (size based on survey responses).

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

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

[4] Based on the average of low and medium densities for garden vegetation from (Victorian EPA, 2016)

6.2 Outdoor burning emissions

Table 6.2 shows that around 12 kilograms of PM_{10} from outdoor burning could be expected per day during the winter months on average in Picton.

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. 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. Additionally the survey has a sample error of 9.6% owing to the difficulties in capturing a higher respondent rate in a small town. For other sources using the inventory data are supplemented to reduce uncertainties but this is not possible for outdoor burning owing to differing rules in Blenheim to Picton and because no census data exists that could assist this assessment.

The estimated annual average emissions from outdoor burning are shown in Table 6.3. The major uncertainties surrounding the daily emission estimates do not apply to annual estimates as no assumptions about when the stated burning occurs throughout a week is needed.

Table 6.2: Outdoor burning emission estimates.

	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
Summer (Dec-Feb)	2	13	1	0	2	2	13
Autumn (Mar-May)	12	65	5	1	12	12	65
Winter (June-Aug)	12	61	4	1	12	12	61
Spring (Sept-Nov)	10	55	4	1	10	10	55

Table 6.3: Outdoor burning emission estimates (annual).

PM_{10} tonnes/year	CO tonnes/year	NOx tonnes/year	SOx tonnes/year	VOC tonnes/year	CO_2 tonnes/year	$PM_{2.5}$ tonnes/year
3	18	1	0	2	1	3

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 of 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. Historically a Pacific Air and Environment (1999) figure of around 0.07 grams of PM_{10} per household per day has been used. This was re-evaluated with more recent information in Wilton (2019). This indicated a range of 0.0012 to 0.05 g/household/day and results in an estimate of less than 0.1 kilograms of PM_{10} per day from these sources.

8 TOTAL EMISSIONS

Around 103 kilograms of PM_{10} is discharged to air in Picton on an average winter's day. Figure 8.1 shows that domestic home heating is the main source of PM_{10} emissions contributing 75% of the daily wintertime PM_{10} emissions and 53% of the annual PM_{10} emissions. Industry and outdoor burning are the next most significant sources of both daily and annual PM_{10} emissions.

Figure 8.2 shows similar relative contributions of sources to daily winter and annual average $PM_{2.5}$.

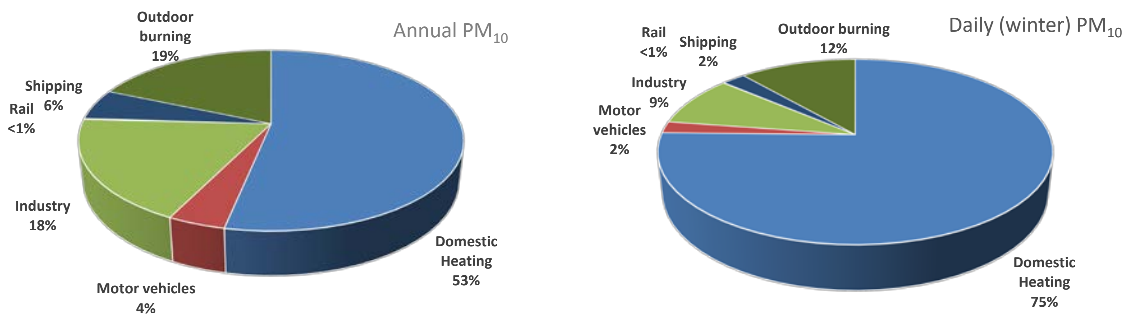

Figure 8.1: Relative contribution of sources to daily winter PM_{10} and annual PM_{10} emissions.

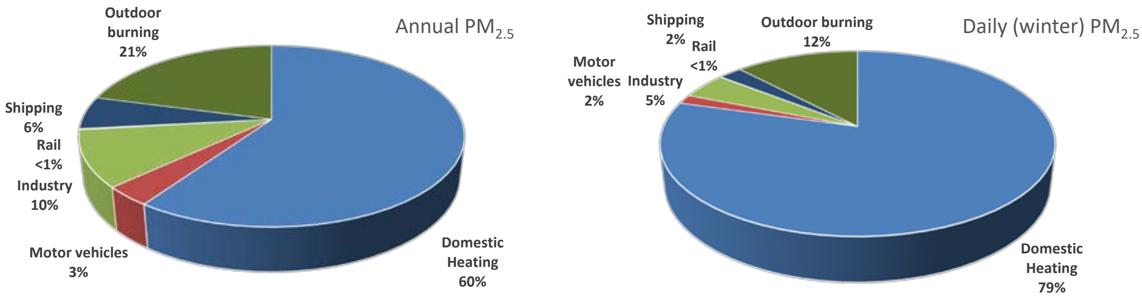

Figure 8.2: Relative contribution of sources to daily winter $PM_{2.5}$ and annual $PM_{2.5}$ e missions.

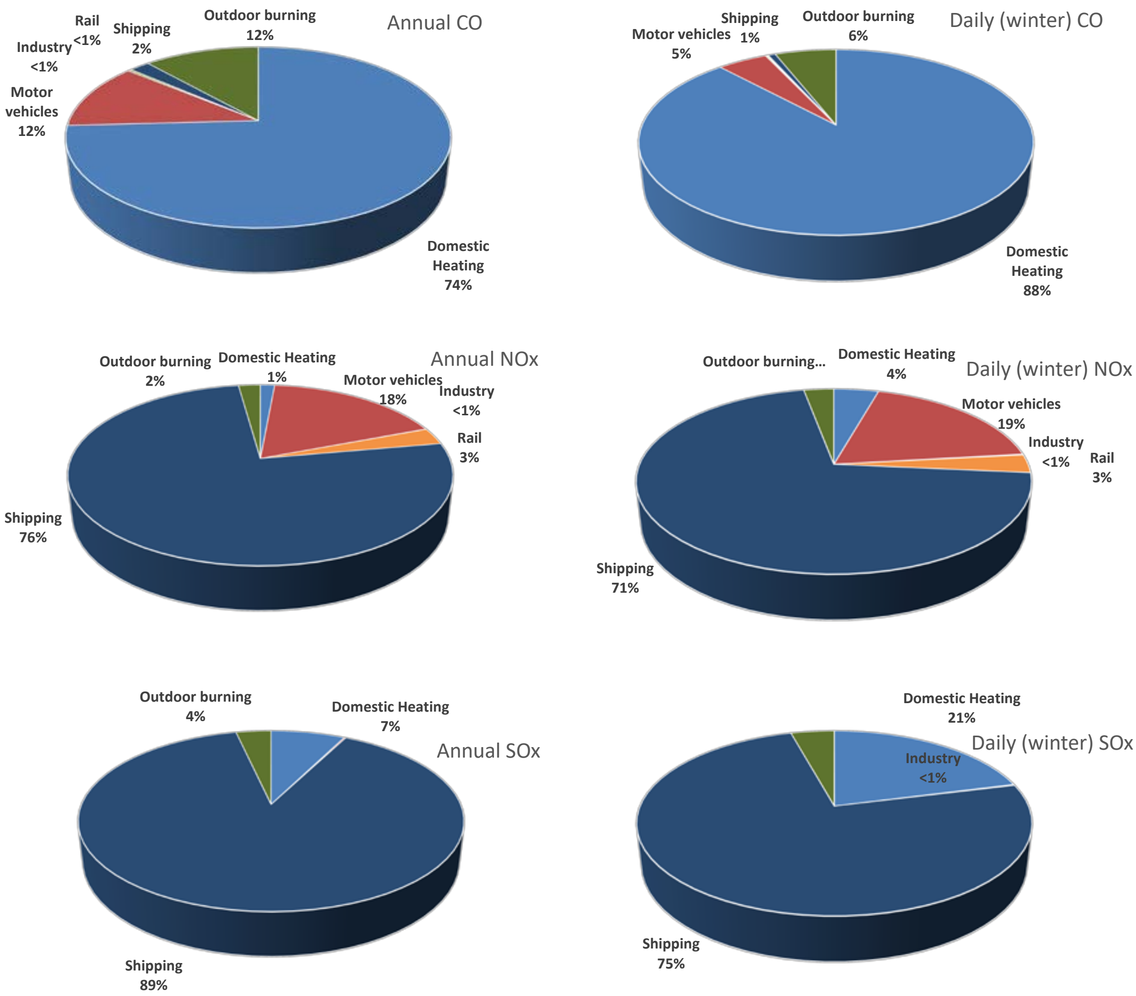

Figure 8.3: Relative contribution of sources to daily winter and annual contaminant emissions.

Domestic home heating is also the main source of daily winter CO. Shipping is the main source of NOx and SOx in Picton (Figure 8.3).

Table 8.1 shows seasonal variations in PM_{10} and $PM_{2.5}$ emissions. Daily wintertime emissions of PM_{10} and other contaminants (kg/day and g/day/ha) are shown in Table 8.2.

Table 8.1: Monthly variations in daily PM_{10} and $PM_{2.5}$ emissions.

PM_{10}	Domestic Heating		Outdoor Burning		Industry		Shipping		Motor vehicles		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	2	15%	9	54%	3	20%	2	12%	17
February	0	0%	2	15%	10	59%	2	14%	2	12%	17
March	6	19%	12	38%	9	28%	3	9%	2	6%	32
April	17	38%	12	29%	9	22%	3	6%	2	5%	43
May	34	57%	12	21%	9	15%	2	4%	2	3%	60
June	73	74%	12	12%	9	9%	3	3%	2	2%	99
July	77	75%	12	11%	9	9%	2	2%	2	2%	102
August	62	71%	12	13%	9	10%	3	3%	2	2%	88
September	35	59%	10	18%	9	16%	2	4%	2	3%	59
October	11	32%	10	29%	9	26%	3	7%	2	6%	35
November	1	6%	10	41%	9	37%	2	8%	2	8%	25
December	0	0%	2	14%	9	52%	4	22%	2	12%	17
Total kg year	9703	53%	3377	19%	3367	19%	982	5%	748	4%	18177

$PM_{2.5}$	Domestic Heating		Outdoor Burning		Industry		Motor vehicles		Shipping		Total
	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day	%	kg/day
January	0	0%	2	21%	4	38%	3	27%	2	13%	12
February	0	0%	2	22%	5	44%	2	20%	2	14%	11
March	6	22%	12	46%	4	16%	3	10%	2	6%	27
April	17	44%	12	33%	5	12%	3	7%	2	4%	38
May	34	62%	12	23%	4	8%	2	4%	2	3%	54
June	73	78%	12	12%	5	5%	3	3%	2	2%	93
July	77	80%	12	12%	4	5%	2	2%	2	2%	97
August	62	76%	12	14%	4	5%	2	3%	2	2%	82
September	35	65%	10	20%	5	9%	2	4%	2	3%	53
October	11	37%	10	35%	4	15%	2	8%	2	5%	30
November	1	7%	10	53%	5	23%	2	9%	2	8%	20
December	0	0%	2	20%	4	36%	4	31%	2	13%	12
Total kg year	9661	60%	3377	21%	1625	10%	927	6%	560	3%	16150

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

	PM_{10}		CO		NOx		SOx	
	kg	g/ha	kg	g/ha	kg	g/ha	kg	g/ha
Domestic home heating	77	84	902	984	7	7	4	4
Transport	2	2	50	55	28	31	0	0
Industry	9	10	1	2	0	0	0	0
Rail	0	0	1	1	5	5	0	0
Shipping	2	3	7	8	105	115	13	14
Outdoor burning	12	13	61	67	4	5	1	1
Total	102	112	1023	1116	149	163	17	19

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APPENDIX A: HOME HEATING QUESTIONNAIRE

1. I'm _________from and I am calling from Symphone Research on behalf Marlborough District Council. May I please speak to an adult in your household who knows about your home heating systems? We are currently undertaking a survey in your area on methods of home heating. We wish to know what you use to heat your main living area during a typical year. The survey will take about 5-7 minutes depending on your answers. Is it a good time to talk to you now?

Before we start can I please confirm that you live in Blenheim?

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)

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)During the winter, what times of the day do you typically use your log burner

(f) Approximately what time during the evening would you put your last load of wood on the fire?

(g) 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.

(h) 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.

(i) 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)

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

(k) What proportion would be bought?

l) If you placed your hand on your burner first thing in the morning (e.g., 6am-7am) after having used it the night before would it be?

- ☐ Cold to touch (no feeling of leftover heat)
- ☐ Warm to touch (if you held your hand there for a bit it would warm them up)
- ☐ Hot to touch (too hot to hold a hand on for more than a few seconds)

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.

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 et al., 2009; Smith et al., 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 et al., 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.