

Residential Wood Burning Emissions in British Columbia

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Abstract

The current British Columbia Ministry of Water, Land and Air Protection (WLAP) Service Plan and the BC Lung Association Health and Air Quality 2002 – Phase 1 report both identify particulate matter as the air emission of most concern in British Columbia from a human health perspective. One of the largest cumulative sources of particulate matter in BC is believed to be residential wood burning. To better estimate the size of this source, WLAP commissioned a telephone survey in June 2003 to study wood burning habits of British Columbia residents. Using disproportionate sampling methodology, a total of 2100 wood burning appliance users were interviewed regarding their wood burning habits. The method used results in a margin of error for the survey results of less than 10% at the 95% confidence interval. Combining the results of this survey with results from previous surveys of the Okanagan regions and the Lower Fraser Valley gives emission quantities for chemical species of concern from residential wood burning in British Columbia.

BC Residential Wood Burning Emissions (tonnes/year)

Emission	Provincial Total
CO	65579.0
NO _x	1120.1
SO _x	160.7
VOC	14859.9
Part	11253.0
PM ₁₀	10632.5
PM _{2.5}	10623.1

This document describes the methodology and assumptions used to arrive at the provincial emissions.

* This revised version reflects changes in emissions due to a correction in the calculation of the base quantities.

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1 Introduction

Five common air emissions are associated with direct human health effects:

- Nitrogen oxides (NO_x)
- Sulphur oxides (SO_x)
- Carbon monoxide (CO)
- Ozone (O₃)
- Particulate matter (Part), inhalable particles (PM₁₀), and fine particles (PM_{2.5})

The current British Columbia Ministry of Water, Land and Air Protection (WLAP) Service Plan¹ and the BC Lung Association Health and Air Quality 2002 – Phase 1 report² both identify particulate matter as the air emission of most concern in British Columbia from a human health perspective.

One of the largest cumulative sources of particulate matter in BC is believed to be residential wood burning. Although emission release estimates have been prepared based on national survey data and a number of assumptions, there have not been any province wide studies of residential wood burning habits.

In June 2003, WLAP commissioned a survey³ to study wood burning habits and opinions towards burning of British Columbia residents. Two areas of the province were excluded from the survey; Kelowna* and the Lower Fraser Valley (LFV) since both have been surveyed in independent surveys^{4,5}. Documentation for both of these surveys is readily available. Data from the Okanagan and LFV surveys were incorporated into these survey results to create province wide results.

The main tasks performed were to:

- Revise a draft questionnaire to ensure all required information was gathered in an objective, unbiased manner;
- Program the questionnaire into the contractor's computer-assisted telephone interviewing (CATI) system;
- Develop a random sampling methodology that ensured each airshed and region within the province included at least 100 residential wood heat users, and 50 non-users;
- Interview a total of 3025 residents from the regions with at least 2075 users and 950 non-users; and
- Provide the Ministry with the data for the final outcome of the calls.

This report uses the results of the survey to estimate the quantity of air emissions released as a result of residential wood heating throughout the province (excluding the LFV). To do this, the

* Kelowna was not surveyed due to the premature understanding that it would be the only area surveyed by the Okanagan Air Quality Technical Steering Committee. When the survey was released, it was realized that the survey actually covered the three regional districts of the Okanagan.

randomly sampled area responses were scaled up to represent the province. After this, emission estimates were calculated for each provincial airshed, Ministry Regional Office, and the Province as a whole. Example calculations are provided as appropriate.

It should be recognized that estimating emissions is one of the main intended uses of the survey data. Additional questions were asked regarding residential heating practices, likelihood of switching to wood heating, and general impressions regarding air quality. Each of these areas can also be interpreted as needed. A copy of the survey questions is in Appendix A.

2 Survey Methodology

2.1 Disproportionate Sampling

In order to obtain statistically reliable sub-samples for Ministry specified regions, disproportionate stratified sampling methodology was used in this study. This results in useable sub-samples for each of the specific areas that can be weighted into correct proportion for the provincial population. The margin of error for each of the airsheds is less than 10% at the 95% confidence interval. The populations of the Ministry Regions outside the airsheds were sampled to give less than 6.3% error at the 95% confidence interval.

A telephone survey was used to maximize the cost effectiveness and quality of the survey. The households sampled were drawn at random by Dominion Directory Information Services from their database of published telephone listings.

2.2 Regions

Figure 1 shows the regions and areas that were surveyed. The polling was done for seven main Ministry Regions, as well as twelve regions of particular interest for regional air quality concerns. For example, for the Cariboo Region, there were three groups of responses: Quesnel, Williams Lake, and the rest of the Cariboo Region.

Kelowna and the Lower Fraser Valley were not surveyed, and are indicated on the map as shaded areas.

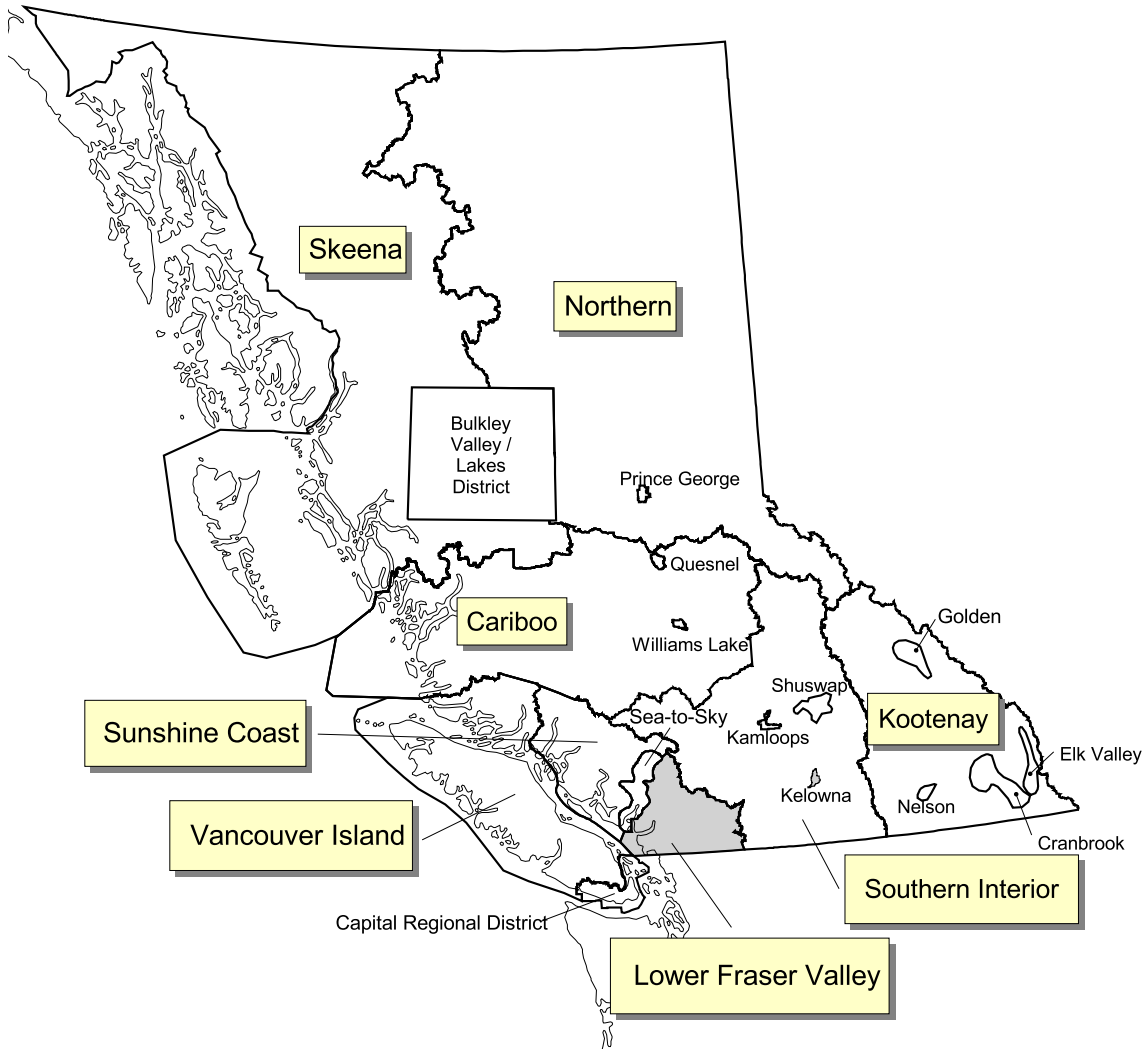


Figure 1: Map Showing Regions Surveyed

2.3 Households Surveyed

Table 1 shows the number of dwellings sampled for the various Ministry Regional Offices and local airsheds. The “Simple Yes/No Query” results are the results for all households sampled to obtain accurate statistics for the numbers of households using wood burning appliances. Of the 9273 households surveyed, 2100 users were interviewed with a complete survey about their wood burning habits, and 1049 non-users were interviewed with a subset of the complete survey (see Appendix A, Questions 1-11 and 64-70) to obtain public opinion statistics.

Table 1: Number of Households Surveyed

	Complete Responses			Simple Yes/No Query		
	User	Non-User	Total Valid	YES TO WOOD/ WOOD PELLETS	NO TO WOOD/ WOOD PELLETS	TOTAL INTER VIEWS
Capital Regional District	100	51	151	126	514	640
Other Vancouver Island	148	57	205	171	300	471
Sunshine Coast	100	48	148	127	160	287
Sea-to-Sky Airshed	104	57	161	123	208	331
Shuswap	106	53	159	134	299	433
Kamloops	101	50	151	113	996	1109
Other Southern Interior	118	66	184	139	334	473
Golden Airshed	100	61	161	112	146	258
Cranbrook Airshed	100	51	151	114	332	446
Elk Valley Airshed	100	52	152	127	449	576
Nelson Airshed	101	52	153	122	618	740
Other Kootenay	134	48	182	173	228	401
Williams Lake Airshed	102	54	156	119	332	451
Quesnel Airshed	111	54	165	130	269	399
Other Cariboo	112	51	163	157	106	263
Prince George	123	51	174	140	526	666
Other Northern	107	78	185	125	261	386
Bulkley Valley/Lakes Air	106	51	157	124	129	253
Other Skeena	127	64	191	147	543	690
Total	2100	1049	3149	2523	6750	9273

2.4 Airshed, Region and Provincial Scaling

In order to calculate emissions for each region, it is necessary to pro-rate the survey results by the number of households in the region. Two sources were used to obtain this:

- 1) BC Stats⁶
- 2) Canada Post⁷

The BC Stats data is for 2001, and the survey was performed in 2003. Household data for 2003 was extracted from the Canada Post website, where household numbers are maintained on a month-by-month basis. The data for December 12, 2003 - January 8, 2004 was used. From Table 2, it can be seen that where BC Stats data exists, the comparison to Canada Post values is good, so results based on Canada Post numbers can be used with confidence.

Table 2: Regional Household Numbers

Region Surveyed	Number of Households	
	BC Stats	Canada Post
Capital Regional District	151,461	149,324
Other Vancouver Island		155,076
Sunshine Coast		20,050
Sea-to-Sky Airshed		20,958
Lower Fraser Valley		853,377
Shuswap		16,631
Kamloops	32,076	35,181
Kelowna*	41,604	31,582
Other Southern Interior		126,857
Golden Airshed		3,137
Cranbrook Airshed		15,217
Elk Valley Airshed		6,236
Nelson Airshed		7,921
Other Kootenay		36,969
Williams Lake Airshed		9,040
Quesnel Airshed		10,256
Other Cariboo		10,544
Prince George	29,345	33,918
Other Northern		34,767
Bulkley Valley/Lakes Air		13,621
Other Skeena		23,641
Total British Columbia	1,643,969	1,614,303

*Kelowna boundaries for this survey (determined by Canada Post Postal Codes) do not agree with the Census boundaries.

Disproportionate samples need correcting for regional populations. Once the total emissions have been calculated for the households surveyed in a given region ($Emissions_{surveyed}$), it becomes possible to calculate the estimated emissions for the region in general:

$$Emissions_{region} = Emissions_{surveyed} \times \frac{Number_{region}}{Number_{surveyed}} \quad (1)$$

Where $Number_{region}$ is the number of households in the region (from Table 2), and $Number_{surveyed}$ is the total number of households (users and non-users) that were surveyed (from Table 1).

3 Emission Calculations

In order to calculate emissions, it is necessary to have a base quantity, which is the weight of the fuel being consumed, and an emission factor, which describes the quantity of a given emission released for a given weight of fuel.

In order to calculate the amount of wood burned in a given appliance, survey respondents were asked to quantify the number of cords of wood consumed by the household, the number and type of appliances used to burn the wood, and the fraction of each tree species in their wood supply. See Appendix B for the steps used to prepare the data.

To calculate the weight of wood burned, it is necessary to calculate the volume of solid wood burned, and estimate the moisture content. When this information is combined with the density of the wood species, it becomes possible to calculate the weight. The following sections describe the details of these calculations.

3.1 Volume

It was assumed that typically^{8,9,10},

$$1 \text{ cord of wood} = 80 \text{ ft}^3 \text{ of solid wood} .$$

Also,

$$1 \text{ ft}^3 = 0.0283168 \text{ m}^3 ,$$

giving

$$80 \text{ ft}^3 = 2.265344 \text{ m}^3 \cong 2.27 \frac{\text{m}^3}{\text{cord}} . \quad (2)$$

3.2 Moisture Content

Moisture content in wood fuel is calculated as the percentage difference between the wet weight of the wood and the dry weight of the wood. If the percentage is calculated relative to the wet weight, it is called the *wet basis* moisture content.

$$M_w = \frac{W_w - W_d}{W_w} \times 100\% \quad (3)$$

If the percentage is calculated relative to the dry weight, it is called the *dry basis* moisture content.

$$M_D = \frac{W_w - W_d}{W_d} \times 100\% \quad (4)$$

The two methods of reporting moisture content are related by the equation:

$$M_D = \frac{M_w}{100 - M_w} \times 100\% \quad (5)$$

For Stove testing, the CSA testing procedure¹¹ requires that the moisture content of the wood be between 16 and 20% (wet basis), for an average of 18%.

3.3 Wood Densities

The responses given by the householders polled were compared to a list of tree species indigenous to British Columbia¹² and the Latin name of each species was recorded. The Latin

name was then used to identify the density of the wood from *Softwoods of North America*¹³ and *Hardwoods of North America*¹⁴. The species and their densities are compiled in Table B. 3. The values in these references are given for 12% dry basis moisture content. In order to calculate wood weights for typical fuel wood moisture contents, a value of 18% wet basis moisture content is needed. This has a value of

$$\frac{18}{100 - 18} \times 100\% = 22\% \text{ (dry basis),}$$

and values for Table B. 3 were calculated for this moisture content using the formula¹⁵:

$$D = p_w \left(\frac{G_b(1 + M/100)}{1 - 0.265aG_b} \right), \quad (6)$$

where D is the density of the wood at moisture content M (dry basis), p_w is the density of water, G_b is the basic specific gravity of the wood, and $a = (30 - M)/30$.

Equation (6) was derived by W.T. Simpson¹⁵ to allow calculation of wood densities for moisture contents under 30%. It corrects for volumetric shrinkage, which can lead errors of up to 5% in densities for values in Table B. 3.

For example, for Silver Fir (*Abies amabilis*), the density at 12% is 433 Kg/m^3 . To find the density at 22%, we perform the following conversion:

$$D = 433 \text{ Kg/m}^3 = 1000 \text{ Kg/m}^3 \left(\frac{G_b(1 + 12/100)}{1 - 0.265 \left(\frac{30 - 12}{30} \right) G_b} \right)$$

Solving for the basic specific gravity (G_b), we obtain $G_b = 0.3642 \text{ Kg/m}^3$

Now we can solve for the density at 22%:

$$D = 1000 \left(\frac{0.3642(1 + 22/100)}{1 - 0.265 \left(\frac{30 - 22}{30} \right) 0.3642} \right) = 456 \text{ Kg/m}^3$$

3.4 Wood Weight

Given a density D in Kg/m^3 , and the wood volume per cord from Equation (2), it is possible to calculate a fuel weight (W) per cord for each species:

$$W = D \frac{\text{Kg}}{\text{m}^3} \times 1 \frac{\text{tonne}}{\text{Kg}} \times \frac{2.27 \text{m}^3}{\text{cord}} = D \times 2.27 \times 10^{-3} \frac{\text{tonnes}}{\text{cord}}. \quad (7)$$

Combining all of the information collected in the survey about the fuel consumed, it is now possible to calculate the weight of wood consumed by each appliance in a given household. This is the base quantity (BQ) for the appliance, which will be used in the emission calculation:

$$BQ(\text{tonnes}) = N_{\text{cords}} \times \text{fraction}_{\text{appliance}} \times \text{fraction}_{\text{species}} \times W, \quad (8)$$

where N_{cords} is the number of cords of all wood burned by the household, $\text{fraction}_{\text{appliance}}$ is the fraction of all wood burned by the household in the appliance, $\text{fraction}_{\text{species}}$ is the fraction of all wood burned by the household which is the species for the calculation, and W is the weight of the wood species being burned.

For example, if a householder reports burning 30% of 2 cords of wood in a fireplace, and 25% of the wood burned was Western Red Cedar, the weight of Red Cedar burned in the fireplace would be:

$$2 \times \frac{30}{100} \times \frac{25}{100} \times 390 \times 2.27 \times 10^{-3} = 0.1328 \text{ tonnes}$$

3.5 Emissions

Given the total weight of wood burned in an appliance, and the type of appliance, it is now possible to calculate the emissions from that appliance.

$$\text{Emissions} = \text{Base Quantity} \times \text{Emission Factor}, \quad (9)$$

Base quantities derived from the survey results are given in Table 3, presented by area of interest and appliance type.

Emission factors are available from the National Emissions Inventory and Projections Task Group (NEIPTG) Guidebook, and the United States Environmental Protection Agency publication known as AP-42¹⁶. To maintain consistency with other provinces the guidebook factors were used. These factors are summarized in Table 4.

For example, if a catalytic woodstove burned 2.3 tonnes of wood in one year, the Total Particulate emissions are calculated as:

$$\text{Total Particulate} = 5.1 \times 2.3 = 11.7 \text{ Kg},$$

where the emission factor for a catalytic stove is 5.1Kg/tonne from Table 5.

Tables 3 to 5 show the various numbers used to calculate emission estimates. The level of detail presented allows one to recalculate emissions for “what-if” scenarios such as changing the appliance type.

Table 3: Regional Base Quantities by Appliance Type (tonnes of wood)

Region	Fireplace; Advanced Technology	Fireplace; Conventional Without Glass Doors	Central Furnace/Boiler (inside)	Central Furnace/Boiler	Central Furnace/Boiler (outside)	Fireplace Insert; Advanced Technology	Fireplace Insert; Catalytic	Fireplace Insert; Conventional	Woodstove; Advanced Technology	Woodstove; Catalytic	Woodstove; Conventional	Regional Total
Capital Regional District	1872.8	9377.3	1572.8			82.0		3583.4	13342.6	9868.3	16733.2	56432.4
Other Vancouver Island	1385	8697.7	5100.5			2502.2	1535.8	11527.2	79398.6	10760.1	50390.9	169762.3
Sunshine Coast	608.9	1690.9	3892.1		618.7	365.4	383.8	1441.9	5872.8	2515.2	7579.8	24585.5
Sea-to-Sky Airshed	196.9	2198.4	1255.8			1492.5	149.6	1128.2	8920.7	744.7	5293.8	21230.8
Shuswap	385.4	1037.5	3689		414.2	444.7		775	4434.2	1493	5313.9	17987
Kamloops	312.8	2939.6	556.2			340.7		203.3	1622.9	930.2	1552.8	8458.5
Other Southern Interior	5464.1	18600.2	18325.3		5336.8	1187.3		4740.4	26962.7	4756.7	56967.8	142341.3
Golden Airshed	43	189.9	1211.3		171.1	65.5		51.0	1611.2	465.8	2196.4	6005.2
Cranbrook Airshed	260.8	988.5	623.2		568.1	26.3		475.9	3034.7	1189.3	5892.4	13059.3
Elk Valley Airshed	34.7	430.0	147.2		547.7	29.9	107.5	192.6	1017.5	883.6	1705.9	4989.2
Nelson Airshed	160.9	334.7	172.9			184.1	91.6	116.4	720.4	349.3	1096.5	3135.2
Other Kootenay	1638.8	4217.2	17646.7		783.5	917.9		309.8	10680.5	5985.8	18894.8	61075
Williams Lake Airshed	41.4	550.1	1787.6			26.1		367.0	2093.9	1370.9	2558.8	8795.9
Quesnel Airshed	301.3	863.4	3663.5		1607.4	36		283.8	3210.4	659.1	4538.2	15163.1
Other Cariboo	674.8	869.1	6279.5		667	346.2	67.2	36.3	8761.9	3558.7	10250.1	31443.6
Prince George	604.8	3114.9	5949.8			216.7	509.4	928.7	6251.6	2740.6	4749.0	24556.1
Other Northern	396.6	4886.3	10840.8	473.4	3365.6			425.2	11883.6	9838.2	13067.0	55176.8
BVLD Airshed	392.3	1689.3	7537.5		4838.1			1212.5	6211.7	1620.1	12212.4	35714.0
Other Skeena	212.6	1806.7	4197.3		208.8	306.4		315.4	5831.1	1505.5	9018.6	23402.6
Provincial Total	14987.8	64481.7	94448.9	473.4	19127.1	8570.0	2845.0	28114.2	201863.1	61235.1	230012.3	723313.6

Table 4: Wood Burning Appliance Emission Factors (Kg/tonne)

Appliance	CO	NOx	SOx	VOC	Part	PM ₁₀	PM _{2.5}
Fireplace; Advanced Technology	70.4	1.4	.2	7	5.1	4.8	4.8
Fireplace; Conventional Without Glass Doors	77.7	1.4	.2	6.5	19.3	18.5	18.4
Fireplace; Conventional With Glass Doors	98.6	1.4	.2	21	13.5	13	12.9
Central Furnace/Boiler (inside)	68.5	1.4	.2	21.3	14.1	13.3	13.3
Central Furnace/Boiler	68.5	1.4	.2	21.3	14.1	13.3	13.3
Central Furnace/Boiler (outside)	68.5	1.4	.2	21.3	14.1	13.3	13.3
Fireplace Insert; Advanced Technology	70.4	1.4	.2	7	5.1	4.8	4.8
Fireplace Insert; Catalytic	70.4	1.4	.2	7	5.1	4.8	4.8
Fireplace Insert; Conventional	115.4	1.4	.2	21.3	14.4	13.6	13.6
Woodstove; Advanced Technology	70.4	1.4	.2	7	5.1	4.8	4.8
Woodstove; Catalytic	70.4	1.4	.2	7	5.1	4.8	4.8
Woodstove; Conventional	100	1.4	.2	35.5	24.6	23.2	23.2
Woodstove; Conventional, Not Air-Tight	100	1.4	.2	35.5	24.6	23.2	23.2
Woodstove; Conventional, Air-Tight	115.4	1.4	.2	21.3	14.4	13.6	13.6
Other Equipment	115.4	1.4	.2	21.3	14.4	13.6	13.6

Values derived from Residential Wood Combustion¹⁷

Table 5: Emissions from Wood Burning Appliances in British Columbia (tonnes/year)*

Region	Fuel	CO	NOx	SOx	VOC	Part	PM ₁₀	PM _{2.5}
Capital Regional District	56432.4	4694.9	79.0	11.3	941.0	794.7	752.1	751.2
Other Vancouver Island	171298.1	14123.5	239.8	34.3	2868.7	2132.9	2013.4	2012.5
Sunshine Coast	24969.4	2050.9	35.0	5.0	475.1	353.2	333.5	333.3
Sea-to-Sky Airshed	21380.4	1726.3	29.9	4.3	333.5	265.3	250.8	250.5
Lower Fraser Valley**		4625.4	50.9	8.0	840.6	533.2	505.4	502.7
Shuswap	17987.0	1458.2	25.2	3.6	346.6	254.2	240.0	239.9
Kamloops	8458.5	671.0	11.8	1.7	112.9	122.1	116.0	115.7
Kelowna***	14561.0	1301.2	20.4	2.9	345.4	299.6	283.8	283.4
Other Southern Interior	142341.3	12011.2	199.3	28.5	3016.8	2358.0	2229.1	2227.3
Golden Airshed	6005.2	488.8	8.4	1.2	125.0	89.1	84.0	84.0
Cranbrook Airshed	13059.3	1120.2	18.3	2.6	282.7	210.7	199.0	198.9
Elk Valley Airshed	5096.7	419.8	7.1	1.0	96.8	73.4	69.3	69.3
Nelson Airshed	3226.7	267.0	4.5	0.6	57.8	45.2	42.7	42.7
Other Kootenay	61075.0	4868.7	85.5	12.2	1231.9	908.6	858.0	857.6
Williams Lake Airshed	8795.9	712.1	12.3	1.8	165.0	122.1	115.3	115.2
Quesnel Airshed	15163.1	1210.9	21.2	3.0	314.5	228.2	215.4	215.3
Other Cariboo	31510.9	2516.5	44.1	6.3	612.1	435.8	411.1	411.0
Prince George	25065.5	1958.4	35.1	5.0	407.6	326.9	309.1	308.8
Other Northern	55176.8	4298.1	77.2	11.0	972.2	741.7	700.7	700.3
Bulkley Valley/Lakes Air	35714.0	2919.1	50.0	7.1	791.5	566.9	535.1	535.0
Other Skeena	23402.6	1933.5	32.8	4.7	487.5	363.5	343.3	343.1
Provincial Total		65375.7	1087.8	156.1	14825.2	11225.3	10607.1	10597.7

* Not including pellet stoves; see Section 3.6.

** See Appendix D for data.

*** See Appendix C for calculations.

The above report sections assume that data received from the survey does not contain any errors or inconsistencies. Of course this was not the case. Therefore a number of adjustments had to be

made to the survey data. Also, a number of assumptions were made which have an effect on the end results. A detailed discussion is presented in Appendix B.

3.6 Pellet Burning Appliances

Pellet stoves were included in the survey, and householders were asked to estimate the number of 40 pound bags of pellets they burned in a year. From these numbers, and the emission factors in Table 6, it was a simple matter to calculate the emissions for each stove, and therefore for each region.

The NEIPTG guidebook emission factors that agree with the U.S. EPA AP-42 factors were used.

Table 6: Pellet Stove Emission Factors (Kg/tonne)

Appliance	CO	NO _x	SO _x	VOC	Part	PM ₁₀	PM _{2.5}
Pellet Stove	8.8	1.4	.2	1.5	1.2	1.1	1.1

Table 7: Pellet Stove Emissions (tonnes/year)

Region	Base Quantity	CO	NO _x	SO _x	VOC	Part	PM ₁₀	PM _{2.5}
Capital Regional District	10.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Other Vancouver Island	5112.8	45.0	7.2	1.0	7.7	6.1	5.6	5.6
Sunshine Coast	596.9	5.3	0.8	0.1	0.9	0.7	0.7	0.7
Sea-to-Sky Airshed	340.4	3.0	0.5	0.1	0.5	0.4	0.4	0.4
Shuswap	1042.0	9.2	1.5	0.2	1.6	1.3	1.1	1.1
Kamloops	119.4	1.1	0.2	0.0	0.2	0.1	0.1	0.1
Other Southern Interior	4520.3	39.8	6.3	0.9	6.8	5.4	5.0	5.0
Golden Airshed	74.3	0.7	0.1	0.0	0.1	0.1	0.1	0.1
Cranbrook Airshed	84.2	0.7	0.1	0.0	0.1	0.1	0.1	0.1
Elk Valley Airshed	63.7	0.6	0.1	0.0	0.1	0.1	0.1	0.1
Nelson	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Kootenay	1607.6	14.1	2.3	0.3	2.4	1.9	1.8	1.8
Williams Lake Airshed	297.6	2.6	0.4	0.1	0.4	0.4	0.3	0.3
Quesnel Airshed	843.6	7.4	1.2	0.2	1.3	1.0	0.9	0.9
Other Cariboo	84.3	0.7	0.1	0.0	0.1	0.1	0.1	0.1
Prince George	342.5	3.0	0.5	0.1	0.5	0.4	0.4	0.4
Other Northern	2875.4	25.3	4.0	0.6	4.3	3.5	3.2	3.2
Bulkley Valley/Lakes Air	4277.6	37.6	6.0	0.9	6.4	5.1	4.7	4.7
Other Skeena	807.6	7.1	1.1	0.2	1.2	1.0	0.9	0.9
Provincial Total	23100.9	203.3	32.3	4.6	34.7	27.7	25.4	25.4

Appendix A. The Survey

British Columbia Woodstove and Residential Heating Survey

FINAL

Good afternoon/evening, my name is NAME, and I am calling from Mustel Research Group on behalf of the British Columbia Ministry of Water, Land and Air Protection. May I please speak to the person in your household who is most knowledgeable about your home heating equipment? Please be assured that we are not selling or soliciting anything.

IF NECESSARY, REINTRODUCE SELF, THEN READ:

We are conducting a province-wide survey to gather information on home heating equipment use. This information will assist in the design of programs and services to help residents use their equipment more efficiently, save money on fuel costs and keep our air clean. All participants in this survey will remain anonymous.

IF ASKED: The survey takes between 10 and 20 minutes to complete, depending on the type and number of wood burning appliances you use in your home.

1) POSTAL CODE (FROM SAMPLE)

2) Please note that the questions I am going to be asking you refer to the residence you are in right now. Is the residence you are in right now in a rural area, that is, in a country setting?

1 Yes 2 No 9 Don't know

3) Is this your primary residence or a seasonal residence?

1 Primary 2 Seasonal 9 Don't know

4) And what type of residence are you in right now, is it a home, an apartment, condominium, something else? READ IF NECESSARY, CHECK ONE ONLY

- 1 Detached house
- 2 Duplex, triplex or semi-detached
- 3 Apartment building
- 4 Rowhouse or townhouse
- 5 Condominium
- 6 Manufactured trailer or mobile home
- 98 Don't know

5) Do you own or rent this residence?

1 Rent 2 Own 9 Don't know

6) Do you happen to recall which year this residence was built?

___ 9998 - DON'T KNOW

7) Approximately how much floor space does your current residence have? Would it be:

READ

- 1 Less than 1,000 square feet
- 2 1,000 to less than 1,500 square feet
- 3 1,500 to less than 2,500 square feet
- 4 2,500 square feet or more
- 9 Don't know

8) How many years have you lived in your current residence?

_____ YEARS 98 Don't know

9) How many people live in your home?

ENTER NUMBER _____ 98 Don't know

10) I am now going to mention some fuels that people burn and/or use to heat their homes.

As I mention each one, please tell me if you have burned and/or used this fuel to heat your home over the last 12 months or not. The first type of fuel is: READ

- a) Electricity **1 YES 2 NO 9 - DON'T KNOW**
- b) Natural gas **1 YES 2 NO 9 - DON'T KNOW**
- c) Fuel oil or heating oil **1 YES 2 NO 9 - DON'T KNOW**
- d) Wood **1 YES 2 NO 9 - DON'T KNOW**
- e) Wood pellets **1 YES 2 NO 9 - DON'T KNOW**
- e) Any others? SPECIFY **1 Propane 96 Miscellaneous**

IF YES TO BOTH NATURAL GAS AND WOOD ASK:

10B) Has the increased price of natural gas increased the amount of wood you used to heat your home during the past 12 months?

1 Yes 2 No 9 Don't know

IF ONLY ONE FUEL USED IN QUESTION 10, GO TO APPROPRIATE QUESTIONS BELOW

- Electricity **GO TO QUESTION 56**
- Natural gas **GO TO QUESTION 59**
- Fuel oil or heating oil **GO TO QUESTION 56**
- Wood **GO TO QUESTION 12**
- Wood pellets **GO TO QUESTION 12**

IF MORE THAN ONE TYPE OF FUEL IN QUESTION 10, ASK:

11) Of all the heat used in your home, approximately what percentage comes from: READ ONLY THOSE IDENTIFIED IN QUESTION 10

- A Electricity ___% 998 Don't know
- B Natural gas ___%
- C Fuel oil or heating oil ___%
- D Wood ___%
- E Wood pellets ___%
- F Other from above ___%

WOOD BURNER QUESTIONS (ASK IF WOOD OR ‘WOOD PELLETS’ IDENTIFIED IN QUESTION 10)

12) Which of the following types of wood burning fixtures or equipment did you use to heat your home in the past 12 months? READ, CHECK ALL THAT APPLY

Wood fireplace	1 YES	2 NO	9 Don't know
Wood stove	1 YES	2 NO	9 Don't know
Wood furnace or boiler	1 YES	2 NO	9 Don't know
Wood pellet stove	1 YES	2 NO	9 Don't know

13) Of all the wood burned in your home over the past year, approximately what percentage did you burn in your: ASK ONLY THOSE THAT APPLY FROM QUESTION 12

A Wood fireplace(s)	___%	998 Don't know
B Wood stove(s)	___%	
C Wood furnace or boiler(s)	___%	

Fireplace Identification Section (complete only if ‘Wood fireplace’ identified in Question 12)

14) Do you burn real wood in your fireplace, artificial logs, or both?

- 1 Wood only
- 2 Artificial logs only
- 3 Both wood and artificial logs
- 9 Don't know

15) **IF RESPONDENT BURNS ARTIFICIAL LOGS, ASK:** Approximately how many artificial logs did you burn in your fireplace(s) over the past 12 months?

ENTER # OF LOGS: _____ 998 Don't know

READ:

You may be aware that there are three main types of wood burning fireplaces – common fireplaces, fireplace inserts and advanced technology heating fireplaces.

Common fireplaces are primarily decorative and either have no doors or doors without gaskets. That is, they are not airtight. This category of fireplace includes ‘heatilators’ and fireplaces with tubular grates or other devices intended to provide heat to a room. It also includes free-standing fireplaces, but not wood stoves.

16) Do you use a common fireplace in your primary residence?

- 1 Yes
- 2 No
- 9 Don't know

The second type of fireplace is known as a fireplace insert. These are wood stoves that are adapted for installation within or partly within a common fireplace. There are three types of fireplace inserts, including:

- 1) Conventional fireplace inserts, which are more than 15 years old.
- 2) Advanced technology inserts, which are less than 15 years old and have baffles inside the firebox to burn the smoke.
- 3) Catalytic technology inserts, which are less than 15 years old and have catalysts that burn off the smoke.

17) Do you use a fireplace insert in your primary residence?

1 Yes 2 No 9 Don't know

The third type of fireplace is known as an advanced technology, heating fireplace. These look like fireplaces, but operate like wood stoves. That is, they have doors, can be used for home heating, and have baffles inside the firebox to burn off the smoke. They are certified for low smoke emissions by the U.S. Environmental Protection Agency.

18) Do you use an advanced technology, heating fireplace in your primary residence?

1 Yes 2 No 9 Don't know

Common Fireplace Section (ASK IF 'YES' TO QUESTION 16)

19) How many common fireplaces do you use in your primary residence?

_____ 9 Don't know

20) Blank question so that the numbering works for the rest of the survey.

Fireplace Insert Section (ASK IF 'YES' TO QUESTION 17)

21) How many fireplace inserts do you use in your primary residence?

_____ 9 Don't know

22) What type of fireplace insert(s) do you use? Would it or they be: **READ, CHECK ONE ONLY FOR EACH INSERT**

- 1) **Conventional** fireplace inserts, which are more than 15 years old.
- 2) **Advanced** technology inserts, which are less than 15 years old and have baffles inside the firebox to burn the smoke.
- 3) **Catalytic** technology inserts, which are less than 15 years old and have catalysts that burn off the smoke.

- A) Fireplace Insert #1: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know
- B) Fireplace Insert #2: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know
- C) Fireplace Insert #3: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

Advanced Technology, Heating Fireplace Section (ASK IF 'YES' TO QUESTION 18)

23) How many advanced technology, heating fireplaces do you use in your primary residence?

_____ 9 Don't know

Wood Stove Section (ASK IF 'WOOD STOVE' IDENTIFIED IN QUESTION 12)

24) How many woodstoves do you use in your primary residence?

_____ 9 Don't know

25) What type of woodstove do you use? Would it or they be: **READ, CHECK ONE ONLY FOR EACH INSERT**

- 1) **Conventional** wood stoves, which are more than 15 years old.
- 2) **Advanced** wood stoves, which are less than 15 years old and have baffles inside the firebox to burn the smoke.
- 3) **Catalytic** wood stoves, which are less than 15 years old and have catalysts that burn off the smoke.

A) Woodstove #1: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know
B) Woodstove #2: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know
C) Woodstove #3: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

Wood-burning furnace or boiler (ASK IF 'WOOD FURNACE OR BOILER' IDENTIFIED IN QUESTION 12)

26) Is your wood-burning furnace or boiler located inside or outside your house?

1 Inside 2 Outside 9 Don't know

Wood Pellet Stove (ASK IF 'WOOD PELLET STOVE' IDENTIFIED IN QUESTION 12)

27) How many pellet stoves do you use in your primary residence?

_____ 9 Don't know

28) A standard bag of pellets weighs 40 pounds. Approximately how many bags of pellets did you burn over the past 12 months?

ENTER NUMBER OF BAGS OF PELLETS: _____ 998 Don't know

AMOUNT OF WOOD BURNED (ASK IF ANY WOOD BURNING EQUIPMENT OTHER THAN A PELLET STOVE IDENTIFIED IN QUESTION 12):

29A) Now I would like to know how much wood, in total, you burned in your wood burning equipment(s) over the past 12 months. In answering this question, I would like you to express the amount of wood in 'cords', which is the standard measure of firewood volume. As you may know, one full cord is a stack of firewood that measures 4 feet in width, 8 feet in length, and 4 feet in height.

Is the amount of wood in one full cord clear to you?

1 YES GO TO QUESTION 30
2 NO CONTINUE
9 Don't know

Q29B) Okay, forgetting about measurement in cords, can you tell me in your own words approximately how much wood, in total, you burned in your wood-burning equipment(s) over the past 12 months?

96 MISCELLANEOUS 97 NO, CAN'T EXPLAIN 98 Don't know

30) Approximately how many cords of wood, in total, did you burn in your wood-burning equipment(s) over the past 12 months?

- | | |
|-----------------|----------------------------------|
| 1)- ¼ of a cord | 7)-2 ½ cords |
| 2)- ½ of a cord | 8)- 3 cords |
| 3)- ¾ of a cord | 9)- 3 ½ cords |
| 4)- 1 full cord | 10)- 4 cords |
| 5)- 1 ½ cords | 11)- less than ½ of a cord |
| 6)- 2 cords | 96)- More than 4 cords (SPECIFY) |
| 98 Don't know | |

Wood Users Only Section (ASK QUESTIONS 31 TO 36 ONLY IF 'WOOD' MENTIONED IN QUESTION 10)

31) Of all the wood that you burn, what percentage would be: **READ**

- | | | |
|---------------|---------|----------------|
| A Pine | _____ % | 998 DON'T KNOW |
| B Spruce | _____ % | |
| C Cedar | _____ % | |
| D Birch | _____ % | |
| E Douglas fir | _____ % | |

32) Do you burn any other type of wood and, if so, what percentage of all the wood that you burn does it represent?

- | | | |
|-------------------|---------|----------------|
| A Other (SPECIFY) | _____ % | 998 DON'T KNOW |
| B Other (SPECIFY) | _____ % | |

33) How long do you typically dry/season your firewood before the heating season? **DO NOT READ, ONE ANSWER ONLY**

- 1 NOT AT ALL
- 2 LESS THAN FIVE MONTHS
- 3 SIX TO TWELVE MONTHS
- 4 MORE THAN ONE YEAR
- 9 Don't know

34) Do you usually have your firewood split before drying/seasoning it?

- 1 Yes **PROBE:** Would that be: **READ**
- 2 No
- 9 Don't know

- 34a) 1 Hardly ever
- 2 Some of the time
- 3 Most of the time
- 4 All of the time
- 9 Don't know

35) How do you store the majority of your wood? Would it be: **READ, CHECK ALL THAT APPLY**

- 1 Outside, covered
- 2 Outside, uncovered
- 3 Inside, heated
- 4 Inside, unheated
- 5 50% outside, covered AND 50% Inside, unheated
- 6 50% Outside, covered AND 50% Outside, uncovered
- 7 50% Outside, covered AND 50% Inside, heated
- 8 50% Outside, uncovered AND 50% Inside, unheated
- 9 Don't know

36) At what time or times of the day do you usually add wood to your fire, either to get it started or keep it going? **PROBE:** Any other times? **CHECK ALL THAT APPLY**

- 1 Don't Know
- B) 6:00 – 8:59 AM
- C) 9:00 – 11:59 AM
- D) NOON – 2:59 PM
- E) 3:00 – 5:59 PM
- F) 6:00 – 8:59 PM
- G) 9:00 – 11:59 PM
- H) OVERNIGHT
- I) VARIABLE

Wood Users Section (ASK QUESTIONS 37 TO 54 IF 'WOOD' MENTIONED IN QUESTION 10)

37) How many years, in total, have you been burning wood in your home?

ENTER NUMBER OF YEARS: _____ 998 Don't know

38) Some people have mentioned to us several reasons for burning wood in their home. As I read each reason, please tell me if this is NOT A REASON, A MINOR REASON OR A MAJOR REASON for burning wood in your home. First...**READ**

- a) A wood supply readily available
- b) It is relatively inexpensive compared to other fuels
- c) I like the smell or aesthetic beauty of a fire
- d) Natural gas is not available in my area
- e) The increasing cost of natural gas

1 NOT A REASON 2 MINOR 3 MAJOR 4,9 NOT SURE

39) Thinking back over the past year, approximately how many days per week would you have had a fire going in your wood burning equipment in: **READ, ONE ANSWER ONLY FOR EACH MONTH**

	NUMBER OF DAYS PER WEEK								
A June of last year	0	1	2	3	4	5	6	7	(9 DK)
B July of last year	0	1	2	3	4	5	6	7	(9 DK)
C August of last year	0	1	2	3	4	5	6	7	(9 DK)
D September of last year	0	1	2	3	4	5	6	7	(9 DK)
E October of last year	0	1	2	3	4	5	6	7	(9 DK)
F November of last year	0	1	2	3	4	5	6	7	(9 DK)
G December of last year	0	1	2	3	4	5	6	7	(9 DK)
H January of this year	0	1	2	3	4	5	6	7	(9 DK)
I February of this year	0	1	2	3	4	5	6	7	(9 DK)
J March of this year	0	1	2	3	4	5	6	7	(9 DK)
K April of this year	0	1	2	3	4	5	6	7	(9 DK)
L May of this year	0	1	2	3	4	5	6	7	(9 DK)

40) And in the months when you used your wood burning equipment, approximately how many hours per day would you have had a fire going, beginning with: **READ, RECORD NUMBER OF HOURS PER DAY FOR EACH MONTH IN WHICH EQUIPMENT WAS USED (FROM QUESTION 39)**

A June	_____	hours per day	98 Don't know
B July	_____	hours per day	98 Don't know
C August	_____	hours per day	98 Don't know
D September	_____	hours per day	98 Don't know
E October	_____	hours per day	98 Don't know
F November	_____	hours per day	98 Don't know
G December	_____	hours per day	98 Don't know
H January	_____	hours per day	98 Don't know
I February	_____	hours per day	98 Don't know
J March	_____	hours per day	98 Don't know
K April	_____	hours per day	98 Don't know
L May	_____	hours per day	98 Don't know

41) During the months that you use your wood or wood pellet burning equipment, which days of the week do you usually use it? **CHECK ALL THAT APPLY**

- A Monday
- B Tuesday
- C Wednesday
- D Thursday
- E Friday
- F Saturday
- G Sunday
- H Every day
- I No set days
- 98 DON'T KNOW

42) How often – always, often, sometimes, rarely or never - do you burn the following materials in your wood or wood pellet burning equipment? READ

1 Always 2 Often 3 Sometimes 4 Rarely 5 Never 9 Don't know

a) Newspapers

b) Magazines

c) Cardboard

d) Coated cartons such as milk or juice containers

e) Manufactured wood products such as plywood, chipboard, fibreboard, etc.

f) Painted or treated wood

g) Plastics

43) Do you sometimes start a fire with or burn any other materials that I haven't already mentioned?

1 Yes 2 No 9 Don't know

43b) 1 OTHER PAPER PRODUCTS (JUNK MAIL, OFFICE PAPER, ETC.)

2 OTHER WOOD (WOOD CHIPS, BARK, ACORNS, ETC.)

3 COMMERCIAL FIRESTARTERS

4 FLAMMABLE LIQUIDS (PROPANE, DIESEL, FUEL OIL, ETC.)

96 MISCELLANEOUS

44) Have you installed any new wood or wood pellet burning equipment – either as a replacement for old equipment or as a brand new installation – over the past two years?

1 Yes **CONTINUE**

2 No **GO TO QUESTION 48**

9 Don't know

45) Which type of equipment did you install? Was it a: **READ, CHECK AS MANY AS APPLY**

- a) Wood fireplace
- b) Woodstove (PROBE)
 - B2) 1 YES 2 NO 9 Don't know
 - A) Conventional woodstove, which is more than 15 years old.
 - B) Advanced woodstove, which is less than 15 years old and have baffles inside the firebox to burn the smoke.
 - C) Catalytic woodstove, which is less than 15 years old and have catalysts inside the firebox that burn off the smoke.
- c) Fireplace insert (PROBE)
 - C2) 1 YES 2 NO 9 Don't know
 - A) Conventional fireplace insert, which is more than 15 years old.
 - B) Advanced technology inserts, which is less than 15 years old and have baffles inside the firebox to burn the smoke.
 - C) Catalytic technology insert, which is less than 15 years old and has a catalyst that burns off the smoke.
- d) Wood furnace or boiler (PROBE)
 - D2) 1 YES 2 NO 9 Don't know
 - A) Inside
 - B) Outside
- e) Wood pellet stove
 - 1 YES 2 NO 9 Don't know

46) What was the single most important reason you installed this new equipment?

- 01 AESTHETIC REASONS
- 02 AGE OF EQUIPMENT
- 03 ELECTRICITY SUPPLY UNRELIABLE
- 04 ENVIRONMENTAL/AIR QUALITY CONCERNS
- 05 EQUIPMENT FAILURE
- 06 GAS ISN'T AVAILABLE IN MY AREA
- 07 HIGH ELECTRICAL PRICES
- 08 HIGH GAS/FUEL PRICES
- 09 HOME INSURANCE PURPOSES
- 10 INCONVENIENT TO USE OLD EQUIPMENT
- 11 OLD EQUIPMENT USES TOO MUCH FUEL
- 12 SAFETY REASON S
- 13 FUEL EFFICIENCY
- 14 COST SAVINGS
- 96 MISCELLANEOUS
- 98 Don't know

47) Any other reasons? **DO NOT READ, CHECK AS MANY AS APPLY. PROBE**

- 01 AESTHETIC REASONS
- 02 AGE OF EQUIPMENT
- 03 ELECTRICITY SUPPLY UNRELIABLE
- 04 ENVIRONMENTAL/AIR QUALITY CONCERNS
- 05 EQUIPMENT FAILURE
- 06 GAS ISN'T AVAILABLE IN MY AREA
- 07 HIGH ELECTRICAL PRICES
- 08 HIGH GAS/FUEL PRICES
- 09 HOME INSURANCE PURPOSES
- 10 INCONVENIENT TO USE OLD EQUIPMENT
- 11 OLD EQUIPMENT USES TOO MUCH FUEL
- 12 SAFETY REASON S
- 13 FUEL EFFICIENCY
- 14 COST SAVINGS
- 96 MISCELLANEOUS
- 98 Don't know

48) How likely do you think you will be to install any new wood or wood pellet burning equipment – either as a replacement for old equipment or as a brand new installation – over the next three years? Will you be very likely, somewhat likely, somewhat unlikely or very unlikely?

- | | |
|---------------------|-------------------|
| 1 VERY LIKELY | CONTINUE |
| 2 SOMEWHAT LIKELY | CONTINUE |
| 3 SOMEWHAT UNLIKELY | GO TO QUESTION 52 |
| 4 VERY UNLIKELY | GO TO QUESTION 52 |
| 9 DON'T KNOW | GO TO QUESTION 52 |

49) Which of the following types of equipment do you think you would most seriously consider installing in the next 3 years? Would it be: **READ, CHECK ONE ANSWER ONLY**

1) Wood fireplace

2) Woodstove (PROBE)

49a) 1 YES 2 NO 9 Don't Know

1 Conventional woodstove, which is more than 15 years old.

2 Advanced woodstove, which is less than 15 years old and have baffles inside the firebox to burn the smoke.

3 Catalytic woodstove, which is less than 15 years old and have catalyts inside the firebox that burn off the smoke.

3) Fireplace insert (PROBE)

49b) 1 YES 2 NO 9 Don't Know

1 Conventional fireplace insert, which is more than 15 years old.

2 Advanced technology inserts, which is less than 15 years old and have baffles inside the firebox to burn the smoke.

3 Catalytic technology insert, which is less than 15 years old and has a catalyst that burns off the smoke.

4) Wood furnace or boiler (PROBE)

49c) 1 YES 2 NO 9 Don't Know

1 Inside

2 Outside

5 Wood pellet stove

96 MISCELLANEOUS

98 DON'T KNOW

50) What would be the single most important reason why you would install new equipment?

1 AESTHETIC REASONS

2 AGE OF EQUIPMENT

3 ELECTRICITY SUPPLY UNRELIABLE

4 ENVIRONMENTAL/AIR QUALITY CONCERNS

5 EQUIPMENT FAILURE

6 GAS ISN'T AVAILABLE IN MY AREA

7 HIGH ELECTRICAL PRICES

8 HIGH GAS/FUEL PRICES

9 HOME INSURANCE PURPOSES

10 INCONVENIENT TO USE OLD EQUIPMENT

11 OLD EQUIPMENT USES TOO MUCH FUEL

12 SAFETY REASONS

13 FUEL EFFICIENCY

14 COST SAVINGS

96 MISCELLANEOUS

98 Don't Know

51) Any other reasons? **DO NOT READ, CHECK AS MANY AS APPLY. PROBE**

- 1 AESTHETIC REASONS
- 2 AGE OF EQUIPMENT
- 3 ELECTRICITY SUPPLY UNRELIABLE
- 4 ENVIRONMENTAL/AIR QUALITY CONCERNS
- 5 EQUIPMENT FAILURE
- 6 GAS ISN'T AVAILABLE IN MY AREA
- 7 HIGH ELECTRICAL PRICES
- 8 HIGH GAS/FUEL PRICES
- 9 HOME INSURANCE PURPOSES
- 10 INCONVENIENT TO USE OLD EQUIPMENT
- 11 OLD EQUIPMENT USES TOO MUCH FUEL
- 12 SAFETY REASONS
- 13 FUEL EFFICIENCY
- 14 COST SAVINGS
- 96 MISCELLANEOUS
- 98 Don't Know

NOTE: ASK QUESTION 51, THEN GO TO QUESTION 53

52) IF 'SOMEWHAT UNLIKELY', 'VERY UNLIKELY' OR 'DON'T KNOW' TO QUESTION 48, ASK: Would you consider replacing your existing wood or wood pellet burning equipment if a cash back incentive program existed?

- 1 Yes 2 No 9 Don't know

53) In all likelihood, what will be the main type of fuel that you will use to heat your home over the next three years? **DO NOT READ, ONE ANSWER ONLY**

- 1 ELECTRICITY
- 2 NATURAL GAS
- 3 FUEL OIL OR HEATING OIL
- 4 WOOD
- 5 SOLAR
- 6 PROPANE
- 7 50% WOOD AND 50% ELECTRICITY
- 8 50% WOOD AND 50% NATURAL GAS
- 96 MISCELLANEOUS
- 98 Don't Know

54) Were you aware that new stoves sold in British Columbia have low emissions rates?

- 1 YES, AWARE 2 NO, NOT AWARE 9 Don't Know

55) Were you aware that it is possible to burn wood in a wood stove or fireplace without causing visible smoke?

- 1 YES, AWARE 2 NO, NOT AWARE 9 Don't Know

IF NATURAL GAS NOT MENTIONED IN QUESTION 10, ASK QUESTIONS 56 TO 58

56) Is natural gas available in your area?

- 1 Yes 2 No 9 Don't know

IF NO SKIP QUESTIONS 57 AND 58

57) Are you connected to natural gas?

- 1 Yes 2 No 9 Don't know

58) Has the increased price of natural gas kept you from using this fuel to heat your home?

- 1 Yes 2 No 9 Don't know

IF 'WOOD' NOT MENTIONED IN QUESTION 10, ASK QUESTIONS 59 TO 63

59) Over the past two years have you installed, or over the next three years would you consider installing, any new home heating equipment? **IF YES, PROBE FOR ALREADY INSTALLED OR CONSIDERING INSTALLING**

- 1 YES, ALREADY INSTALLED **CONTINUE**
2 YES, CONSIDERING **CONTINUE**
3 BOTH ALREADY INSTALLED AND CONSIDERING INSTALLING
4 NO **GO TO QUESTION 63**
9 Don't Know

60) Did or would this installation require a switch from one energy source to another? That is from oil to gas, gas to electricity, and so on. **READ, CHECK ONE ANSWER ONLY**

- 1 YES **CONTINUE**
2 NO **GO TO QUESTION 62**
9 DON'T KNOW **GO TO QUESTION 62**

61) From what energy source to what other energy source did or might this installation require? **DO NOT READ, AS MANY AS APPLY. PROBE**

- 98 DON'T KNOW YET
B OIL TO GAS
C OIL TO ELECTRICITY
D OIL TO WOOD
E GAS TO OIL
F GAS TO ELECTRICITY
G GAS TO WOOD
H ELECTRICITY TO OIL
I ELECTRICITY TO GAS
J ELECTRICITY TO WOOD

62) And why are you planning or considering to install this new type of heating equipment?

DO NOT READ, CHECK AS MANY AS APPLY. PROBE

- 1 CURRENT HEATING EQUIPMENT USES TOO MUCH FUEL
- 2 CURRENT HEATING EQUIPMENT IS UNSAFE
- 3 HOME INSURANCE IS TOO HIGH
- 4 CURRENT HEATING EQUIPMENT PRODUCES TOO MUCH SMOKE
- 5 AESTHETIC REASONS
- 6 EQUIPMENT FAILURE
- 7 AGE OF EQUIPMENT
- 8 HIGH GAS/FUEL PRICES
- 9 FUEL EFFICIENCY
- 10 COST SAVINGS
- 11 ELECTRICITY SUPPLY UNRELIABLE/ NEED A BACKUP SOURCE OF ENERGY, HEAT
- 96 MISCELLANEOUS
- 98 DON'T KNOW

63) In all likelihood, what will be the main type of fuel that you will use to heat your home over the next three years? **DO NOT READ, ONE ANSWER ONLY**

- 1 ELECTRICITY
- 2 NATURAL GAS
- 3 FUEL OIL OR HEATING OIL
- 4 WOOD
- 5 SOLAR
- 6 PROPANE
- 7 WOOD PELLETS
- 96 MISCELLANEOUS
- 98 DON'T KNOW

Opinion – ASK EVERYONE

64) To what extent is chimney smoke in your local area a concern to you and your family? Is it... **READ**

- | | |
|-------------------------|--------------------------|
| 1 A strong concern | CONTINUE |
| 2 Somewhat of a concern | CONTINUE |
| 3 Not much of a concern | GO TO QUESTION 66 |
| 4 Not at all a concern | GO TO QUESTION 66 |
| 9 DON'T KNOW | GO TO QUESTION 66 |

65) Why is chimney smoke a concern to you? **DO NOT READ, CHECK AS MANY AS APPLY. PROBE**

- 1 HEALTH-RELATED CONCERNS
- 2 AESTHETIC (APPEARANCE)
- 3 AESTHETIC (SMELL)
- 4 ENVIRONMENTAL CONCERNS (POLLUTION, AIR QUALITY, ETC.)
- 96 MISCELLANEOUS
- 98 DON'T KNOW

- 66) There are a number of actions that can be taken to reduce the amount of smoke from wood burning equipment. Please tell me if you would generally approve or disapprove of each of the following. First: **READ**
- a) Establishing a bylaw to reduce the amount of smoke
1 APPROVE 2 DISAPPROVE 9 NOT SURE
 - b) Providing a cash back incentive for removing old woodstoves and wood inserts
1 APPROVE 2 DISAPPROVE 9 NOT SURE
- 67) How would you rank the following sources – Low, Medium or High – for their contribution to air pollution in your area?
- a) Industry
 - b) Transportation (includes vehicles, trains, aircraft, ships)
 - c) Households (includes woodstoves & backyard burning)
 - d) Forestry, Land Clear, Agricultural Burning
1 LOW 2 MEDIUM 3 HIGH 9 DON'T KNOW
- 68) I am now going to read a list of six different groups that could be involved in determining ways of improving air quality in your area. As I read each one, please tell me if you think that group should have a lot of involvement, some involvement, little involvement or no involvement in determining ways of improving air quality in your area.
- a) Senior Government (Provincial and Federal)
 - b) Local Government (Municipal or Regional)
 - c) Regional Health Authorities
 - d) Industry
 - e) Environment Groups
 - f) The Public
1 A LOT 2 SOME 3 LITTLE 4 NONE 9 DON'T KNOW
- 69) Suppose there is poor air quality in the area where you live. In general would you approve or disapprove of temporarily suspending non-essential woodstove and fireplace burning until the air quality improves?
- 1 Yes 2 No 9 Don't know
- 70) Which of the following statements best describes how you feel about the air quality in the area where you live? The air quality in the area where I live is: **READ AND ROTATE, ONE ANSWER ONLY**
- 1 Almost always good
 - 2 Good most of the time, poor on occasion
 - 3 Good about half of the time, poor the other half
 - 4 Poor most of the time, good on occasion
 - 5 Almost always poor
 - 9 DON'T KNOW

Appendix B. Raw Survey Data Interpretation

When interpreting the survey data, a number of adjustments were required to remove obvious inconsistencies and ensure reasonable data integrity. In some cases the adjustments were needed to interpret recorded descriptive responses, while in others, more detailed deductions were made regarding the intended correct responses.

Also, in order to interpret the surveyed responses in terms that could be used to calculate wood burning appliance emissions, it was necessary to introduce background data about wood species.

The following sections describe the adjustments made regarding data about appliances, wood quantities burned, and wood species.

B.1 Appliances

12) Which of the following types of wood burning fixtures or equipment did you use to heat your home in the past 12 months?

Wood fireplace

Wood stove

Wood furnace or boiler

Wood pellet stove

13) Of all the wood burned in your home over the past year, approximately what percentage did you burn in your:

A Wood fireplace(s)

B Wood stove(s)

C Wood furnace or boiler(s)

16) Do you use a common fireplace in your primary residence?

17) Do you use a fireplace insert in your primary residence?

18) Do you use an advanced technology, heating fireplace in your primary residence?

(ASK IF 'YES' TO QUESTION 16)

19) How many common fireplaces do you use in your primary residence?

(ASK IF 'YES' TO QUESTION 17)

21) How many fireplace inserts do you use in your primary residence?

22) What type of fireplace insert(s) do you use?

A) Fireplace Insert #1: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

B) Fireplace Insert #2: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

C) Fireplace Insert #3: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

(ASK IF 'YES' TO QUESTION 18)

23) How many advanced technology, heating fireplaces do you use in your primary residence?

(ASK IF 'WOOD STOVE' IDENTIFIED IN QUESTION 12)

24) How many woodstoves do you use in your primary residence?

25) What type of woodstove do you use?

A) Woodstove #1: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

B) Woodstove #2: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

C) Woodstove #3: 1 Conventional 2 Advanced 3 Catalytic 9 Don't know

(ASK IF 'WOOD FURNACE OR BOILER' IDENTIFIED IN QUESTION 12)

Is your wood-burning furnace or boiler located inside or outside your house?

Question 12 gave general categories of appliances which were used. These responses were then refined in Questions 15 through 27.

B.1.1 Adjustments to Raw Data

- 1) There were responses in which users knew they used a type of appliance, but did not know enough to give a specific response to help classify the appliance to allow assigning accurate emission factors. In these cases, a worst case decision was made to choose the appliance with the greatest emissions matching the respondent's answers.
- 2) Question 13 was the only question available to allow apportioning of the amount of fuel burned in each type of device. Unfortunately, the question was not specific enough, and it was necessary to assume that all devices in a single household which fit in one of the three categories of Question 13 consumed an equal quantity of fuel.

For example, several responses reported that the household used a common fireplace, and an insert of some sort. Question 13 does not distinguish between the different appliances, and both were classified as "Wood fireplace(s)" for this question, so it was assumed that each of the two devices burned 50% of the fuel burned in "Wood fireplace(s)".

- 3) In at least twenty cases, although the respondent indicated that they used a fireplace in Question 12, they did not indicate any wood burning appliance in Questions 16, 17 or 18. This is not logically consistent, but the responses were allowed by the survey method. This meant that there is no information about the type of appliance used. If there were valid responses indicating that wood was burned, it was assumed that they had a common fireplace.
- 4) There were responses where the householder could not estimate how much fuel was burned in each appliance. These were entered with "Don't know" for the ratio of fuel burned in each time. In order to make emission calculations possible, it was assumed that equal quantities of fuel were burned in each appliance. By making this assumption, the total emissions for the survey increased by 4 to 6 %, depending on the region.
- 5) For a number of households, the sum of responses for Question 13 was not 100%. In these cases, each fraction was pro-rated by the total so that the fractions used in the calculations summed to 100%.
- 6) Suspected Problem: A fireplace and an insert are reported separately by the householder so that they are recorded as two appliances when in fact they are a single appliance. There was

no means to determine whether this was indeed the case, so emissions for two appliances had to be calculated.

- 7) Suspected Problem: A common fireplace and an advanced technology fireplace are reported separately by the householder so that they are recorded as two appliances when in fact they are a single appliance. There was no means to determine whether this was indeed the case, so emissions for two appliances had to be calculated

B.1.2 Appliance Types

Table B. 1: Appliance Types by Region

Region	Total Number of Appliances	Fireplace; Advanced Technology	Fireplace; Conventional Without Glass Doors	Central Furnace/Boiler (inside)	Central Furnace/Boiler	Central Furnace/Boiler (outside)	Fireplace Insert; Advanced Technology	Fireplace Insert; Catalytic	Fireplace Insert; Conventional	Woodstove; Advanced Technology	Woodstove; Catalytic	Woodstove; Conventional	Pellet Stove
Capital Regional District	38512	3%	44%	2%	0%	0%	1%	0%	8%	11%	6%	24%	1%
Other Vancouver Island	69236	2%	13%	4%	0%	0%	2%	1%	9%	34%	5%	25%	4%
Sunshine Coast	11445	3%	21%	9%	0%	1%	4%	2%	6%	16%	5%	27%	6%
Sea-to-Sky Airshed	9361	1%	22%	2%	0%	0%	7%	1%	8%	31%	3%	22%	2%
Shuswap	6555	3%	19%	14%	0%	1%	5%	0%	5%	17%	6%	21%	9%
Kamloops	4188	3%	45%	3%	0%	0%	3%	1%	8%	12%	6%	18%	3%
Other Southern Interior	46125	4%	23%	8%	0%	1%	2%	0%	5%	20%	3%	28%	6%
Golden Airshed	1566	3%	7%	17%	0%	2%	2%	0%	3%	25%	10%	29%	2%
Cranbrook Airshed	4434	4%	16%	4%	0%	2%	1%	0%	4%	19%	11%	34%	5%
Elk Valley Airshed	1581	3%	22%	3%	0%	4%	1%	1%	8%	16%	11%	30%	3%
Nelson Airshed	1681	5%	28%	2%	0%	0%	6%	2%	6%	18%	8%	25%	0%
Other Kootenay	19520	5%	14%	16%	0%	2%	4%	1%	4%	18%	8%	24%	5%
Williams Lake Airshed	2853	1%	18%	12%	0%	0%	2%	0%	9%	20%	10%	25%	3%
Quesnel Airshed	4064	1%	16%	14%	0%	4%	1%	1%	6%	18%	4%	24%	10%
Other Cariboo	7756	3%	11%	17%	0%	2%	1%	1%	1%	27%	8%	25%	4%
Prince George	8985	4%	32%	10%	0%	1%	3%	1%	8%	12%	7%	20%	2%
Other Northern	14100	2%	16%	12%	1%	3%	0%	0%	2%	23%	12%	23%	8%
Bulkley Valley/Lakes Airshed	8124	2%	7%	11%	0%	5%	0%	0%	2%	14%	4%	29%	26%
Other Skeena	5592	1%	14%	13%	0%	1%	3%	0%	1%	20%	6%	35%	6%

Table B. 1 gives the percentage of each type of appliance with respect to all of the appliances reported for the region. It should be noted that due to the way in which “advanced technology” stoves and inserts were identified (“less than 15 years old”, see Appendix A), the results may not be in close agreement with other surveys where “advanced technology” is defined differently.

B.2 Wood Quantities

(ASK IF ANY WOOD BURNING EQUIPMENT OTHER THAN A PELLET STOVE IDENTIFIED IN QUESTION 12):

30) Approximately how many cords of wood, in total, did you burn in your wood-burning equipment(s) over the past 12 months?

Question 30 was asked in two parts when necessary. In the first part, a list of quantities was given, allowing the householder to pick one. If nothing on the list was suitable, they were asked to give a specific quantity. The form of the data required converting the non-list responses to quantities manually.

There were a few responses which were rejected. As no reasonable data could be deduced, the quantity of wood burned was set to zero, leading to no emissions from these households, even though they indicated that they burn some sort of fuel. Setting these results to zero will reduce the total emissions, but does not have a significant effect on the resulting emission quantities if we assume that the real values would be typical for the survey.

Text Field response	Reason for rejection
zero	Zero value
Only there 4 months. Don't burn any cords	No numbers given
No cords only pellets	Zero value (Shouldn't have been asked?)
Cords burn in about six months	No numbers given
13 CORDS (NOT ONLY FOR THE HOUSE BUT ALSO A GREENHOUSE)	Survey was for household heating only – this is an invalid response.
80	Seems to be too large – this would be almost ¼ cord of wood burned every day of the year.
1000 cords stacked	Clearly an unreasonable response.

Using all valid responses, it is possible to calculate an average number of cords of wood burned per wood burning household. Pro-rating the regional averages by the regional household numbers allows the Provincial average to be calculated. The results of these calculations are given in the following table.

Table B. 2: Average Cords Burned

Region	Average number of cords burned per wood burning household
Capital Regional District	1.61
Other Vancouver Island	2.62
Sunshine Coast	2.45
Sea-to-Sky Airshed	2.32
Shuswap	2.80
Kamloops	2.01
Other Southern Interior	3.22
Golden Airshed	3.86
Cranbrook Airshed	2.74
Elk Valley Airshed	3.22
Nelson Airshed	1.99
Other Kootenay	3.17
Williams Lake Airshed	3.26
Quesnel Airshed	3.83
Other Cariboo	4.50
Prince George	3.00
Other Northern	4.59
Bulkley Valley/Lakes Air	4.85
Other Skeena	4.21

B.3 Wood Species

(ASK QUESTIONS 31 TO 36 ONLY IF 'WOOD' MENTIONED IN QUESTION 10)

30) Of all the wood that you burn, what percentage would be:

- Pine
- Spruce
- Cedar
- Birch
- Douglas fir

31) Do you burn any other type of wood and, if so, what percentage of all the wood that you burn does it represent?

Questions 31 and 32 allowed the calculation of the quantity of wood of each species that was burned per household. Using Table B. 3, the weight of wood burned in each appliance was determined.

Table B. 3: Wood Densities

Common Name	Genus species	kg/m3 @ 12% dry basis moisture	basic specific gravity	kg/m3 @ 22% dry basis moisture	Notes
Pacific Silver Fir	Abies amabilis	433	0.3642	456	
Balsam Fir	Abies balsamea	401	0.3388	423	Not indigenous to BC
Grand Fir	Abies grandis	449	0.3769	472	
Subalpine Fir	Abies lasiocarpa	449	0.3769	472	
FIRS				467	Simple average
Douglas Maple	Acer glabrum			569	Assume same as Acer macrophyllum
Bigleaf Maple	Acer macrophyllum	545	0.4517	569	
Chestnut	Aesculus sp.	401	0.3388	423	
Red Alder	Alnus rubra	449	0.3769	472	
Mountain Alder	Alnus tenuifolia			472	Assume same as alnus rubra
Arbutus	Arbutus menziesii	721	0.5840	743	
Paper Birch	Betula papyrifera	609	0.5005	633	
Pacific Dogwood	Cornus nuttallii	817	0.6537	836	
Tamarack	Larix laricina	593	0.4884	617	Only indigenous east of the Rockies
Western Larch	Larix occidentalis	577	0.4762	601	
Apple	Malus sp.	753	0.6074	774	
Engelmann spruce	Picea engelmannii,	368	0.3123	390	
White spruce	Picea glauca	449	0.3769	472	
Black spruce	Picea mariana,	449	0.3769	472	
Sitka spruce	Picea sitchensis,	449	0.3769	472	
SPRUCES				452	Simple average
White Bark Pine	Pinus albicaulis				No data
Lodgepole Pine	Pinus contorta,	465	0.3895	489	
Western White Pine	Pinus monticola,	433	0.3642	456	
Ponderosa Pine	Pinus ponderosa,	449	0.3769	472	
PINES				472	Simple average
Black Cottonwood	Populus balsamifera	368	0.3123	390	
Trembling Aspen	Populus tremuloides	417	0.3515	440	

Common Name	Genus species	kg/m3 @ 12% dry basis moisture	basic specific gravity	kg/m3 @ 22% dry basis moisture	Notes
Apricot	Prunus			585	Assumes all fruit and nut trees based on genus Prunus.
Plum	Prunus domestica			585	
Cherry	Prunus sp.	561	0.4639	585	
Douglas-fir (coastal)	Pseudotsuga menziesii	540	0.4478	564	
Douglas-fir (Interior)	Pseudotsuga menziesii	500	0.4168	524	
DOUGFIR				544	Cannot distinguish subspecies from responses
Garry oak	Quercus garryana	801	0.6422	821	
Western Red cedar	Thuja plicata	368	0.3123	390	
Western Hemlock	Tsuga heterophylla	465	0.3895	489	
Mountain Hemlock	Tsuga mertensiana	529	0.4393	553	
HEMLOCKS				521	Simple average
Butternut	Juglans cinerea	433	0.3642	456	
Black Walnut	Juglans nigra	609	0.5005	633	
Canadian rock elm	Ulmus thomasii	705	0.5722	727	
Black Willow	Salix nigra	417	0.3515	440	Not clear that this is correct, but it's the only data available for any willow
Yellow Cedar	Chamaecyparis nootkatensis	497	0.4145	521	
Cypress	Chamaecyparis lawsoniana	465	0.3895	489	
Softwood				492	Simple average of all softwoods indigenous to BC
Driftwood				492	Assume this is the same as softwood
Hardwood				595	Simple average of all hardwoods indigenous to BC
Unknown				530	Simple average of all woods indigenous to BC

B.3.1 Adjustments to Raw Data

There were a number of problems with matching data from the survey to Table B. 3. Therefore, a number of assumptions were necessary:

- 1) Verbal responses were not entered with correct spelling or grammar. These were corrected as best as possible, and the remainder designated as “Unknown”.

Entered response	Assumed intended response
camarack, CAMRACK, tamarac, tarmarca, tamerak, camarac, Tanmarck, tararack, temorack	Tamarack
Hamlock, Helmlock, MEMLOCK, emwalk, hemlockl, hemlot	Hemlock
Aldar, arder, aldere,	Alder
aple wood	Apple
buch, bp, dk, dead trees, mix one, mixed one, all dk percentages, all mixed dk type, not shur, etc.	Unknown
Balsa, balsom, basswood, bolsom,	Balsam
HARDWARE OAK	Oak
popper, popler, poplar, oppler, popller, poperla, popular, pulper	Poplar
laarch, ludge, Laarch, lurch	Larch
ced	Cedar
pretel loggs	Presto Logs
Mapple Wook	Maple

- 2) If all (or most) species were listed as “Don’t know”, the wood burned was assumed to be 100% UNKNOWN.
- 3) If some species were listed as “Don’t know”, but the remainder added up to 100%, the “Don’t know” values were set to zero.
- 4) If a few species were listed as “Don’t know”, but most were zero, the “Don’t know” species were assigned equal fractions which summed to 100%.
- 5) Percentages did not sum to 100%. In this case, the percentages were prorated to give a total for the household of 100%.
- 6) “Balsam” was given as a wood burned, but Balsam Fir is not a species indigenous to BC. Also, it seems more likely that respondents were referring to a fir rather than the Balsam Poplar, so any “Balsam” responses were changed to “Firs”.
- 7) “Tamarack” was given as a wood burned, but the true Tamarack (*Larix laricina*) is not indigenous west of the Rocky Mountains, and is often confused with the Western Larch

(*Larix occidentalis*). Therefore, Tamarack was changed to Western Larch, as there were no “Tamarack” responses for north-eastern BC.

- 8) There were a number of ambiguous cases.
- a) The most general was the case where a species was UNKNOWN. In this case, all of the indigenous species which were mentioned by respondents were averaged to give the values in Table B. 3.
 - b) A more specific mention of SOFTWOOD, or HARDWOOD was given. In this case, the species were separated according to type, and a simple average was calculated.
 - c) A generic tree was mentioned, such as “Fir” or “Spruce”. In this case, average values for all trees of that genus were calculated. See Table B. 3 for values.

Identifying and assigning a density for “UNKNOWN”, “SOFTWOOD”, “HARDWOOD”, etc... accounts for roughly 8% of total fuel consumption.

Once the data for the number of cords and species were interpreted and entered into the database, it was possible to calculate the weight of fuel burned in each appliance.

Appendix C. Kelowna Results

The emissions from Kelowna sources were calculated using the results of the *Okanagan Indoor Wood Burning Appliance Inventory Survey*⁴, assuming that the Central Okanagan results are representative for Kelowna¹⁸. The results relevant to emissions are:

Table C. 1: Okanagan Survey Results

Fraction of Central Okanagan households using a wood burning appliance	18.7% of households burn wood	
Fraction of each type of wood burning appliances	Advanced Technology Stove	10%
	Conventional Stove	42%
	Conventional FP	46%
	Pellet stoves	1%
	Central Furnace	1%
Fuel consumption by appliance type	Advanced Technology Stove	2.2 cords/yr
	Conventional Stove	2.7 cords/yr
	Conventional FP	1.2 cords/yr
	Central Furnace	7 cords/yr
Fuel type by species	Pine	33.5%
	Douglas Fir	20.9%
	Apple	13.2%
	Birch	10.6%
	Spruce	9.6%
	Unknown (Don't know + Other)	12.3%

Based on these results, we can estimate emissions in the following way:

$$\left(\begin{array}{l} \text{Number of households} \\ \text{burning wood} \end{array} \right) = \left(\begin{array}{l} \text{Number of households} \\ \text{in Kelowna} \end{array} \right) \times \left(\begin{array}{l} \text{fraction of households using} \\ \text{a wood burning appliance} \end{array} \right),$$

$$\left(\begin{array}{l} \text{Number of one} \\ \text{type of appliance} \end{array} \right) = \left(\begin{array}{l} \text{Number of households} \\ \text{burning wood} \end{array} \right) \times \left(\begin{array}{l} \text{Fraction of each type of} \\ \text{wood burning appliance} \end{array} \right),$$

$$\left(\begin{array}{l} \text{Weight of wood burned} \\ \text{in one type of appliance} \end{array} \right) = \left(\begin{array}{l} \text{Fuel consumption} \\ \text{by appliance type} \end{array} \right) \times \left(\begin{array}{l} \text{Fraction of fuel} \\ \text{type by species} \end{array} \right) \times (D \times 2.27 \times 10^{-3}).$$

The weight of wood burned in one type of appliance is the base quantity, which, multiplied by the emission factors for that appliance, gives the emissions from that appliance.

For example, to calculate the amount of CO emitted from apple burned in conventional fireplaces:

$$\begin{aligned}
 \text{CO emissions} &= (\text{num households}) \times (\% \text{ that burn}) \times (\% \text{ conv. fireplaces}) \\
 &\quad \times (\text{fuel consumed}) \times (\% \text{ apple}) \times (\text{emission factor}) \\
 &= 31582 \times 0.187 \times 0.46 \times (1.2 \times 0.00227 \times 774) \times 0.132 \times 77.7 \\
 &= 58747 \text{ Kg} = 58.7 \text{ tonnes}
 \end{aligned}$$

To obtain the total emissions for Kelowna, the emissions from each type of fuel wood and each type of appliance were summed to give the results in Table C. 2.

Table C. 2: Kelowna Wood Burning Appliance Emissions (tonnes/year)

	CO	NOx	SOx	VOC	Part	PM ₁₀	PM _{2.5}
Kelowna	1301.2	20.4	2.9	345.4	299.6	283.8	283.4

Appendix D. Lower Fraser Valley Results

Table D. 1: Total LFV Residential Wood Burning Emissions for 2000

	(tonnes)						
	CO	NO _x	SO _x	VOC	TPM	PM10	PM2.5
Anmore	2.123	0.025	0.0036	0.380	0.242	0.231	0.230
Belcarra	2.300	0.027	0.0039	0.412	0.263	0.250	0.249
Bowen Island	10.107	0.120	0.0171	1.809	1.154	1.100	1.093
Burnaby	278.180	3.304	0.4720	49.780	31.760	30.278	30.092
Coquitlam	176.209	2.093	0.2990	31.533	20.118	19.179	19.061
Delta	164.278	1.951	0.2787	29.398	18.756	17.881	17.771
Langley City	40.841	0.485	0.0693	7.308	4.663	4.445	4.418
Langley Township	159.021	1.889	0.2698	28.457	18.156	17.309	17.202
Lions Bay	2.813	0.033	0.0048	0.503	0.321	0.306	0.304
Maple Ridge	109.768	1.304	0.1862	19.643	12.532	11.948	11.874
New Westminster	83.751	0.995	0.1421	14.987	9.562	9.116	9.060
North Vancouver City	64.104	0.761	0.1088	11.471	7.319	6.977	6.934
North Vancouver District	142.588	1.693	0.2419	25.516	16.279	15.520	15.424
Pitt Meadows	27.653	0.328	0.0469	4.949	3.157	3.010	2.991
Port Coquitlam	83.233	0.988	0.1412	14.894	9.503	9.059	9.004
Port Moody	38.103	0.453	0.0646	6.819	4.350	4.147	4.122
Richmond	282.817	3.359	0.4798	50.610	32.289	30.783	30.594
Surrey	520.969	6.187	0.8839	93.227	59.480	56.704	56.356
Vancouver	750.709	8.916	1.2737	134.339	85.709	81.710	81.208
West Vancouver	80.211	0.953	0.1361	14.354	9.158	8.731	8.677
White Rock	39.696	0.471	0.0673	7.104	4.532	4.321	4.294
Electoral Area 'A' [UEL]	5.695	0.068	0.0097	1.019	0.650	0.620	0.634
GVRD Total	3,065.170	36.403	5.2004	548.512	349.953	333.626	331.591
City of Abbotsford	678.008	6.314	1.2319	126.931	79.622	74.659	74.339
Chilliwack	527.004	4.908	0.9575	98.661	61.889	58.031	57.783
Harrison Hot springs	10.463	0.097	0.0190	1.959	1.229	1.152	1.147
Hope	46.942	0.437	0.0853	8.788	5.513	5.169	5.147
Kent	32.244	0.300	0.0586	6.036	3.787	3.551	3.535
Mission	188.480	1.755	0.3425	35.286	22.134	20.754	20.666
Electoral Areas A - H	89.934	0.837	0.1634	16.837	10.561	9.903	9.861
FVRD Total	1,573.075	14.649	2.8582	294.498	184.735	173.219	172.478
LFV 2000 Total	4,625.384	50.932	8.0352	840.602	533.178	505.429	502.659

Table D. 1 is excerpted from the GVRD Residential Wood Burning Survey⁵ details provided by the GVRD.

Appendix E. References

- ¹ *British Columbia. Ministry of Water, Land and Air Protection. Service plan. — 2002/2003/2004/2005*
- ² *Health and Air Quality 2002 – Phase 1, Methods for Estimating and Applying Relationships between Air Pollution and Health Effects*, May 2003, (Available online at <http://www.bc.lung.ca/airquality.pdf>)
- ³ *BC Residential Woodstove and Wood Burning Survey*, British Columbia Ministry of Water, Land and Air Protection Contract # 1070-20/WAC-03-238-RFP, McIntyre & Mustel Research Limited, June 2003.
- ⁴ *Okanagan Indoor Wood Burning Appliance Inventory Survey*, A Project of the Okanagan Air Quality Technical Steering Committee, August 29, 2001.
- ⁵ *GVRD Residential Wood Burning Survey*, Ipsos Reid, April 2002.
- ⁶ *The 2001 Census of Population and Housing*, <http://www.bcstats.gov.bc.ca/data/cen01/c2001pop.htm>
- ⁷ *Householder Counts and Maps*, <http://www.canadapost.ca/cpc2/addrm/hh/current/indexp/tpALL-e.asp>
- ⁸ *Forestry Extension Notes; Firewood Production and Use, F-370*, Iowa State University, University Extension, August 1998
- ⁹ *Firewood Selection*, Don Hanley, University of Idaho UI Extension Forestry Information Series
- ¹⁰ *G5450 Wood Fuel for Heating*, John P. Slusher, University Extension, University of Missouri-Columbia. 1999.
- ¹¹ *B415.1-00 Performance Testing of Solid-Fuel-Burning Heating Appliances*, Canadian Standards Association International, December 2000.
- ¹² *Tree Book; Learning to Recognize Trees of British Columbia*, BC Ministry of Forests. (Available online at <http://www.for.gov.bc.ca/hfd/library/documents/treebook/index.htm>)
- ¹³ *Softwoods of North America*, Harry A. Alden, USDA Forest Service, Forest Products Laboratory, General Technical Report FPL-GTR-102, September 1997. (Available online at <http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr102.pdf>)
- ¹⁴ *Hardwoods of North America*, Harry A. Alden, USDA Forest Service, Forest Products Laboratory, General Technical Report FPL-GTR-83, September 1995. (Available online at <http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr83.pdf>)
- ¹⁵ *Specific Gravity, Moisture Content, and Density Relationship for Wood*, William T. Simpson, USDA Forest Service, Forest Products Laboratory, General Technical Report FPL-GTR-76, July 1993.
- ¹⁶ *AP-42*, <http://www.epa.gov/ttn/chief/ap42/index.html>
- ¹⁷ *Residential Wood Combustion*, Overview of Appliance Categories, John Gulland, June 2003, Updated September 2003.
- ¹⁸ *Private Communication*, Cory Davis, City of Kelowna.