Fine Particulate Sampling Project In Port Alberni

by

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Executive Summary

The Alberni Air Quality Council (AQC) is a volunteer group of citizens who are concerned about the air quality in the Alberni Valley. At meetings with the Ministry, they have expressed concerns regarding lack of spatial information about air quality data, especially regarding fine particulate matter (i.e. $PM_{2.5}$). There is only one existing air quality station in Port Alberni and it is a Permittee station that measures coarse particulate matter (PM_{10}).

The AQC secured a grant from Air Protection Section (Victoria) to conduct a sampling project to measure fine particulate matter at several sites in Alberni during times when levels would be expected to be elevated (during the fall open burning season (November) and winter woodstove usage times (February)). The samplers were run every second day to maximize the number of samples. Six sites were chosen to represent all types of land use.

Ministry staff secured the samplers and conducted training for the AQC volunteers. Ministry staff also expedited the filter analysis through the ministry laboratory. AQC volunteers did all the sampling during the two month long sampling periods. NorskeCanada also supported this study.

While there were some logistical problems, the volunteers did an excellent job with very few spoiled samples. Some of the results indicate that sites along the highways showed elevated results, residential areas can have elevated levels due to woodstove usage and a region wide open burning impact was not shown but a high local impact (due to burning next door) was shown. Also, the sampling showed that the current monitoring site is not a good location to measure regional fine particulate matter concentrations.

1. Location and History

The city of Port Alberni lies at the north end of the Alberni Inlet in central Vancouver Island. The topography to the south, along the inlet, is very mountainous with peaks reaching 1 to 2 thousand metres. To the northwest a wide valley, the Alberni Valley, is formed by the Stamp River. This valley is framed by the Beaufort Range on the north and the Vancouver Island range on the west. To the east is a pass-like feature that encompasses Cameron and Horne Lakes. This topographic situation gives rise to frequent meteorological situations that restrict dispersion of air pollutants.

The main industry in the city is forestry based with two major sawmills and a pulp mill located on the inlet. Previous to 1990 there were also other forest based industries such as a plywood mill which had significant air emissions. The pulp mill was a combined kraft and mechanical mill until 1996. At that time the kraft mill was closed and now only mechanical pulp is produced.

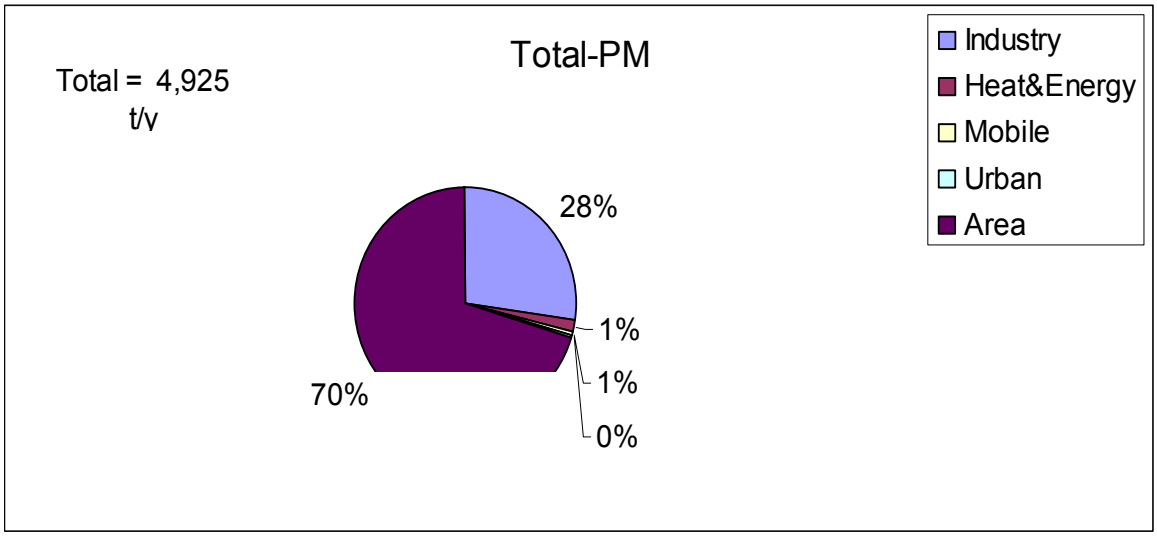
The largest combustion source at the mill now is a fluidized bed hog fuel (waste wood) power boiler. Tire Derived Fuel (TDF) is also used in this boiler along with natural gas when required. The TDF can be used at a rate of 5% of the hog fuel usage.

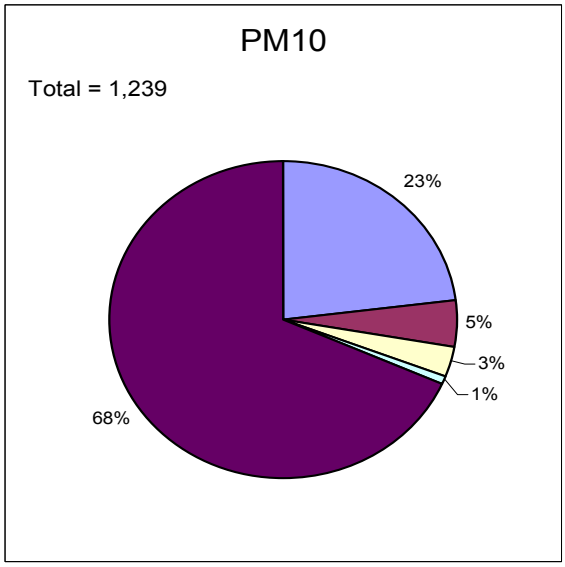
The Alberni Air Quality Council (AQC) is a group of concerned citizens who have had discussions with the Ministry concerning the lack of spatial information about air quality in the Alberni Valley, especially concerning fine particulate matter.

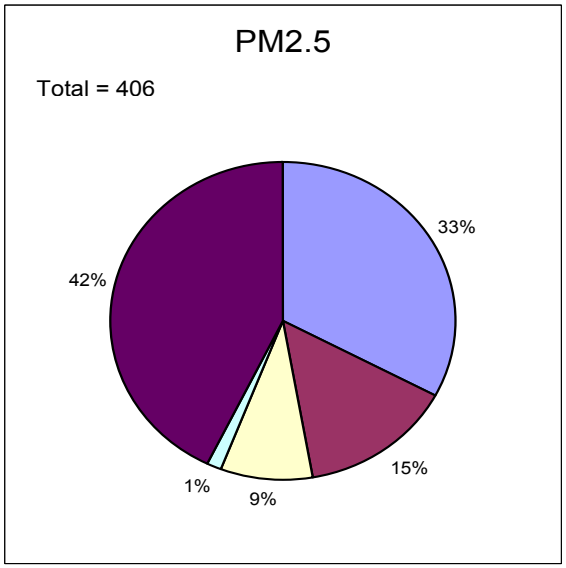
2. Current Emission Estimates

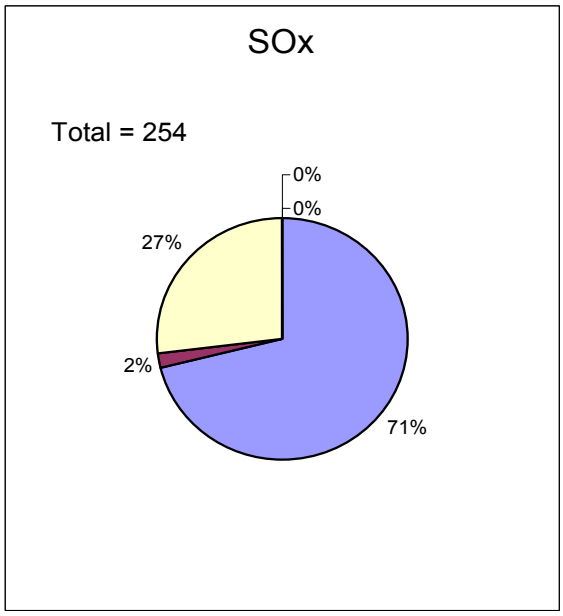
The following graphs show the estimated air emissions from all sources in the Alberni Valley as representing the year 2000. The data is from the National Pollutant Release Inventory database operated by Environment Canada. Total values are in units of tonnes per year of pollutant.

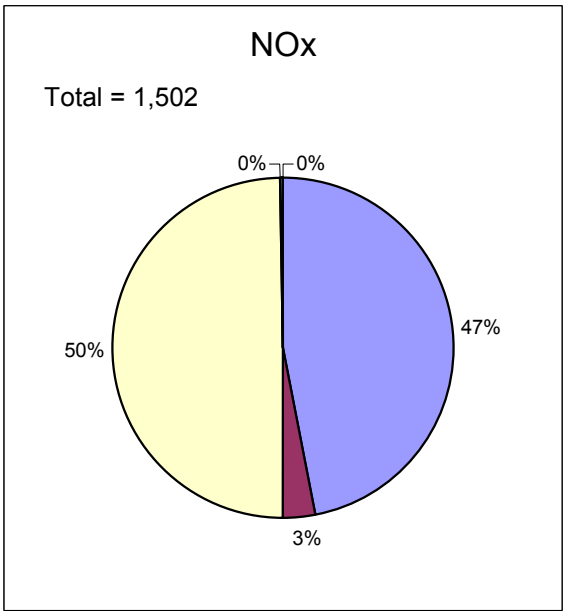
Industry emissions are derived from plant surveys and other process estimates. The “Area” sector includes emission estimates from agriculture, construction, road dust (from paved and unpaved roads), and some open burning. The “Urban” sector includes emission estimates from activities such as cooking, solvent use, and other urban activities. Mobile sector estimates are from emission models that take into account vehicle age distribution (and associated tailpipe emissions), climate and road network. The sector “Heat&Energy” includes emission estimates from all types of fuels used for space heating in commercial and residential buildings.


Total-PM
Total = 4,925
t/y
Industry
Heat&Energy
Mobile
Urban
Area
28%
1%
1%
0%
70%


PM10
Total = 1,239
23%
5%
3%
1%
68%


PM2.5
Total = 406
33%
42%
15%
1%
9%


SOx
Total = 254
0%
0%
27%
2%
71%


NOx
Total = 1,502
0%
0%
47%
50%
3%

It can be seen that the estimated largest source of coarse particulate matter, more than 50%, is from the Area source sector. Industry accounts for approximately a third of particulate matter. Industry and mobile sources account for almost all of the nitrogen oxides and sulphur dioxides.

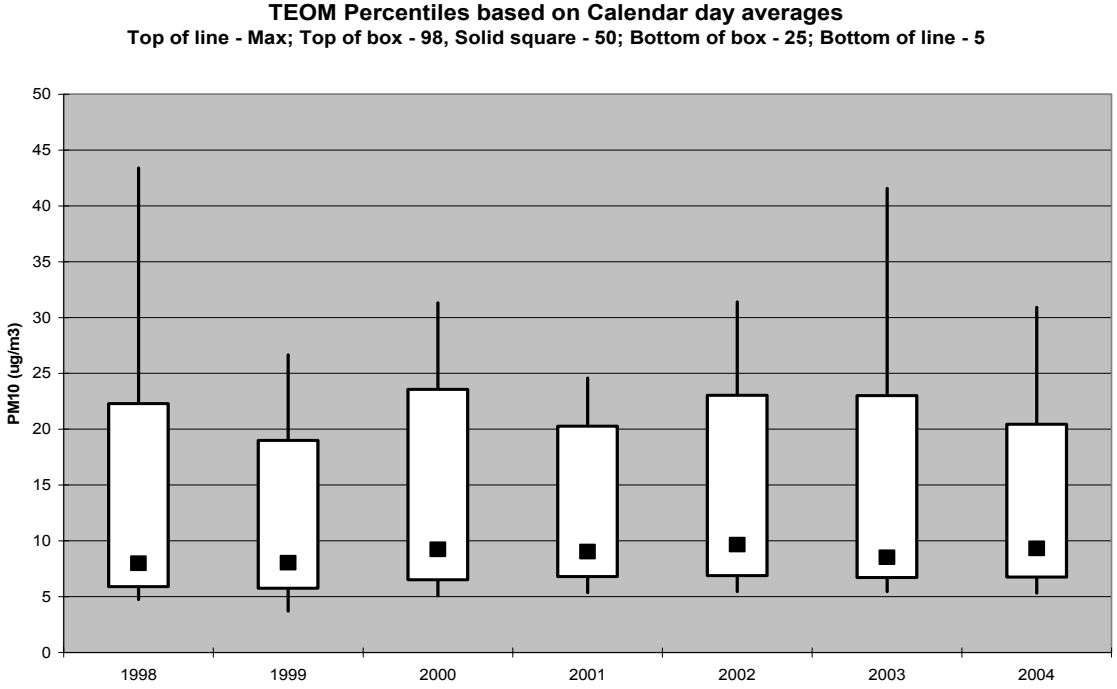
3. Existing Ambient Monitoring

Since the close of the kraft mill, ambient monitoring in Port Alberni consists of one site that measures particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) at the Boat House on the Quay (also called Townsite, see map in Section 4.3). The site is owned and operated by NorskeCanada under the direction of the Ministry of Environment. The analyzer used at this site is called a TEOM (Tapered Element Oscillating Microbalance). The measurement principle is based on the physics of vibration. The frequency of vibration is directly related to the mass of the object. The sensing unit uses a small filter secured on top of a hollow cone made of quartz. Quartz has a well known natural frequency response when excited by an electrical field (e.g. digital watches). As particles collect on the filter, the mass of the filter increases and the frequency changes. The sensing unit applies an electrical field to return the quartz cone to its natural frequency. The amount of force needed to keep the cone at this frequency is related to the mass collected and, by measuring the volume of air, the PM_{10} mass concentration can be calculated.

The picture on the left shows a PM_{10} head and the picture on the right shows a TEOM sensing unit. Not shown is the TEOM analyzing unit.

The following graph shows a summary of the TEOM data measured at the Harbour Quay site. The BC PM_{10} objective is 50 $\mu g/m^3$ (24 hour average). There have been no exceedances of this objective since 1998. The 98th percentile value of the PM_{10} data is approximately 23 $\mu g/m^3$. This is already below the $PM_{2.5}$ Canada Wide Standard (CWS) of 30 $\mu g/m^3$ (24 hour average, 3 year average). Using the most common

factor relating $PM_{2.5}$ to PM_{10} in an urban environment of 0.6 (i.e. $PM_{2.5}$ to PM_{10} ratio equals 0.6) , a 98th percentile value for $PM_{2.5}$ at this site would likely be around 14 µg/m^3.



4. Sampling Project

4.1. Rational

The Alberni Air Quality Council (AQC) has expressed concerns regarding the lack of spatial information about air quality data, especially concerning fine particulate matter. The existing monitoring is Permittee based and thus was located with the industrial sources in mind. Community concerns raised were traffic sources with respect to schools in Port Alberni, woodstove usage and open burning.

Through grants from the Air Protection Branch of the Ministry of Water, Land and Air Protection, a sampling project for particulate matter with aerodynamic diameters less than 2.5 microns ($PM_{2.5}$) was devised using 5 low volume (LoVol) $PM_{2.5}$ filter based samplers. With the support of NorskeCanada (Alberni Division) a 6th sampler was added to the project. Fine particulate matter ($PM_{2.5}$) was the chosen parameter due to its greater health concern. AQC volunteers did the filter changes and the grant covered the cost of the rental for 5 samplers and laboratory analysis. NorskeCanada paid for the operation of 1 sampler.

The objective of the project was to sample $PM_{2.5}$ levels in various parts of

the community during times of known concern (fall open burning and winter woodstove usage).

4.2. Equipment

The equipment used for the sampling project is a filter based sampler using a 47mm filter. Filters and laboratory analysis was supplied by the Ministry lab (PSC in Vancouver). The sampler (supplied by Airmetrics of Eugene, OR) consists of a stacked impact particle separator (a PM_{10} over a $PM_{2.5}$ separator) directly over the filter. The sampler has a programmable controller to start and stop the pump without human control and is powered by a rechargeable lead-acid battery. The samplers are portable and easy to site. The samplers are designed to run at 5 litres per minute (actual) and are manually set by the operator.

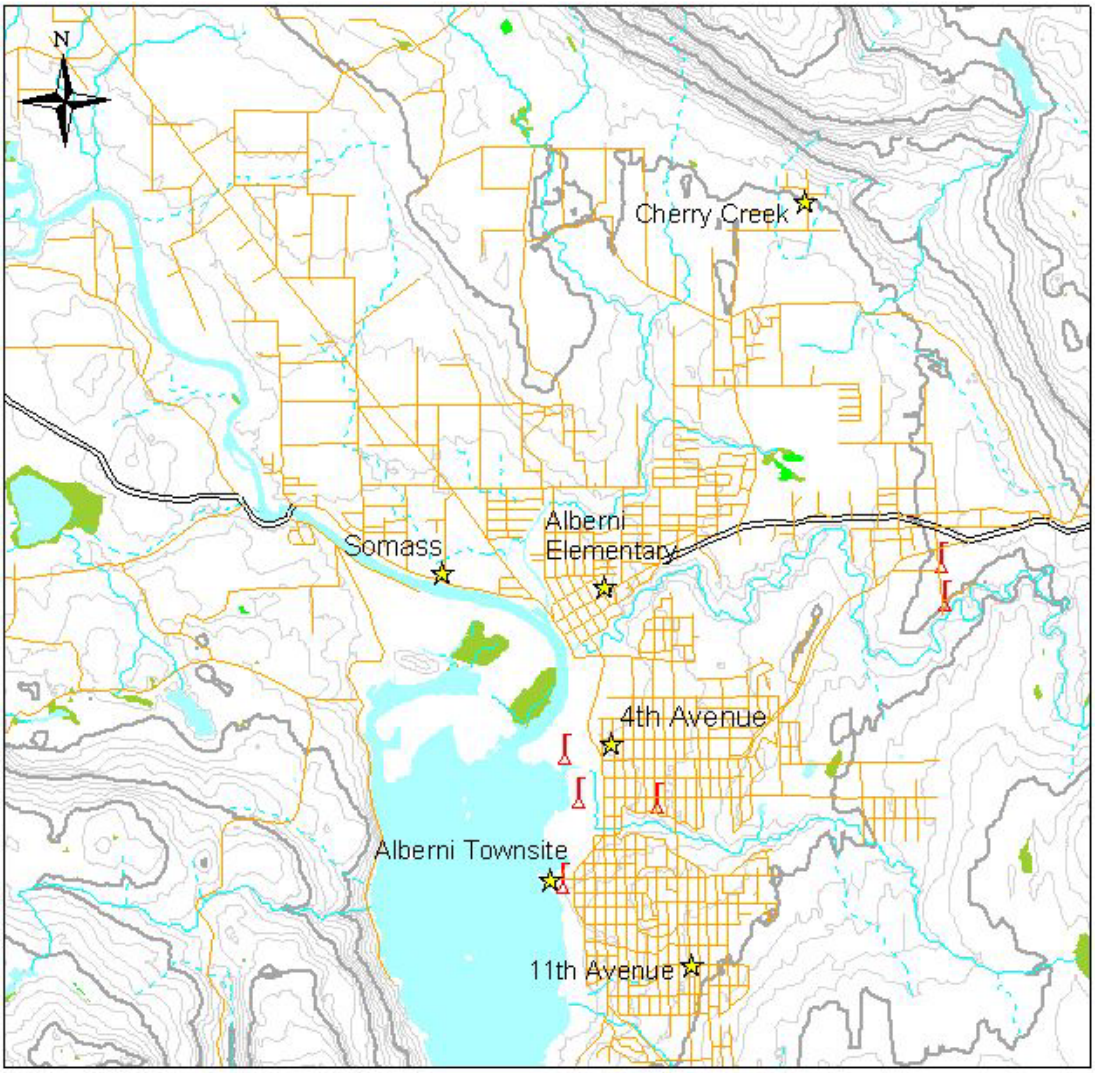
The picture to the left shows a typical sampler. The bottom third is the battery. The rest of the sampler contains the pump, programmable timer and other electronics. The black object on top is the PM_{10} and $PM_{2.5}$ heads that separate the particles. Below the heads is the filter holder (not visible) where the filter is located.

To collect the most number of samples in the least time, sampling was conducted every second day for a 24 hour period from midnight to midnight. The operator was required to change the filters and batteries in the intervening day.

4.3. Sites

Six sites were chosen to cover a range of areas within the Alberni Valley: rural residential (Cherry Creek), urban residential (11th and Bruce), industrial (or near by) Harbour Quay and 4th Ave., Highway (Alberni Elementary and Somass Motel). The following map shows the location of the sampling sites.

Air Particulate Monitoring Stations in Port Alberni



1:65,000

1 0 1 Kilometers

Transportation Network
Highway
Road
2000 Permitted Stack Releases
EMS Air Site - Air Permit
Water Linear Features
River/Stream - Definite
River/Stream - Intermittent
Contours - 20m Interval
Contour - Index
Contour - Intermediate
Water Polygon Features
River
Lake
Coastline
Wetland Features
Marsh
Swamp

Ministry of Water, Land and Air Protection

BRITISH COLUMBIA

5. Sources of Uncertainty

5.1. TEOM

The TEOM instrument is a very sophisticated machine. It uses temperature and pressure sensors to accurately measure the volume of air associated with each mass measurement. The mass measurement is not a discrete measurement but rather a rolling measurement. The mass collected over a timestep is the mass at the end of the timestep minus the mass at the beginning of the timestep.

Since we do not want to measure liquid water in these mass measurements (liquid water is not considered part of particulate matter) a heated inlet tube is used to evaporate any water on the particles. This TEOM uses a set temperature of 40^{o}C. However, some Volatile Organic Compounds (VOC) can be evaporated as well. This is known to occur especially in heavy woodsmoke environments. Studies have shown that a TEOM using a set temperature can under-estimate 24 hour values by 15 to 30% compared to filter based reference methods in woodsmoke dominated environments.

For long term measurements over a variety of environments the TEOM is considered to have an accuracy of about +/- 2 µg/m^3.

5.2. Samplers

For this study it was important that the samplers be easy to use, small and portable. One downside to this type of sampler is that they are less sophisticated and thus are susceptible to effects from environmental conditions and operator miscue. Further, there are uncertainties with the lab pre- and post-weighting of the filters.

Studies in highly controlled conditions report that these samplers have a precision of about +/- 4 µg/m^3 compared to other filter based Reference Samplers. Reference Samplers are those that meet strict requirements of the US EPA for legal attainment monitoring. Given the less precise operation and some of the challenging environmental operating conditions during this study, it is reasonable to expect that precision would be in the +/- 6 µg/m^3 range.

Laboratory quality control procedures involve field blanks and duplicate weightings of the filters. A few field blanks were done and all were reported as less than detectable (i.e. 2 µg/m^3). Duplicate weightings showed precisions in the +/- 3 µg/m^3 range.

It is also reasonable to expect that these uncertainties are distributed randomly and that the overall uncertainty is not always the sum of the individual uncertainties. Therefore one might expect that the total uncertainty for the sampling results might be in the +/- 7 to 8 µg/m^3 range.

6. Results

There are no existing objectives or guidelines for $PM_{2.5}$ in BC or with the Federal Government as there are with other common air contaminants, such as ozone or sulphur dioxide. Recently Health Canada did establish a new standard for $PM_{2.5}$ called the Canada Wide Standard (CWS). This standard is new in terms of a value and the application of the standard compared to older objectives and guidelines.

The numerical value of the standard is 30 $\mu g/m^3$ (24 hour average). The full application of the standard is a 3 year average of the annual 98^{th} percentile of the daily averages (to be achieved by 2010).

For a short term sampling project like this study, a result exceeding 30 $\mu g/m^3$ does not necessarily mean that the CWS will be exceeded. There must be enough samples throughout the year to properly determine an annual 98^{th} percentile value and sampling must continue for at least 3 years.

However for a rough comparison in this study, if a $PM_{2.5}$ result exceeds 30 $\mu g/m^3$ it is likely that the PM_{10} value for that day at that site will be close to or exceed the BC PM_{10} objective of 50 $\mu g/m^3$ (since $PM_{2.5}$ is a sub-set of PM_{10}). A PM_{10} value exceeding 50 $\mu g/m^3$ would be classified as POOR on the Air Quality Index scale. One could use a $PM_{2.5}$ value of 30 $\mu g/m^3$ as *likely to have a similar air quality level* as a PM_{10} result of 50 $\mu g/m^3$ for that day at that measuring site .

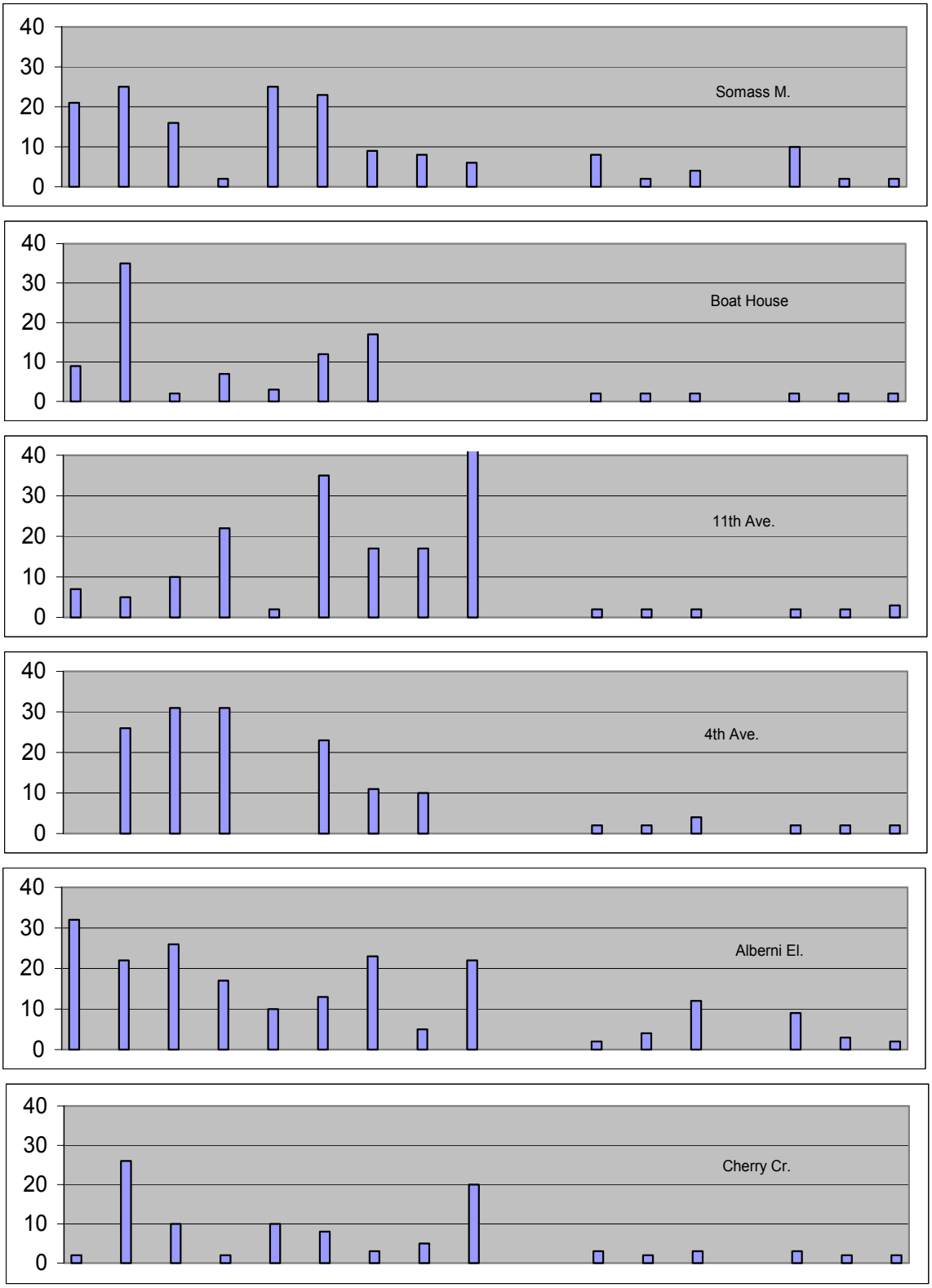
In the research leading up to the CWS, Health Canada also determined a Health Reference Level for $PM_{2.5}$. This was defined as the level at which the relationship between $PM_{2.5}$ ambient levels and statistically significant health effects could be determined in large population studies. They determined that this level was 15 $\mu g/m^3$ (24 hour average).

6.1. November Period

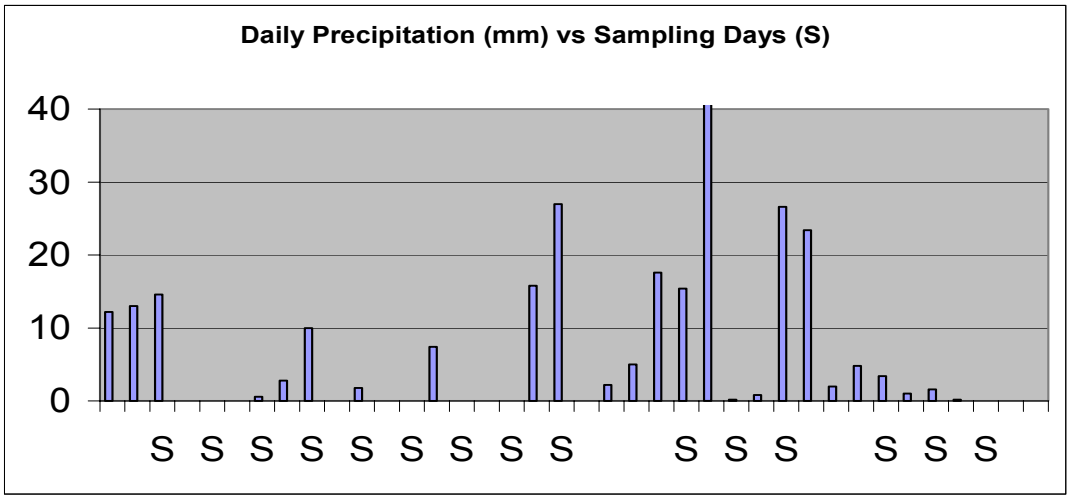
The following graph shows the results for the first period, running from 18 November to 21 December. The schedule was planned to sample every second day (from midnight to midnight). In the intervening day the operator would change the battery and filter. In all, 15 sampling days per site were scheduled; however, logistical problems with the delivery of new filters during the sampling period lead to gaps in the sampling schedule, thus the sampling period extended beyond the expected end day.

The minimum detection level (MDL) for the laboratory analysis is 2 $\mu g/m^3$. Samples reported as below MDL by the lab were plotted here using the value of 2 $\mu g/m^3$.

PM2.5 Sampling Results for Nov 18-Dec 21 (ug/m3, 24hour average)



There is a marked difference between the first half of the period and the last half. Weather records from the Alberni Airport automatic observing system show that the first half of the period had spotty precipitation compared to the last half. The following graph shows the daily precipitation and the days on which sampling occurred (as indicated by the 'S' on the x-axis).



A controlling factor regarding ambient fine particulate matter concentrations is the amount of rain that falls in the day or two preceding the sampling since it takes about that amount of time to wash the particles from the air. This will explain some of the difference between the first half of the period and the last half.

Some emission sources are constant such as larger industrial sources and traffic sources. Some emission sources are weather dependent such as wood stove usage (related to lower night temperatures) and open burning (related to fair weather days) making them more intermittent in nature.

Average maximum and minimum temperatures during the first half of the period were about 6 and 2 ^{o}C, respectively. This would indicate that woodstove usage was probably not a great factor in the results. While late in the open burning season there could still be some sources of large open burning or backyard burning during this period, especially during days of little or no precipitation.

Using the CWS numerical values as a guide, the following table summarizes the sampling results:

Site	Mean	Maximum	No. > 15	No. > 30
Somass	10.8	25	5	0
Boat House	7.5	35	2	1
11th Ave.	12.3[1] / 9.4	57[1] / 35	5 / 4[1]	2 / 1[1]
4th Ave.	12.2	31	4	2
Alberni Elem.	13.4	32	6	1
Cherry Cr.	6.7	26	2[1]	0

Notes: 1- filter was wet, possible interference, second number shown without high value for comparison

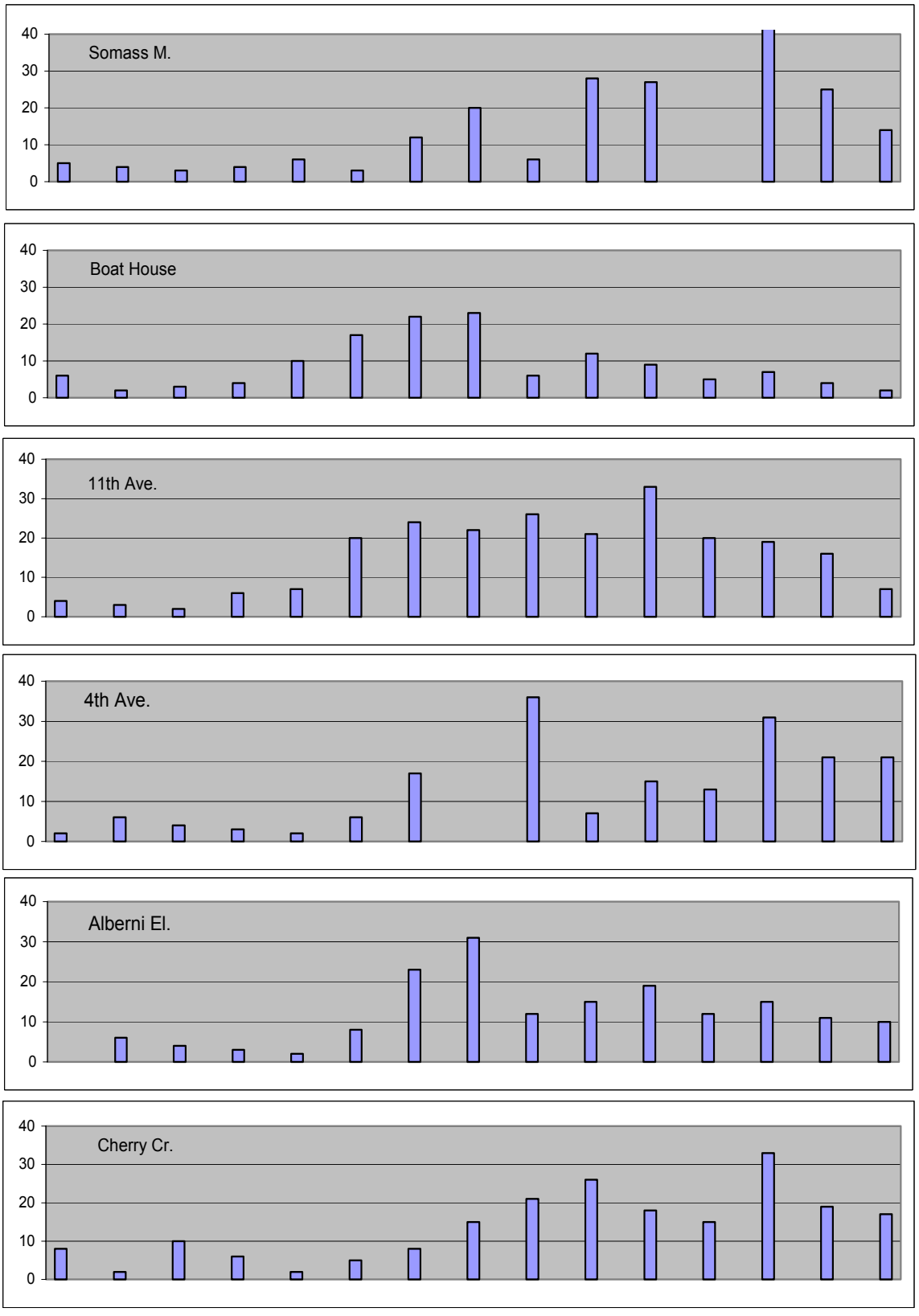
The general pattern in the results seems to reflect the expected levels given the land use around each site. For example during the last half of the period (the rainy part) the only sites that measured values above the MDL was at Alberni Elementary and Somass Motel. Both sites are along the highway which would have continuous near-by emissions regardless of the weather.

Cherry Creek and the Boat House had some of the lowest values (in terms of mean and number of exceedances over 15). Excluding the one questionable result, the higher means and number of exceedances were recorded at Alberni Elem., 4th Ave., and Somass, all sites near highways or commercial areas.

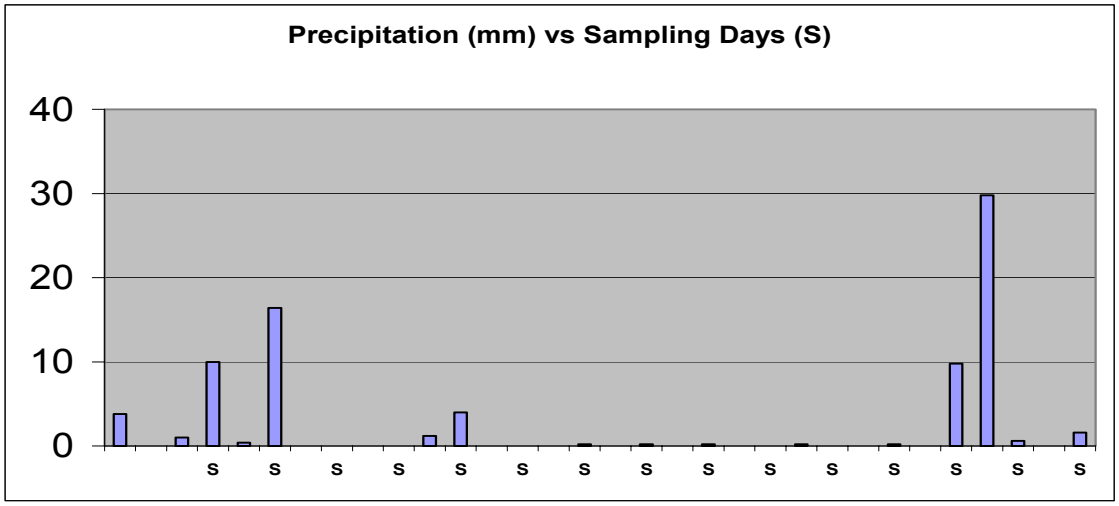
6.2. February Period

The following graph shows the results for the first period, covering the period from 4 February to 2 March. The schedule was to sample every second day (from midnight to midnight). In the intervening day the operator would change the battery and filter. In all 15 sampling days per site were scheduled.

PM2.5 Sampling Results for Feb 3-Mar 3 (ug/m3, 24hour average)



There is a marked difference between the first half of the sampling period and the last half. Particulate levels were fairly low during the first half and began to elevate during the last half of the period; this is opposite in effect from the November sampling period. Weather records from the Alberni Airport show a period of very dry weather during the middle of the sampling period. The following graph shows the daily precipitation and the days on which sampling occurred (as indicated by the 'S' on the x-axis).



During this dry spell overnight low temperatures averaged about -4°C and average highs were about 10°C. While the days were quite warm, the low temperatures at night will have precipitated the use of wood stoves for heating. The sample results at sites near older residences seem to follow the weather pattern, especially at the 11th Ave site.

The following table summarized the results:

Site	Mean	Maximum	No. > 15	No. > 30
Somass	19.8[1] / 12.1	120[1] / 28	6 / 5[1]	1 / 0[1]
Boat House	8.8	23	3	0
11th Ave.	15.3	33	9	1
4th Ave.	13.1	36	5	2
Alberni Elem.	12.2	31	3	1
Cherry Cr.	13.7	33	6	1

Notes: 1- high value (120) is considered valid, operator noted backyard burning near by, second numbers show results without high value for comparison.

Regarding the mean values and number of exceedances over 15 (excluding the one high value at Somass) the sites with the highest values are now at the 11th Ave. followed by Cherry Cr. both in residential areas

and likely having woodstove usage during this period.

Although the one very high result at Somass site was not counted above, it is considered a valid result. The operator noted that some backyard burning had been occurring at a nearby residence during this time and smoke was clearly visible in the area. It gives an indication of what levels can be during this type of activity.

7. Conclusions

A two month fine particulate sampling project was carried out at six sites in and around Port Alberni. Sites were chose to represent different land uses in the community from rural residential to commercial and industrial.

The first sampling month (mid-November to mid-December) was envisioned to capture some of the typical open burning season which usually occurs from October to November, depending on the local weather. The second sampling month (early February to early March) was envisioned to capture times of typical woodstove usage.

While the weather did not totally cooperate, some interesting patterns have emerged.

> The Boat House site (current site of the Permittee monitoring program) is not a good site to measure community wide levels of particulate matter.

> During woodstove usage times residential areas can have consistently higher ambient levels (at least above Health Reference Level) when weather is dry and cold.

> It is possible that the sampling period missed the major open burning season or that on a regional basis there is not a measurable impact from open burning but the one result at the Somass site (where the operator noted that backyard burning was being conducted next door) indicate that high ambient levels of fine particulate matter can occur from this activity in localized areas.

> Sites near highways (Somass and Alberni Elem.) show higher ambient levels at all times due to the proximity of the highway.

> Lack of in town weather data was a problem for more detailed analysis.

> Comparison to the Canada Wide Standard cannot be done with these results due to the long term nature of the standard.

Appendix A

Sample Results

	Results	PM2.5	Concentrations in ug/m3			
	Cherry Cr.	Alberni El.	4th Ave.	11th Ave.	Boat House	Somass M.
18-Nov-04	*2*	32		7	9	21
20-Nov-04	26	22	26	5	35	25
22-Nov-04	10	26	31	10	*2*	16
24-Nov-04	*2*	17	31	22	7	*2*
26-Nov-04	10	10	s	*2*	3	25
28-Nov-04	8	13	*23*	35	12	23
30-Nov-04	3	23	11	17	17	9
2-Dec-04	5	5	10	17	m	8
4-Dec-04	*20*	*22*	s	*57*	m	6
9-Dec-04	3	*2*	*2*	*2*	*2*	8
11-Dec-04	*2*	4	*2*	*2*	*2*	*2*
13-Dec-04	3	12	4	*2*	*2*	4
17-Dec-04	3	9	*2*	*2*	*2*	10
19-Dec-04	*2*	3	*2*	*2*	*2*	*2*
21-Dec-04	*2*	*2*	*2*	3	*2*	*2*
4-Feb-05	8	m	*2*	4	6	5
6-Feb-05	*2*	6	6	3	*2*	4
8-Feb-05	10	4	4	*2*	3	3
10-Feb-05	6	3	3	6	4	4
12-Feb-05	*2*	2	*2*	7	10	6
14-Feb-05	5	8	6	20	17	3
16-Feb-05	8	23	17	24	22	12
18-Feb-05	15	31	m	22	23	20
20-Feb-05	21	12	36	26	6	6
22-Feb-05	26	15	7	21	12	28
24-Feb-05	18	19	15	33	9	27
26-Feb-05	15	12	13	20	5	
28-Feb-05	33	15	31	19	7	120
2-Mar-05	19	11	21	16	4	25
4-Mar-05	17	10	21	7	*2*	14

Notes:
m – missing,
s – spoiled,
blank – sample sent as a field blank,
italic small ‘2’ – result less than minimum detection level