Skeena Region 2008/09

Custom Venting Forecast Program

A partnership between the

B.C. Ministry of Environment and the

Bulkley Valley – Lakes District Airshed Management Society

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1 Abstract

In British Columbia's Skeena Region, forestry continues to be one of the dominant economic activities. Residual woody debris associated with tree harvesting, land clearing and other forestry and agriculture related activities is a major concern mainly due to the associated wild fire hazard. The most common technique practiced today in dealing with this issue, is the piling and burning of wood debris at the location of origin. Due to the high fire danger rating during the spring through early fall months, most open burning activities take place October through December, when atmospheric dispersion of smoke particulates begins to deteriorate.

As a result air quality episodes can arise if open burns are conducted before or during extended periods of poor atmospheric venting. To protect human health and the environment, operators burning under the Open Burning Smoke Control Regulation (OBSCR) are required to ensure that good atmospheric venting conditions exist prior to ignition. Several options are available for operators to determine the venting conditions, one of which is a customized venting forecast (CVF) issued by the BC Ministry of Environment. These spot forecasts have been made available to interested parties by the BC Ministry of Environment for the previous six burning seasons (2003 - 2009) by employing a venting forecaster part time.

This report was prepared under a partnership between the BC Ministry of Environment and the Bulkley Valley – Lakes District Airshed Management Society. It describes and summarizes the custom venting forecast program of the 2008/09 season. It highlights successes as well as challenges in the goal to increase open burning opportunities while simultaneously protecting human health and the environment.

2 Introduction and Background

The B.C. Ministry of Environment initiated an airshed planning process for the Bulkley Valley – Lakes District (BVLD) in the spring of 2002. Community working groups were formed in four communities to identify and address local air quality concerns. The community working groups consisted of approximately 80 stakeholders from a variety of backgrounds including local and provincial government, industry, non-governmental organizations as well as the general public.

One of the goals of the "Community Action Plan for Clean Air" *is to reduce or eliminate air quality episodes attributable to resource management, agricultural and land clearing debris burning*. Strategies designed to meet this goal include education, coordination of burning operations to take advantage of available venting (avoid overloading the airshed) and continued operation of the Resource Management Burning Subcommittee.

A major tool used to assist these strategies is a custom venting forecast (CVF), available to any operator burning in accordance with the Open Burning Smoke Control Regulation (OBSCR). This forecast projects the ability of the atmosphere to disperse smoke particulates over the next three days. The CVF service is offered in addition to the already available general Venting Index (VI), which is issued by Environment Canada (see chapter 2.1). Operators may choose to use either of those two forecasts available.

CVFs were originally offered to stakeholders involved in the airshed planning process in two forest districts (Nadina and Skeena-Stikine). In 2004 a 1-866 number was set up and forecasts were issued to stakeholders and other operators in northwest B.C. as well as the Vanderhoof Forest District. In the 2005 and 2006 burn seasons the service expanded greatly and forecasts were issued to any interested party stretching from the Queen Charlotte Islands/Haida Gwaii to the Cariboo. In the years 2007 through 2009 the program experienced further expansion into the McBride and Okanagan Regions, and further requests were received from the lower mainland and the B.C. south coast. The use of the custom forecasts increased largely due to accelerated harvesting associated with the Mountain Pine Beetle (MPB) epidemic and some companies having developed a significant backlog of slash piles.

Operators burning under the OBSCR need to observe the venting conditions for the actual day of the burn as well as the following day. Atmospheric dispersion for both days are needed since standard slash piles burn and smoulder for 48 hours or even longer (unless piles are extinguished manually). The forecast venting conditions for the day of the burn and the following day must meet the minimum requirements laid out within the OBSCR or a Ministry of Environment air discharge permit. For this reason, a burn contractor usually needs a venting forecast projecting conditions for the next two days, to burn.

Different regions of the province use different techniques to manage emissions from open burning. In the Skeena Region, MOE has collaborated with the forest industry to develop smoke sensitivity zones to assist in management efforts. Most commonly (under the OBSCR) a venting forecast of “Good” on the day of ignition and “Good” or “Fair” for the following afternoon is required for high sensitivity areas such as along major highways and near population centres. (This combination of “Good” and “Good” or “Fair” is commonly referred to as a Good/Good or Good/Fair forecast.) Alternatively, a forecast of Fair/Fair or better is usually required for burning in a low sensitivity area or very small fires from some “fall and burn” operations (as stipulated in authorizations). Some areas outside of the Skeena Region are not divided into high/low sensitivity and thus commonly require at least Good/Fair venting conditions for burning, while others allow open burning under “Poor” venting conditions for up to 3 days.

2.1 Environment Canada’s Venting Index (VI)

Environment Canada’s Meteorological Service of Canada (MSC) issues a venting forecast daily at 7:00AM for the current and next day (see Appendix 10.2 for a sample forecast). MSC forecasts a single venting index for large areas called “Ventilation Zones”, some of which are larger than small European countries. For this reason, MSC’s ventilation index (VI) is considered a ‘general area index’ rather than a detailed spot forecast. The index is also geared towards larger population centres within the venting zones (to protect Canadians) while a huge proportion of slash burns in northern BC are conducted far away from population centres.

Additionally, the MSC venting index is largely determined by weather model output, and strongly influenced by low-level moisture and temperature, two of the most difficult parameters to forecast by any weather model within the planetary boundary layer. Furthermore, the current model input that calculates the MSC venting index does not consider mechanical mixing, a process by which smoke can be distributed by locally high winds through turbulent mixing even against an otherwise thermally stable atmosphere. This process is particularly important along valleys of the central and north coast of B.C., where strong, channelled valley winds occur frequently. While future high resolution weather models will likely incorporate this effect, the current operational models are too coarse (at 15km resolution) to even 'see' it.

As a result this general area index is often either too strict or too lenient for locations that are not well represented either by the weather model's resolution or the average topography within the venting zone. This can unnecessarily restrict burn operators by limiting burning opportunities, or can potentially contribute air quality episodes, which may harm the general public and environment, when the forecast is too lenient.

2.2 The Custom Venting Forecasts (CVF) of the BC Ministry of Environment

To address the aforementioned limitations of the Venting Index (VI) the custom venting forecast program was created to minimize air quality impacts of slash burns on the general population, while at the same time maximizing burn opportunities for operators. Burn contractors may sign up to the program and can obtain custom venting forecasts that are specific to a particular burn site. Participating licensees then may use the venting forecast from the CVF to determine if they can burn according to the rules outlined in the applicable regulation.

The Ministry of Environment in Smithers has created a part time position filled by a venting forecaster, who issues custom venting spot forecasts five times a week before 4:00PM. Since the forecasts are written manually (as opposed to being computer generated) and apply specifically to each spot, this custom venting index has several advantages over the general VI:

1. The forecaster takes the general venting index as a guideline (just like other meteorological parameters) and additionally considers local factors that influence the dispersion and air quality near the burn location. This way the custom venting index is valid for a very particular location and can deviate from the general index.
2. The CVF is issued in the afternoon and applies for burning during the *next* day. This allows operators to make important logistical decisions the day before the burn (rather than being informed the morning of the day the burn is scheduled to take place).
3. The CVF venting index is issued for three days rather than only two. This way operators get a 'heads up' about venting conditions for the second day, which

gives even more time to prepare, but puts additional workload on the forecaster to be consistent from day to day.

4. Since the forecaster is available for phone consultations during work hours, some operators take advantage of this to get a heads up as far as a week ahead. This interaction has also proven to be a very powerful tool for feedback, which can be instrumental, since verification of the forecast is otherwise impossible. Forecast verification is also crucial for the forecaster to improve skill.
5. The venting forecaster can use discretion in a situation that is poorly defined meteorologically: Often meteorological conditions are not clearly showing a "burn" or "not burn" scenario. Under these conditions, the forecaster could make a judgement-call to give a favourable or unfavourable forecast for the burn contractor. An example would be a marginal condition under which usually a 'no burn' forecast would be issued, but the forecaster is very confident that the wind will be blowing the smoke into uninhabited areas and will not linger. As a result, of high confidence in the wind direction a favourable forecast can be issued especially if only a small number of piles are to be burnt. In contrast, an unfavourable forecast could be issued due to a high confidence in a wind direction that would transport smoke into a nearby community, despite otherwise good or fair venting conditions.
6. Burn operators can choose to abide by the general index OR the custom venting index. Most contractors who have experienced advantages of CVFs begin to rely solely on this program within one burn season, which is encouraged by the ministry.

2.3 Partners and Funding

Clients receiving custom venting forecasts range from large forestry companies to small-scale operations and private land owners. The larger licensees in the Bulkley Valley - Lakes District receiving CVFs are: Canfor Houston, Pacific Inland Resources (PIR), Houston Forest Products (HFP), Babine Forest Products (BFP) and the Burns Lake Community Forest. British Columbia Timber Sales (BCTS) also receives CVFs.

Smaller clients either contact the Ministry of Environment individually for CVFs or obtain them through a group-forecast issued to local woodlot associations. Currently the Nadina and Bulkley Valley Woodlot Associations subscribe to the service.

Not all operators can burn under the OBSCR and may need to apply for special burn authorizations. These authorizations often contain conditions, which explicitly mandate the use of the MoE CVFs. These clients range from Regional Districts (who conduct burns at landfill and transfer stations) to industrial permitees burning wood waste on facility sites.

Funding for the CVF program comes from a variety of sources. All forestry clients are contributing proportional to their annual allowable cut, based on the formula "Cost = AAC x 0.0015 per m^3", while the remaining costs are covered by MoE, and other special funding programs (including the "Woody Debris Management Program" and the Mountain Pine Beetle initiative).

3 Methods

Any smoke dispersion forecast or venting index is a combination of horizontal transportation (wind) and vertical dispersion (thermal stability of the lower atmosphere, mixing height, etc.) that is consistent with the lower atmosphere's ability to disperse smoke particulates. While a great part of the forecast itself is input from weather models from national agencies like the Meteorological Service of Canada and the US National Center of Environmental Prediction (NCEP), it is not within the scope of this report to show how these model outputs are altered by human intervention to fit a particular location.

Meteorological resources for up to date data are readily available on the internet and some data and software was supplied via a secure connection to Environment Canada's client network.

The overall goal of the forecaster is to find out how the reality over British Columbia's mountainous terrain differs from raw weather model output with respect to wind and vertical stability of the atmosphere. Once this is determined, the forecaster computes the venting index from an empirical equation outlined in chapter 10.1.

Apart from the scientific evaluation, the venting forecaster usually applies a certain amount of discretion to a spot forecast that includes the following considerations:

- Proximity of year round residences to the burn with high winds and uncertain wind directions; and/or lack of any residence within a large radius of the burn
- Smoke funnelling in narrow valleys
- Amount of particulates already contained in the airshed and number of piles to be burned
- Nature of the burn (e.g. slash pile burning versus "fall and burn")
- Long weekends, holidays and other public celebrations that may be impacted by the burn
- History of complaints and infractions by a burn contractor

Due to this discretion, the forecaster may issue venting forecasts that differ from the general venting index.

During the 2008/09 season forecasts were issued from Sunday through Thursday to accommodate burn operators' logistics until mid December. By then, most burning activities had been concluded and forecasts were issued from Monday through Friday. No amendments were issued and the CVF issue deadline was 4:00PM to accommodate next-day-planning for licensees.

Individual spot forecasts consist of a text document containing a general synopsis of the current weather scenario and one table for each spot forecast that contains the resulting categorical venting indices as well as a mixing height and wind forecast (See Appendix 10.3). At some point after issuing the forecast, the parameters are entered into a database (MS Access) for an end of season analysis.

4 Venting Forecast Statistics

4.1 Methods

For the 2008/09 season a MS Access database was populated with date, licensee, lot, and venting categories of each spot forecast. Different queries and filtering techniques (SQL) were used to prepare most tables shown in this report. The underlying data was tabulated daily throughout the season: After every CVF issue, the forecasts were electronically copied and archived in a separate database, For further analysis, the venting requirements stated in the OBSCR (or authorization) at each location was recorded and related to each spot forecast. This way the data could be analysed for “open” or “closed” burn days at each separate location as well as forecast consistency from one forecast date to the next.

Actual burn statistics were obtained via e-mail from the largest licensees (mentioned in Section 2.3), who diligently keep track of their burn activities with dates, locations, number of piles, etc. Other burn activities were compiled from information obtained the Ministry of Forests and Range burn registration database. This database did not contain actual burn dates, but the registration date was cross referenced with the venting index (MSC) to assume that the burn took place at the time of ‘the next favourable forecast’.

4.2 Basic Statistics

Table 4-1 illustrates some basic statistics of the CVF service and Table 4-2 shows the corresponding data obtained from the Ministiy of Forests and Range’s burn registration database. The custom venting season started in 2008 with the first CVF on September 28 and continued until March 26, 2009. Forecasts were issued five days a week (Sunday through Thursday) during the main burn season (until December 18, 2008) and Monday through Friday thereafter. Exceptions were statutory holidays, Christmas week and occasional outside obligations of the CVF forecaster.

Start Day of CVF Service	2008-09-28
End Day of CVF Service	2009-03-26
Total Number of CVF Issued	2242
Total Number of Days for which CVFs were issued.	105
Number of piles burned by “Big 5”	22544
Number of burns by "Big 5"	584
Number of piles burned using CVF (only larger contractors submit burn numbers)	> 23539

Table 4-1: Basic 08/09 Statistics of the CVF program.

During this time the CVF forecaster issued forecasts on 105 days a total of 2242 spot forecasts. The number of forecasts issued is summarized by Venting Zone and month in Table 4-3.

Start Day of MoF Registered Burns	2008-08-20
End Day of MoF Registered Burns	2009-03-06
Total Number of Registered Burns with MoF	665
Total Number of Piles Burned under MoF Registry	Between 18517 and 66777
Number of Registered Burn Operators/Contractors	168

Table 4-2 Basic 2008/09 MoF Burn Registration Statistics

The exact total number of piles burned in the Skeena Region is unknown, due to nature of the registration procedure (see chapter 7.2). The burn registration database of the Ministry of Forest and Range allows us only to say that between 18517 and 66777 piles were burned – a rather large range, that does not allow for detailed conclusions to be drawn. .

EC Venting Zone/Month	9-2008	10-2008	11-2008	12-2008	1-2009	2-2009	3-2009
Burns Lake	20	376	248	102	85	4	15
McBride	4	20	6	0	0	0	0
Okanagan	0	33	41	9	0	0	0
Prince George	2	32	19	12	2	0	0
Smithers	64	340	138	36	54	9	23
Stewart	24	75	33	0	25	0	0
Terrace	0	102	62	26	31	9	10

Table 4-3 CVF Issued by Venting Zone and Month

The five largest licensees that signed up with the CVF program (described as 'Big 5' in the tables), burned a total of 22544 piles on 584 occasions during the burn season.

Month	Number of CVF Burns by the "Big 5"	Number of Piles Burned by the "Big 5"
9-2008	4	665
10-2008	318	14472
11-2008	93	3001
12-2008	31	617
1-2009	19	230
2-2009	0	0
3-2009	1	102
4-2009	0	0

Table 4-4 Burns and piles burned by the five largest clients of the CVF program.

4.3 Burn Opportunities Created by the Custom Venting Program

As the Ventilation Index (VI) issued by MSC is a ‘general area index’, it is often either too strict or too lenient for locations that are not well represented by either the weather model or the average topography within the venting zone. This either deprives burn operators of valuable burning opportunities or causes potentially harmful air quality episodes. As a result the CVF program was established to address these two main goals:

1. Open up burn opportunities when the MSC venting index is too strict, helping burn contractors to complete their burning within one season and thus reduce wildfire hazards.
2. Close burn opportunities when the MSC venting index is too lenient to prevent episodes of poor air quality and associated impacts to human health.

A major benefit for burn contractors to sign up to the CVF program is that the net effect of those two goals have always resulted in an opening of burn opportunities. At the same time, the B.C. Ministry of Environment aims to decrease any health risks to British Columbians.

To illustrate the effect of the CVF compared to the VI, Figure 4-1and Table 4-5 show the total number of CVF which either

- agreed with the VI to not allow burning (“closed days”),
- did not allow burning while the VI would allow it (“CVF closed”),
- did allow burning while the VI would not allow it (“CVF opened”) or
- agreed with the VI to allow burning (“open days”).

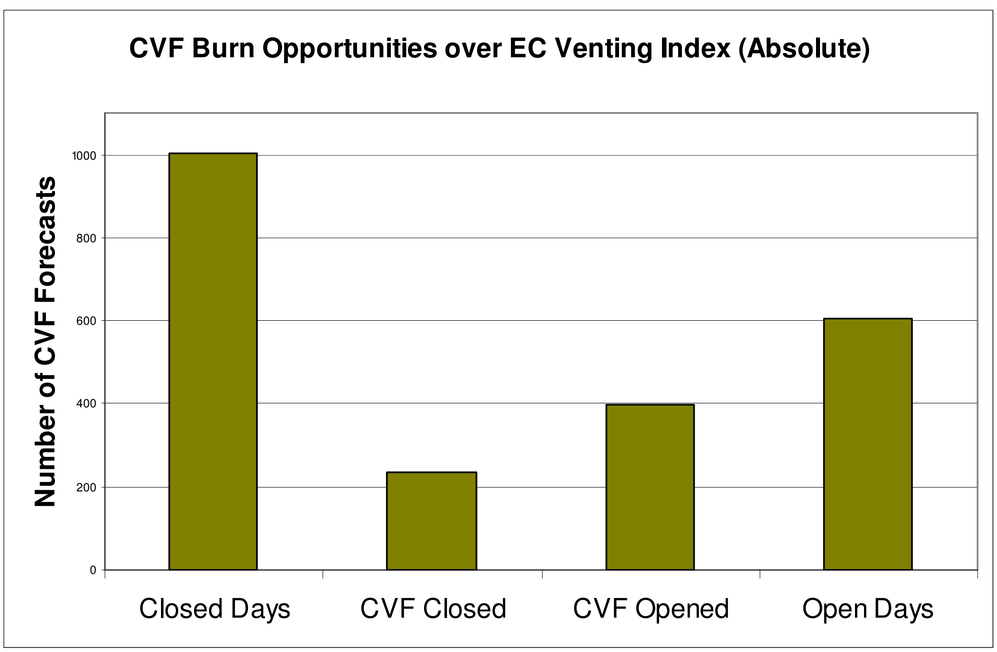

Figure 4-1 Total Opened and Closed Burn Opportunities

The sum of "Closed Days" and "Open Days" constitute the total agreement of CVF with VI forecasts and amount to 71.7% of all issued forecasts. This underlines the value of the MSC venting index. At the same time, it leaves a large number of forecasts (~ 28%) where an improvement can be made by the CVF forecaster with respect to either opening burning opportunities or protecting public health by restricting burning activities.

	Number of CVF	Percentage
Closed Days (CVF and VI do not permit burning)	1003	44.7%
CVF Closed (EC permits, but CVF does not permit burning)	237	10.6%
CVF Opened (CVF permits, but EC does not permit burning)	397	17.7%
Open Days (CVF and VI do permit burning)	605	27.0%
Total:	2242	

Table 4-5 Total Opened and Closed Burn Opportunities

Overall, the increased burn opportunities far outweighed the days the CVF closed. 17.7% of all CVFs enabled contractors to burn on days when they were otherwise not permitted. This constitutes an additional 397 burn opportunities in the season. On the other hand, 10.6% of the custom forecasts closed burn opportunities that would have been available under the VI forecast. At this point, the "CVF closed" days do not necessarily affect burning operations, as operators are permitted to burn under the VI forecasts. At the same time, the CVF program closed these days for the protection of public health (see also chapter 5.3.2). Operators, who followed only the CVF forecasts, still had a net advantage of 160 additional burn opportunities compared to operators not participating in the program.

The strength of a manual forecast (CVF) over the computer generated venting index is particularly easy to illustrate over complex terrain, where current state-of-the-art weather models still have problems resolving terrain, and automated forecasts suffer in accuracy (see 'technical caveats of a venting index' in chapter 7.3). It is here where the knowledge and experience of a forecaster can make a major difference. Figure 4-2 illustrates the same opening and closing statistics as Figure 4-1, but restricted to the Stewart and Terrace venting zones. These venting zones are traditionally difficult to forecast for because of the mountainous, coastal topography containing deep valleys that trap pollutants and channel strong winds. Additionally, venting conditions in this area are frequently poor (especially in the winter) as most burn locations are at low elevations and often close to, or upwind of, population centres. As a result, more than half (about 55%) of the 2008/09 CVF forecasts did not allow burning in this area. Additionally 30.7% of all issued CVF for this zone disagreed with the automated VI and opened up burn opportunities that would otherwise not have been available. This constitutes 122 burn opportunities that were created by the CVF program, while no air quality advisories had to be issued for these zones.

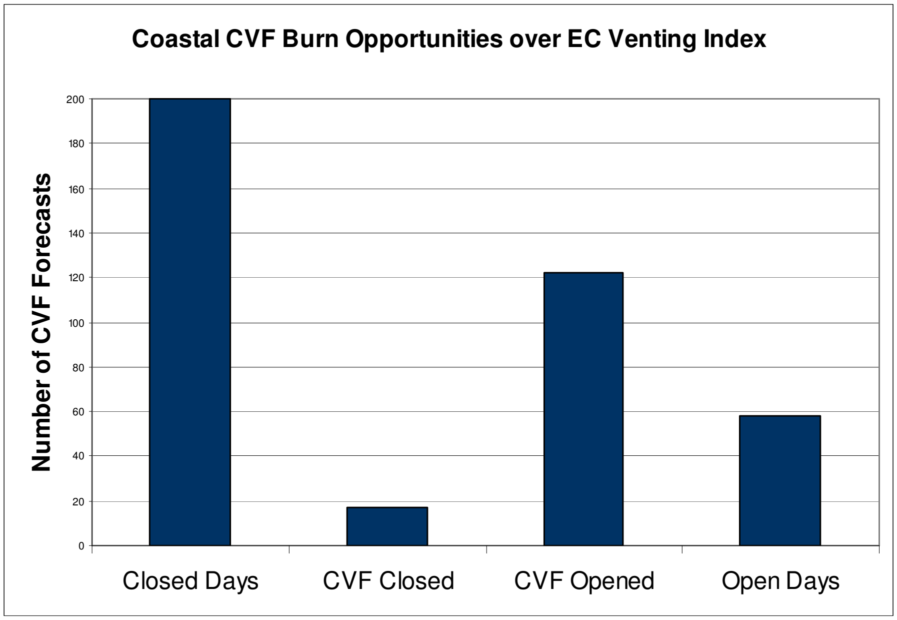

Figure 4-2 Opened and Closed Burning Days at the BC North Coast.

It should also be noted that burns in coastal areas are generally small (<100 piles) and thus less likely to have an impact on the airshed. Therefore, the forecaster can often take a 'greater risk' and open up burn opportunities that would not be possible with larger burns. Due to the topography of this region, the risk of airshed overloading would become much higher if burn pile numbers were increased. As a result, the percentage of favourable CVF forecasts would not be as prominent if significantly more piles were being burned in these areas.

4.4 Forecast Consistency

Another advantage of the CVF over the VI is that it provides a 3-day forecast (the VI contains only 2 days). According to the OBSCR, most operators are only allowed to burn when *two consecutive* days fulfill the minimum venting requirements identified in the regulation. Therefore, a 3-day forecast contains not only the information for burning on the coming day, but it also provides a 'heads up' for burning the day after that.

Operators expect that this forecast will not change from one day to the next (stay consistent), otherwise they might move equipment and personnel in anticipation of a burn day, only to find that on the day of the burn, the venting forecast does not allow it. On the other hand, an operator may be surprised by a favourable forecast without being prepared to burn. As a result, it is critical for the CVF to be as consistent as possible.

All custom venting forecasts were analysed on this categorical basis. (e.g. a change from a poor/poor forecast to a good/fair forecast usually indicates a categorical change from 'burning not permitted' to 'burning permitted'). As part of the consistency analysis, each forecast was also analyzed for consistency of its daily venting conditions. This indicates whether the forecast for a particular day has changed at all. From a burn operator's perspective, this consistency is not very important. It can highlight, however, times of high or low confidence of the forecaster. The categorical consistency shows changes in confidence only very crudely, since a daily change does not necessarily mean a categorical change. (e.g. a forecast change from good to fair is not consistent, but might not impact the permission to burn).

4.4.1 Categorical Consistency

As the forecaster prepares a forecast, the previous day's forecast is used as a starting point. This way the forecaster has a direct way of ensuring that yesterday's forecast will not change significantly. At this point, the forecaster often has to weigh consistency against the change in weather models, and decide whether to change a forecast or not. This is reflected in the overall categorical consistency of the custom venting forecasts (over 83%). This shows a very high reliability of the forecast and underlines why operators depend on the forecast and use it for their planning.

A forecaster might be more comfortable switching categories from 'no burn' to 'burn' than vice versa, since the latter has a larger negative impact on operators. As a result, this will often show up as a slightly pessimistic bias for the day 3 forecast, because the forecaster would rather improve the forecast the next day (which happened in 8.9% of forecasts) rather than worsen it (7.9% of all forecasts) and cause a logistical challenge for operators.

Figure 4-3 illustrates the categorical consistency of CVFs, summarized by venting zones. Green bars indicate percentages of consistent forecasts, yellow bars show the forecasts that changed from 'burn' to 'do not burn' ("close down") and the blue ones show the opposite ("open up"). Almost every venting zone shows a slightly higher percentage for 'opened up' forecasts as opposed to 'closed down' indicating the bias mentioned above. One 'outlier' in this regard were high elevation forecasts in the Okanagan zone, where climatologically good venting is much more frequent than poor venting. As a result, day 2 and 3 forecasts where slightly more optimistic than in other zones.

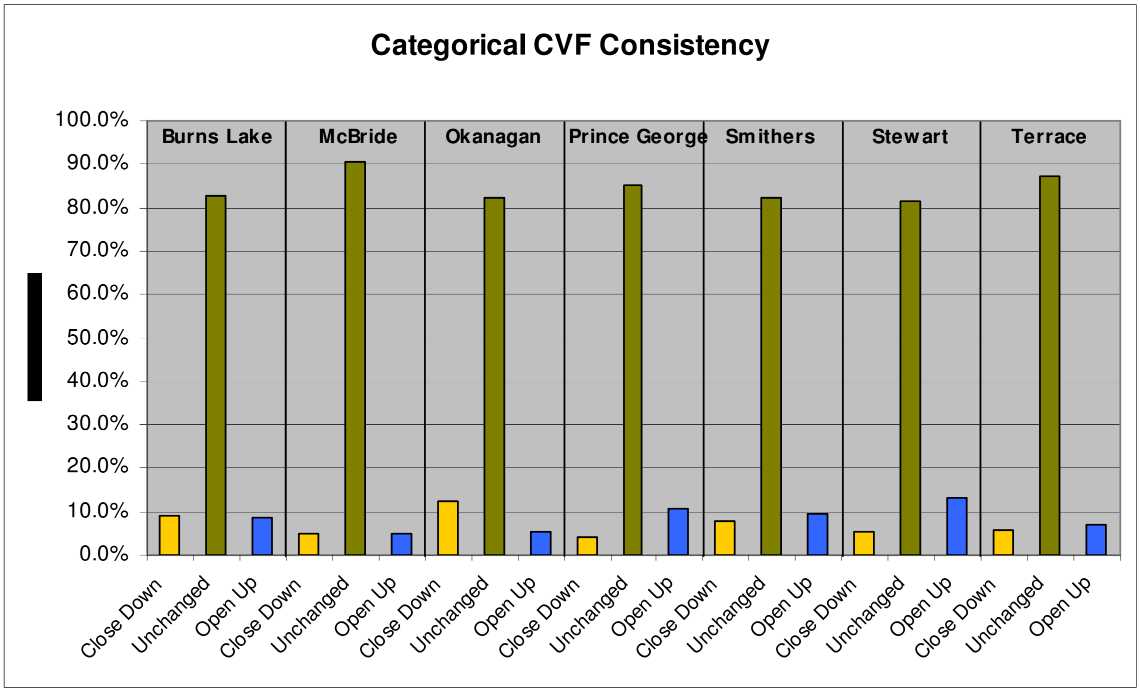

Figure 4-3 Categorical CVF Consistency by Venting Zone

Note that a high consistency does not necessarily correlate with good forecasts nor 'opened opportunities'. High consistency values are more commonly correlated with either a very high or a very low degree of confidence, since the forecaster is more likely to issue a 'low-risk-forecast' when the confidence is low. The McBride Venting Zone is a good example, where the high consistency comes about due to a very high confidence in 'poor' venting. The only forecast location in this zone was in a valley location, that only gets very few sunshine hours per day (causing low mixing heights) and also experiences few wind storms due to its location far inland. As a result generally 'poor' forecasts were issued with high consistency.

4.4.2 Daily Consistency

While day to day consistency of the venting categories Good/Fair/Poor is only of limited operational importance to most operations, it gives some insight into the confidence of the forecaster as well as the day-to-day-variability of the forecasts and weather models. Daily consistency can also be compared to the largely automated VI from Environment Canada to see if a degree of improvement can be achieved by manual input.

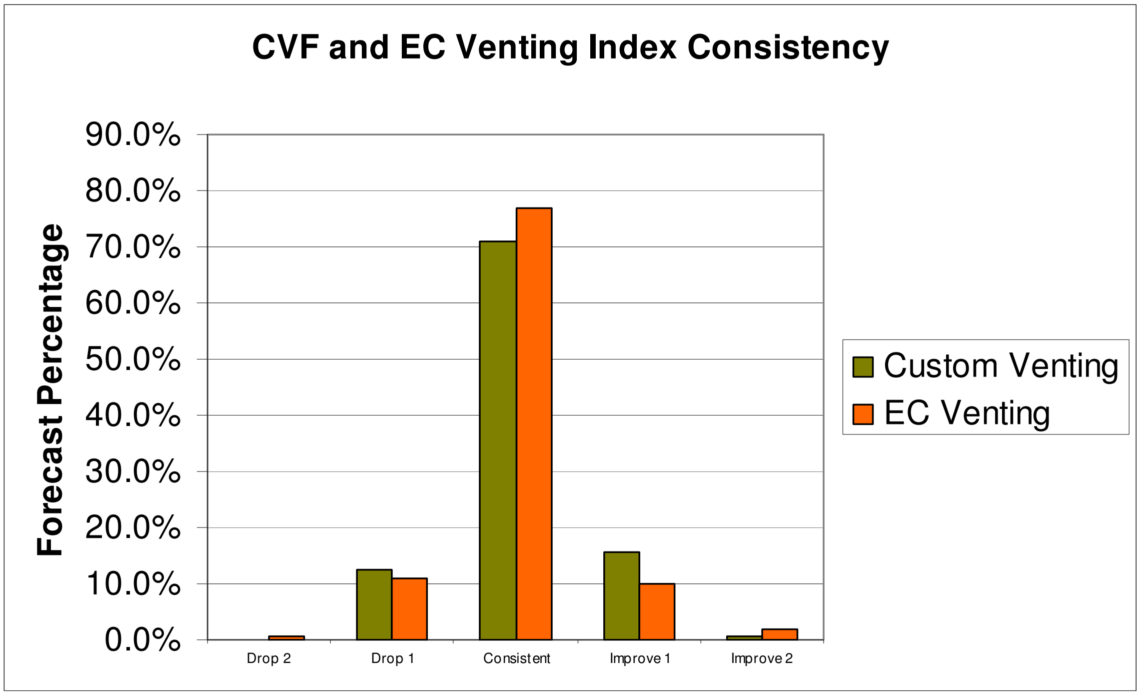

Figure 4-4 Daily CVF and EC Forecast Daily Consistency

Figure 4-4 illustrates this consistency for both venting forecasts.

- "Drop 2" means a downward change by two categories (Good to Poor),
- "Drop 1" means a downward change by 1 category (Good to Fair or Fair to Poor),
- "Consistent" means no change between successive forecasts and
- "improve" categories mean the reverse of "drop" categories.

A consistency of over 70% was reached by both forecast providers, with the EC Venting Index being slightly more consistent. While the difference in daily consistency is largely negligible between the EC and CVF program, there are subtle differences in the drop/improve categories that are worth highlighting.

While the EC venting index is largely computer model output, it tries to be as consistent as possible from day to day. The manual forecaster (CVF) on the other hand tries to avoid a jump over two categories as it would indicate low confidence in the forecast. This can be seen by the fact that the "Drop2" and "Improve2" Categories are lower for the CVF. As a direct result, the "Drop1" and "Improve1" of the CVF are slightly greater compared the VI. Additionally, a daily fine-tuning of yesterday's forecast in the CVF program resulted in lower consistency compared to the EC VI, as the CVF is aiming at categorical consistency (and its operational implications) and "fine-tuning" of forecasts is encouraged. This fine-tuning resulted in higher percentages in the drop/increase 1 categories as seen in Figure 4-4. The consistency of the EC VI is dominated by the consistency of two successive weather model runs. This consistency is commonly quite high as a huge amount of model output data from one model run is used to initialize the next model run.

5 Burning, Venting and Air Quality

5.1 The Poor Venting Season: Mid November until Mid March.

Atmospheric conditions favourable for burning depend on direct solar insolation (a measure of solar radiation energy received on a given surface area in a given time) and wind. Wind is a highly variable parameter that is mostly dictated by storm cycles crossing the north coast and northern B.C. Insolation causes daytime heating of the ground, gradually eroding night time inversions to create vertical mixing which helps smoke dispersion. As the burn season progresses into the winter months, increased night time cooling will create ever deeper inversions which are more and more difficult to erode by the decreasing daytime radiation (shorter days and decreased sun angle). Eventually daytime heating through insolation alone will rarely break the night time inversion and become almost ineffective for vertical mixing. The onset of this event is marked by a sharp seasonal decrease in venting conditions in the fall. The exact date of it depends strongly on latitude and can be masked by storm cycles that might increase dispersion due to wind late into the season.

In northern B.C. (north of latitude ~53˚N), this sharp venting decrease is traditionally near the middle of October. Favourable venting conditions, especially over the interior of B.C., become the exception after this date.

Figure 5-1 illustrates the relative number of spot forecasts with favourable venting conditions, summarized for each week of the year. The average probability of receiving a favourable venting forecast fell drastically from above 60% in September and October 2008 (week 43, the third week of October) to near 10% thereafter (during week 44). Later in the season, three marked storm cycles provided good venting opportunities, while the remaining 11 weeks of the season (weeks 44 of '08 to week 9 of '09) averaged a favourable venting rate of less than 25%.

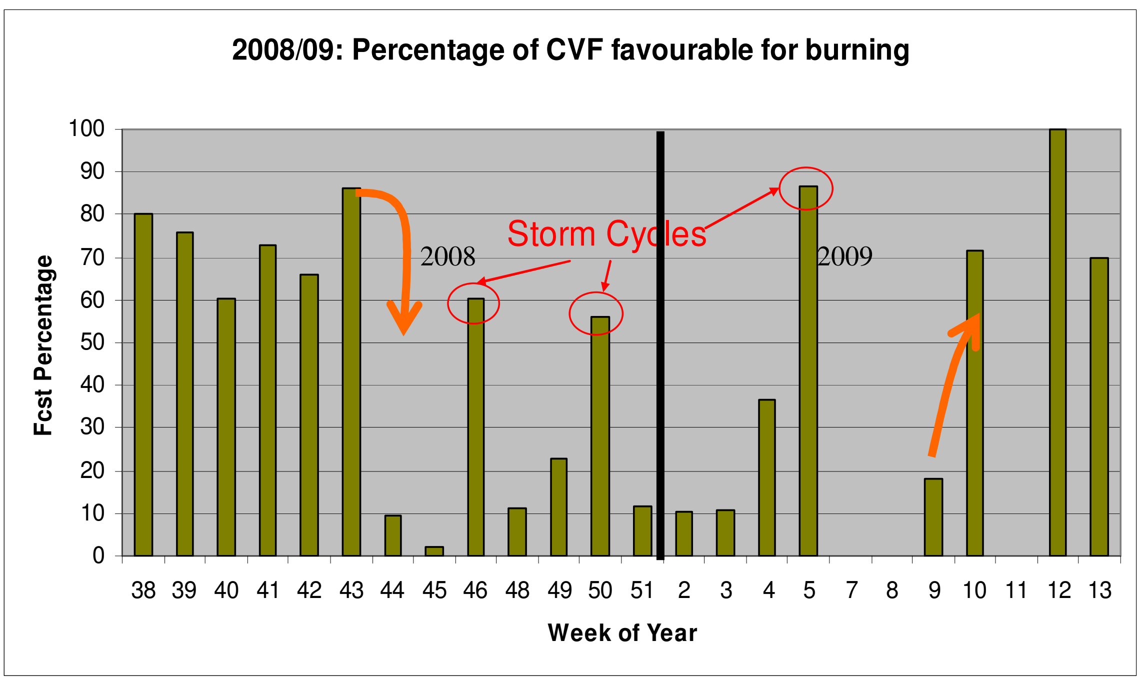

Figure 5-1 Percentage of CVF that were favourable for burning (2008/09 season).

Another major factor in the reduction of mixing heights in the winter is the drastic change in reflection of direct sunlight ("albedo") after the first significant snowfall of the year. Once snow covers the ground, a large part of the sunlight reaching the ground is reflected back to the atmosphere. As a result, daytime hearing and mixing heights are strongly reduced once snow covers the ground. In the 2008/09 season the first significant snowfall was on November 14th (more than 25cm in 24 hours in week 46) which was after the venting had already deteriorated.

This is consistent with the findings from last year's season (Figure 5-2), which illustrated that during the months of November through February venting conditions are predictably so unfavourable in northern BC, that open burning should be generally discouraged and operators should be strongly encouraged to finish any open burning by the end of October.

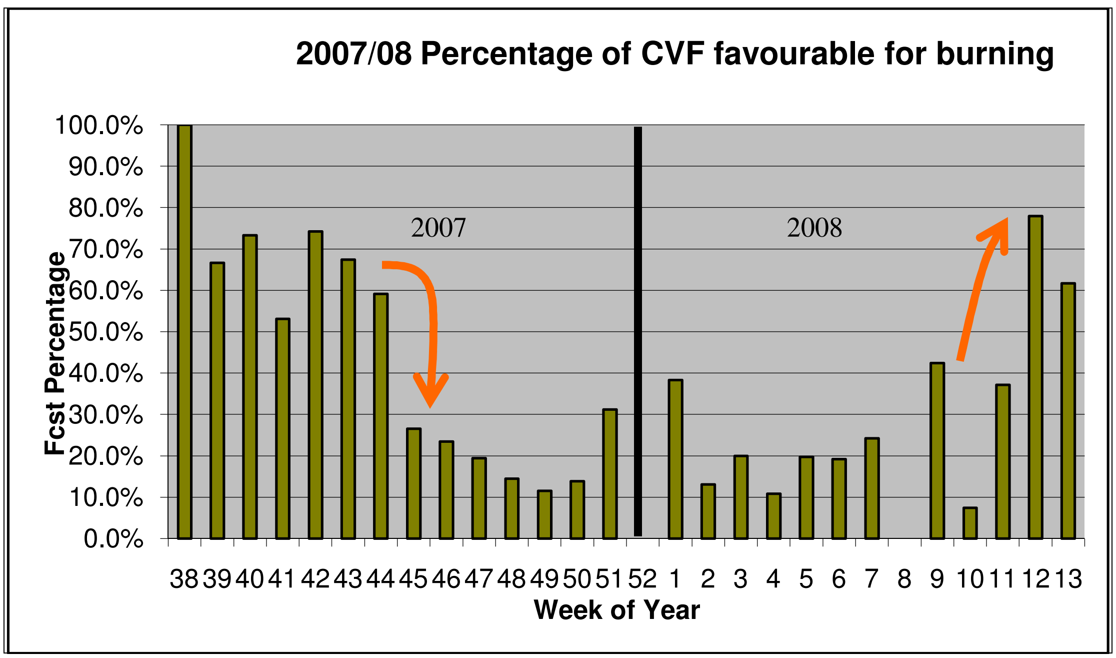

Figure 5-2 Percentage of CVF that were favourable for burning (2007/08 season).

It is crucial for burn contractors to understand this drastic reduction of atmospheric dispersion. Being prepared for this effect and burning early in the season will reduce smoke loading of the airshed later in the year, when it is more vulnerable, and will save burn contractors' money for standby personnel and equipment. Of course, this issue has to be reconciled with after-summer-workload of contractors as well as elevated wildfire hazards late in the season due to dry fall weather.

The same phenomenon likely occurs in southern British Columbia, although good venting conditions may be expected to prevail further into the fall and improve earlier in the spring by days if not weeks.

5.2 Open Burning in the Skeena Region

The 2008/09 burn season had a rather slow start, as even higher elevations remained too dry for slash burning until the end of September. In fact some high elevation test burns in the middle of September had to be extinguished due to fast spreading of flames into the cut block. Once fuel was wet enough, venting cooperated for almost 4 weeks straight. This resulted in large numbers of piles being burned during most of October (see Figure 5-3: weeks 41-43). During this period, several anecdotal reports were received from the Burns Lake venting zone that indicated that the airshed may have been close to an overload. Air quality measurements, however, remained acceptable during this time and no air quality advisories were issued.

Increased open burn activity can also be seen in February (weeks 5 and 7) and March (weeks 11 onward) of 2009. These increases are significant considering the generally unfavourable venting conditions during this period. Although they are small, compared to what was taking place in the fall, these burn activities can still overload the airshed in a vulnerable season. Large burns this late in the season are good examples of where the Custom Venting Program can help minimize the potential risk to human health.

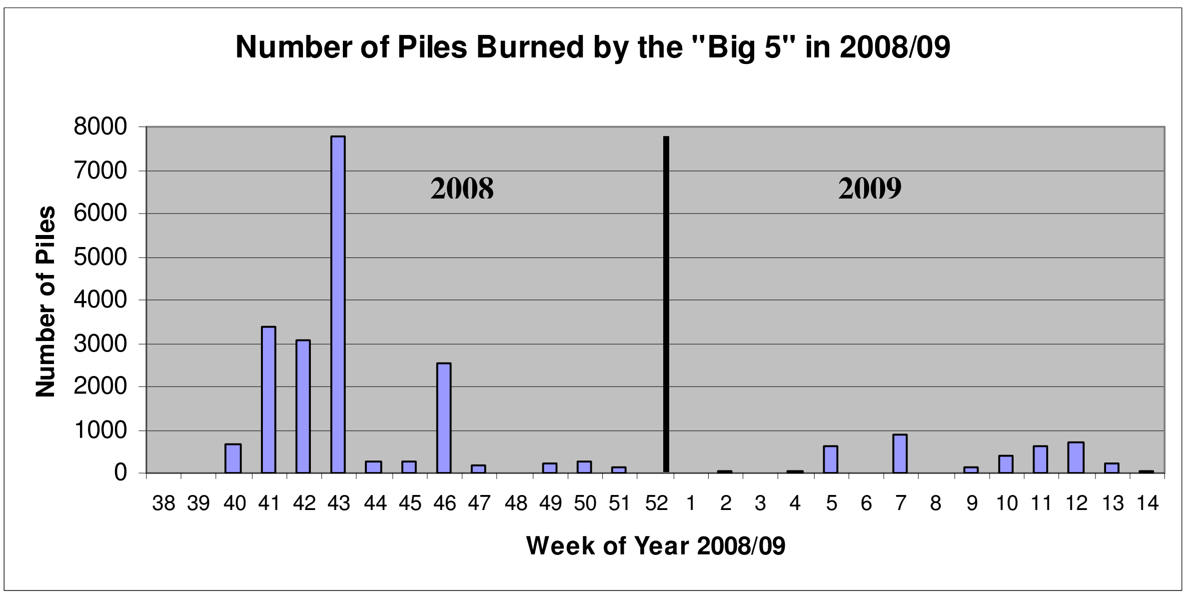

Figure 5-3 Number of slash burns conducted by the "Big 5" in fall/winter of 2008.

5.3 Air Quality Statistics

The CVF program is an important tool used to prevent poor air quality episodes. While the absence of poor air quality during a winter season may be due to any combination of lower emissions, higher storm activity and influence of the CVF program, a presence of air quality episodes may point to a weakness within the CVF program. For this reason a screening overview of air quality statistics is presented.

Poor air quality results from a combination of three factors: Emission sources, topography and weather (see Figure 5-4). Each of these ingredients influence air quality through a number of parameters:

Emission Sources:

- Home heating (wood stoves, etc.)
- Industrial open burning
- Industrial permit burning
- Industrial stack emissions
- Industrial machinery and vehicles
- Backyard open burning
- Private motor vehicles
- Road sweeping

Topography:

- Trough/Ridge location
- Degree of confinement within a trough/ridge
- Elevation
- Aspect
- Upslope/downslope of a community/receptor
- Distance to community/receptor
- Exposure to weather parameters (i.e. upslope precipitation etc.)

Weather:

- Vertical temperature gradient
- Wind direction
- Wind speed
- Vertical wind shear
- Turbulence (mechanical)

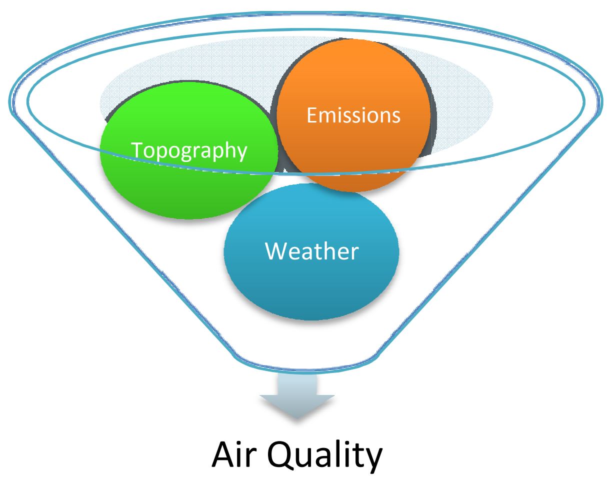

Figure 5-4 Parameters influencing Air Quality

Based on the Draft BVLD Emissions Inventory for 2001 and 2002, approximately 50% of total annual PM2.5 emitted were from open burning sources (large licensees, small licensees and permitees; see Figure 5-5). Since some beehive burners have seized operations since then, it is assumed that the, 2008/09 contributions are not significantly lower today.

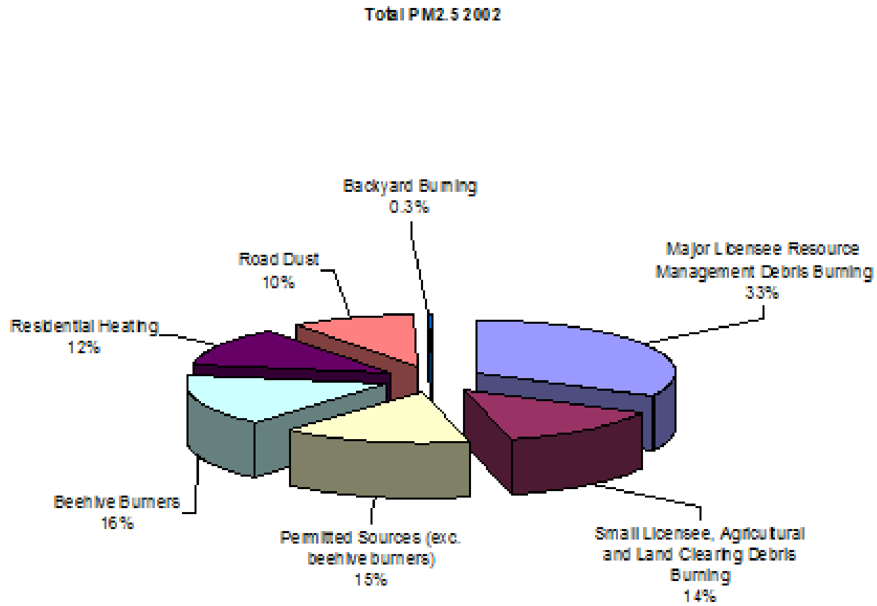

Figure 5-5 PM2.5 Emission Sources from the 2001/2002 Emissions Inventory

Additionally, how a person is affected by poor air quality, depends on a number of variables such as expectations (e.g. a rural person versus an urban observer), the state of health of the person (particularly with respect to pulmonary organs) and age.

The above considerations illustrate that any episode of poor air quality, especially over the mountainous terrain of B.C., is rarely tied to one factor alone.

5.3.1 Air Quality Advisories

Air quality advisories are issued in B.C. when ambient air quality concentrations exceed criteria for a specific pollutant. For $PM_{2.5}$, the main constituent of smoke from wood combustion, the threshold is a 24-hour average concentration of $25 \mu g/m^3$. When an Air quality advisory is issued the B.C. Ministry of Environment has the ability to curtail emissions of particulate matter by restricting open burning.

Figure 5-6 shows the number of air quality advisories issued in the Skeena Region between 1995 and 2009 by month in colour coding. During this period, advisories have been issued in every month except for June, with more intense episodes (ie. more than 10 days) occurring between November and April.

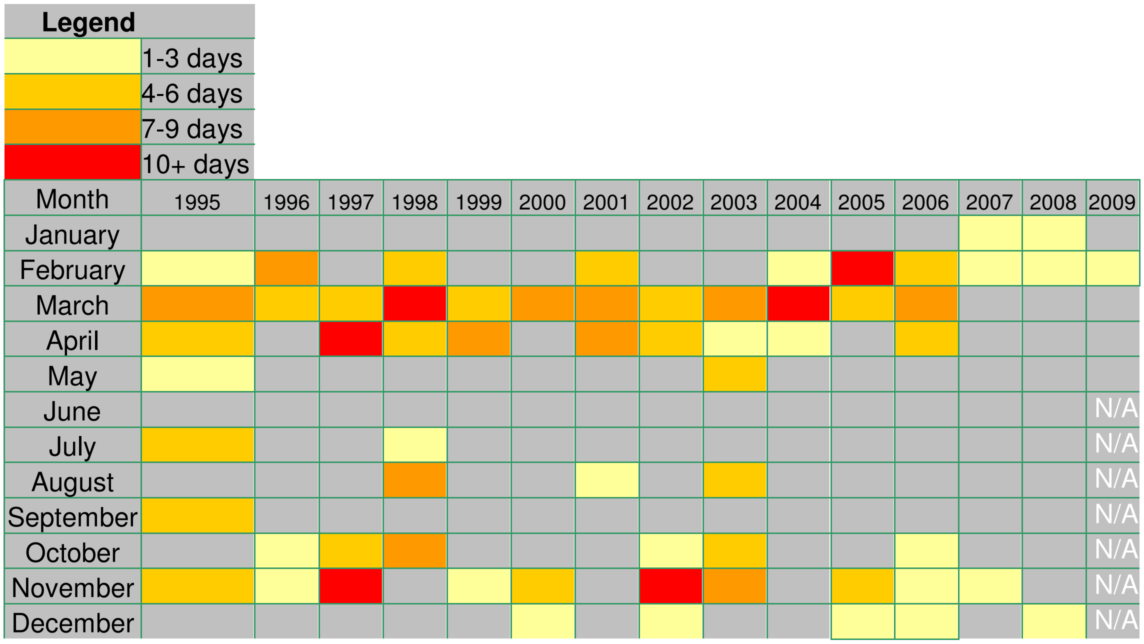

Figure 5-6 Number of Days with Air Quality Advisories in the Skeena Region between 1995 and 2009

While the 2007/08 season was a particularly good season, it was surpassed by the 2008/09 season, which saw only three days of advisories in December 2008 and two days of advisories in February 2009. This success was partially due to a very good start to the burning season, with generally very good atmospheric venting throughout September and October (during which time burn contractors could burn the majority of their piles). CVFs did help to maximize burn opportunities without overloading the airshed during this time (note that no advisories were issued during the prime burning month of October). Additionally, due to the early readiness of contractors, , few piles needed to be burned after November and only isolated air quality episodes were recorded during the winter months. In the last three years (since May 2006), the Skeena region did not record any months with more than 3 days of air quality advisories. This suggests a significant and persistent improvement of the air quality in the Skeena region. It is unlikely that a 3-year persistence of improved air quality is due solely to weather cycles and possibly in part due to change in the nature of emission sources. Changed burn behaviour due to an effective co-operation between burn operators and the CVF program of the B.C. MoE, has likely had a large impact on improving air quality. A comprehensive study of air quality data, which is not within the scope of this report, would be needed to quantify this trend.

Table 5-1 shows the Air Quality Advisories were issued in 2008/09, in chronological order.

Bulletin Issued	Date Valid	Week of Year	Remarks
Air Quality Advisory	December 15-16,2008	51	Mandatory Emission Reductions for Burns Lake, Smithers, Houston,Telkwa and Hazelton
Air Quality Advisory	December 18-20,2008	51	Mandatory Emission Reductions for Burns Lake, Smithers, Houston,Telkwa and Hazelton
Air Quality Advisory (Road Dust Bulletin)	February 19-22, 2009	8	RDB issued for Smithers, Burns Lake, Houston and Telkwa
Air Quality Advisory	February 19-21	8	Mandatory Emission Reductions for Burns Lake, Smithers, Houston,Telkwa and Hazelton
Air Quality Advisory (Road Dust Bulletin)	March 10-13	11	RDB issued for Smithers, Burns Lake, Houston and Telkwa
Air Quality Advisory (Road Dust Bulletin)	April 16-17	16	RDB issued for Burns Lake.

Table 5-1: Public Air Quality Notifications Issued in the Skeena Region for the 2008/09 season.

5.3.2 Two Air Quality Episodes

Air Quality in the Skeena region in the winter is only partially influenced by open burning (see chapter 5.3). Since air quality monitors are co-located with population centres they are also influenced by their typical emissions sources, like public and commercial automobile traffic, domestic woodstoves and industrial emissions. Additionally, most commercial open burning occurs large distances away from the towns where the monitors are situated. Stagnant weather scenarios, especially under the influence of arctic air in B.C. valleys, can be a main factor in the creation of pollution episodes. In such situations, air quality may deteriorate simply due to the fact that slow day-to-day emissions of a population centre are not properly dispersed by the atmosphere. Additionally, since the stagnant arctic outbreaks are commonly associated with cold spells, woodstoves emissions are major contributors to poor air quality under these scenarios.

While open burning is certainly not the only factor in air quality, burning under poor venting conditions (especially in high sensitivity zones) can lead to poor air quality episodes. One of the main reasons of the creation of the CVF program is to eliminate episodes attributable to open burning, by providing accurate venting forecasts and have major burn operators subscribe to and abide by the forecasts.

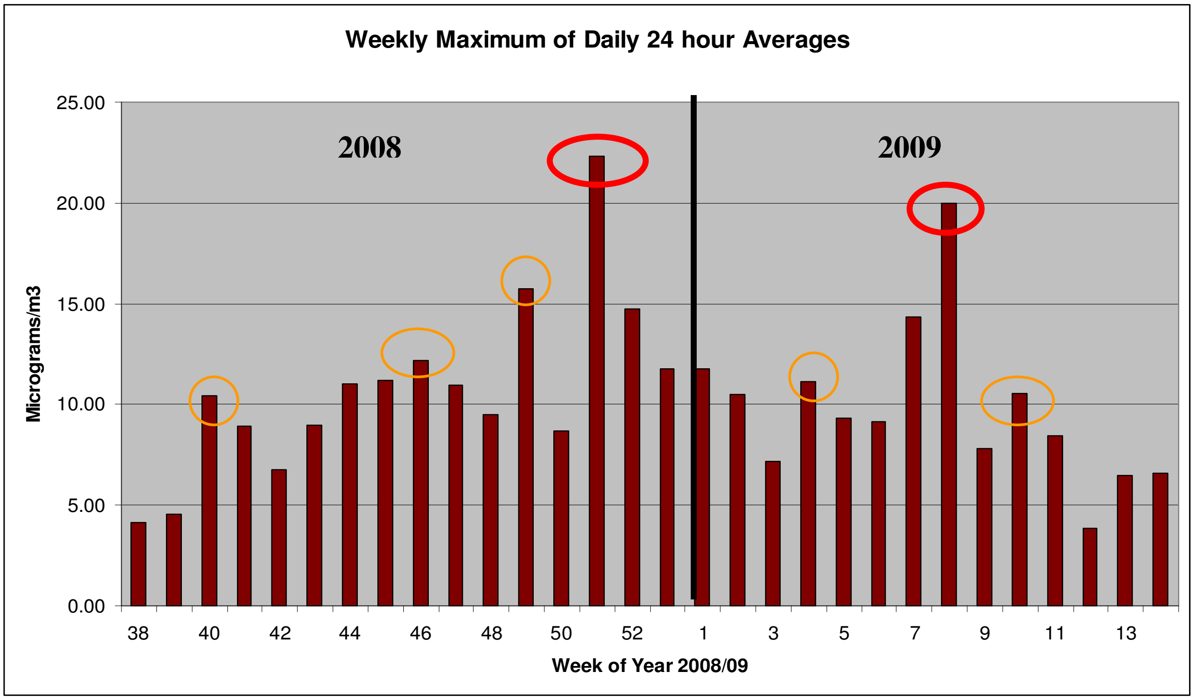

Figure 5-7: Weekly maxima of daily 24-hour and regional averages of PM2.5 values (2008/09).

Figure 5-7 shows weekly maxima of PM2.5 measurements in the Skeena Region. To represent an average of the region, the daily 24-hour-averages of the sensors in Smithers, Telkwa, Houston and Burns Lake were averaged. Of these averages, the weekly maxima are displayed in the Figure. As expected, the air quality generally deteriorates between September and March reaching a weak and poorly defined seasonal peak sometime between the end of December and February. In the 2008/09 season, two air quality episodes were measured during week 51 (Monday December 15th-16th) of 2008 and week 8 (February 19th-21st) of 2009. Air quality advisories were issued during these episodes (see chapter 5.3.1). Five minor peaks can be seen around weeks 40, 46, 49, 4 and 10.

If these episodes were correlated with poor venting conditions it is expected to see a low percentage of favourable CVF (Figure 5-1), assuming that the EC venting index agreed reasonably with the CVF (since some burners may have used the VI for burning) and that both forecasts were reasonably accurate. The peak of poor air quality in week 51 was correlated with stagnant weather (a low favourable CVF and VI percentage) and very low burn activity (Figure 5-3) in this week indicates general compliance by the operators. An active storm cycle preceding this period (week 50) indicates that the airshed was likely 'well vented' before the stagnant air set in and no residual particulates should have contributed to the episode. This is a good example how burn operators generally adhere to the forecasts and how poor air quality episodes are still experienced in the absence of most open burning activity.

Another interesting case is the poor air quality episode of week 8 in 2009. This is the second week of a stagnant weather pattern (arctic outbreak) as weeks 7 and 8 had zero favourable CVF forecasts (although Environment Canada's VI allowed burning on several days during these weeks). As a result, particulate matter likely accumulated over a period of days to result in the concentrations measured during week 8. Additionally, burn activities were slightly enhanced, which suggests that some operators used the EC VI at an unfortunate time (if they had used CVFs, they would not have been allowed to burn). However, without a proper analysis of wind patterns and exact burn locations during this week, it is impossible to determine the relative contribution of these burns (and other emission sources) to the poor air quality measured that week.. Enhanced woodstove emissions were likely a large contributor to poor air quality during this episode since it coincided with an arctic outbreak lasting two weeks.

This case illustrates how the CVF program could further improve air quality protection: if *all* burn operators had signed up with the program and adhered to its forecasts, no open burning would have been conducted and this would almost certainly have had a positive impact on air quality and human health during this episode.

6 Conclusions

The custom venting forecast program offered by the B.C. Ministry of Environment is a popular alternative source of forecast venting conditions for individuals and industrial operators burning under the OBSCR (and government authorizations requiring venting forecasts). The main advantages offered by the CVF service are: their high accuracy (as a spot forecast); an outlook for venting over the next 3 days; a very high consistency of over 80%; more burn opportunities, and better protection of human health from air quality impacts in sensitive airsheds.

Between the end of October 2008 and beginning of March 2009, only 26% of all venting forecasts were favourable for slash burning. Similar values were observed during the 2007/08 season, suggesting that open burning during this period should generally be strongly discouraged.

More than 23,000 piles of wood debris were burned in the 2008/2009 burning season with the help of 2,242 custom venting forecasts. At the same time only five 24-hour periods saw an active air quality advisory despite the complex topography of the region and its tendency to trap pollutants in mountain valleys. Initiatives like the CVF program have likely contributed to the fact that there has not been a month with more than three days of air quality advisories since April of 2006. The continuing reduction of air quality advisories without a significant decrease of open burning is demonstrating the value of the CVF program for burn operators as well as public health protection. At the same time, some burn operators continue to use the generic venting index, which was likely one contributing factor to a poor air quality episode in the third week of February of 2009.

More than 17% of all custom venting forecasts created burn opportunities for clients, compared to the traditional EC VI. This facilitated the burning of some backlog from the 2007/08 season. This was especially noticeable in the valleys of the B.C. North Coast where significant burn opportunities were opened up. This area contains a large potential for growth of the CVF program since relatively few clients are committed to the program in this area and the challenging topography maximizes its benefits.

7 Recommendations

The CVF program has undergone continuous improvement over the years, and is now a well-established and effective program. Nonetheless, during the 2007 through 2009 seasons additional potential improvements were identified, and are summarized here.

7.1 Client Interactions

A challenge with any type of weather-related forecast is communicating it effectively to the client. It is impossible to overstate the importance for the forecaster to understand the client's needs and constraints. Similarly, it is imperative that the client is familiar with the capabilities of weather forecasts and feels comfortable enough to communicate casually with the forecaster via telephone, e-mail or any other means.

Encourage Communication with Clients.

Experience has shown that frequent communication (personal or via e-mail or phone), helps avoid misunderstandings about locations, methods of operation, need to burn a particular location, etc. Communication is invaluable when "forecaster's discretion" is employed as referred to in Chapter 3. Additionally, time has also been wasted issuing CVFs for locations where burns have already taken place, or are not considered for another few weeks. Frequent communications improve efficiency and effectiveness for everyone, while helping to prevent poor air quality episodes.

Vertical Dispersion and Wind

As illustrated later in these recommendations, the definition of the Venting Index (mixing height multiplied by the average wind over that height) is, at this point, still crude and imperfect to describe the atmosphere's ability to disperse smoke. While wind is readily verifiable by any person in the field, the other component to venting, atmospheric stability, is mostly undetectable without a sounding device. As a result, clients will often see a windy day and assume 'good venting'. (Less frequently, some clients also infer a good venting day from 'blue sky' which, in the winter, is usually a sign of poor venting conditions).

It is important that clients understand that wind alone does not make good venting and in fact often even hinders upward dispersion of smoke. This is the most common reason for a client's misjudgement of venting condition in the field. The image on the front page is a good example of such a scenario, where strong winds simply 'flatten' the plume, negatively impacting downwind locations. It is the job of a forecaster to communicate this type of information to clients.

Two neighbours might get different venting indices

Because the custom venting forecast is a spot forecast, it is possible that two nearby locations obtain different venting forecasts. In some cases these forecasts could result in one client burning piles, while another - just a few kilometres away - is not allowed. Due to the location specific nature of the forecast, this is not surprising, but should be communicated to licensees.

Be Ready – Burn Early.

This report, as well as the 2007/08 season report, found that venting conditions deteriorate so drastically between mid November and mid March of every season, that any burning should be strongly discouraged during this time. As a result, it should be communicated to the licensees to start burning as soon as possible in the season.

7.2 Burn Registration Database

This report's statistics are largely based on large forestry companies supplying exact burn dates, numbers and locations. These large companies, however, comprise only part of the total number of piles burned in the region, and this report relies on the Burn Registration System of the B.C. Ministry of Forests and Range for the remainder of the numbers. This system however, does not record the total "number of piles actually burned" since burn registration numbers can be extended without any record of exactly how many piles were burned during which extension. (e.g: An operator can apply for a registration number for 200 piles and decide afterwards not to burn at all. The system, however, will show 200 piles associated with that particular bun registration). As a result it is impossible to determine exactly how many piles were burned and when (in the Skeena Region, we only know that the number of piles burned is somewhere between 18517 and 66777). Actual burn statistics, however, are crucial for air quality research and management in British Columbia. It is recommended the B.C. Government make it mandatory for burners to 'close' a registration number (contact the Ministry again) and report on the "actual number of piles burned".

7.3 Program Recommendations

Complicated OBSCR rules and lack of enforcement

Since the OBSCR is currently undergoing changes that may come about in the near future, the following may soon be obsolete, but for completeness sake, the following were observations the CVF forecaster made during the 2007-09 seasons:

- Many small-scale burners (private citizens and small companies) are not aware of the OBSCR. Even when they are, they assume often that a favourable venting forecast will be issued within one day of applying.
- Current OBSCR rules are too complicated for non-professionals and some professionals. Some burners are poorly informed about allowed materials, pile size, venting indices, venting zones, custom venting forecast, Environment Canada Venting Index, the difference between venting and air quality, the difference between phone recordings of the B.C. MoE versus the Environment Canada 1-900 number, etc. This confusion often results in people simply burning without any permission and 'seeing if anybody notices'. A common misconception among burners is the idea that once they decide to burn (especially if a burn registration number was obtained), they can burn within the next one or two days, not realizing that a favourable venting forecast may be weeks away.
- Lack of enforcement causes frustration especially with participants of the CVF program, who feel, that they are getting a bad name because of some 'cowboys' out there.

Finding Alternatives

Burning slash piles remains a very crude and increasingly outdated method of dealing with logging debris. Fishing lodge operators as well as other tourism-related companies continue to complain about the impact of fall burning to their bottom line. Another common complaint brought forward by the public is the effect of open burning on climate change. Generally, open burning releases carbon that will be re-captured by sustainable forestry practices through appropriate reforestation,

The large volumes of woody debris generated in B.C. constitute potential opportunities for other industrial applications (e.g. biomass energy). This may include treatments that do not immediately release stored carbon to the atmosphere, turning the process into a net carbon sink (e.g. mulching). It is recommended that studies be conducted to identfify and evaluate alternative treatments for woody debris located in close proximity to suitable transportation options (highways and train tracks). It is also recommended to conduct a study that estimates the impact of open burning on neighbouring industries. The results of such studies may become cornerstones for finding and funding alternatives to open burning.

In the meantime the Bulkley Valley and the Lakes District's Airshed Management Society is completing a Woody Debris Inventory to promote alternative uses of woody debris by matching up potential users with businesses that generate it. In addition to potential benefits from a climate change perspective, reducing open burning by finding alternatives will minimize the impacts of open burning on communities and other businesses that are affected by this activity

Technical Caveats of a Venting Index

The Venting Index (the basis for the CVF and the Environment Canada's VI) as an indicator for smoke dispersion has inherent limitations, which have to be considered by the venting forecaster. In its current form (shown in Appendix 10.1), the index increases continuously with increasing wind speed and increasing atmospheric instability. However, strict adherence by the forecaster to its computed value will conflict with practical pollution prevention issues. The following comments illustrate how this can happen, based on observations from the 2008/09 as well as the 2007/08 burn season:

- Wind direction and proximity to residences are not incorporated in the current venting index: Regardless of the venting index, winds above ~10km/h can transport wind directly into nearby buildings/residences. The stronger the wind the worse this problem becomes, as plume rise diminishes due to buoyancy loss caused by rapid heat dispersion of the plume in high winds. In one case a residence was made uninhabitable for a full day (according to the owner), despite an otherwise good venting index (see the image on the front page of this report).
- The venting index's sensitivity to wind speed should diminish over ~30km/h: In open terrain, once the wind has reached speeds above ~30km/h, any further increase contributes insignificantly to smoke dispersion. The only truly bad conditions (with regard to wind) are very low wind speeds (below 5km/h), where

particulates are not transported out of the area. For this reason the venting index sensitivity to wind speed should be maximized somewhere between 5 and 30 km/h and return back to at least 'fair' at very high wind speeds for any downwind location.

- The current venting index neglects the effect of vertical dispersion due to mechanical mixing; without atmospheric instability, the venting index (according to the formula) remains poor, regardless of wind speed. This is particularly detrimental in somewhat narrow valleys (coastal inlets of BC), where mechanical mixing is effective due to wind channelling and can disperse smoke particulates up to 1000 meters in high winds despite an otherwise stable atmosphere. Note, however, that a certain distance downwind of the burn site is required to notice a good effect of mechanical mixing. Residences in close proximity in such a situation may be negatively impacted.
- Analog to wind speeds, over open terrain, once the mixing height has reached 1500-1800 meters (above ground level) any further increase does not contribute significantly to dispersion. The positive influence of mixing height on the venting index should flatten in the formula somewhere between 1500-1800 meters.
- Spotty of character of convectivity is difficult to capture in a mathematically defined venting index: The argument of the previous bullet is particularly important in low wind (pressure gradient) scenarios during high air-mass convectivity. During such cases the venting index may generally be 'good' due to a very high mixing height (e.g. 3000 meters at 2km/h winds), but due to the spotty and local character of such convection, the smoke dispersion may not be realized at the burn location.
- Terrain variability is an important factor that is currently not considered in the venting index. High and exposed locations (ridges, mountain tops etc.) could possibly be suitable for burning under any thermal lapse rate, as long as no inversion is located above the burn location (which would cause fumigation). Conversely, a valley location might be unsuitable for burning under any lapse rate except for straight instability, especially with nearby residences.
- Even if terrain variability were incorporated into the venting index, poor topographic representation by current weather models will make it difficult to automatically forecast terrain effects on venting without manual interference by a forecaster. Due to computational constraints most weather models represent the underlying topography on a grid with finite grid spacing (resolution). Each grid point represents an *average* elevation of the surrounding topography. As a result this grid cannot 'see' any features (valleys and mountains) that are smaller than its resolution and larger features are smoothed. Due to this smoothing, most weather models overestimate valley elevations but underestimate mountain peak elevations. The higher the terrain variability the more intense this smoothing effect becomes (e.g. the steep coastal terrain of the north coast). For this reason the model also cannot resolve or predict any weather phenomena associated with smaller scale topographic features. Table 7-1 illustrates the discrepancy between actual elevations and the topography represented by a typical state-of-the-art weather model with 15km resolution.

Station	Actual Elevation [m]	Model Elevation [m]
Burns Lake	715	983.95
Castlegar	495	1227
Central Vancouver Island (Comox)	24	191.92
Cranbrook	939	1381.29
Lytton	229	1340.47
Golden	785	1734.22
Kamloops	346	1035.98
McBride	730	1592.66
Port Hardy	22	143.09
Kelowna	430	1119.57
Prince George	691	759.97
Smithers	523	1049.38
Victoria	19	115.24
Stewart	15	1124.77
Terrace	217	725.55
Vancouver	2	99.85
Williams Lake	940	914.03

Table 7-1 Weather Model Elevation versus Actual Elevations

It is likely that more issues with the venting index exist and therefore it is recommended that a proper literature review be conducted, incorporating recent research regarding venting index computations, improvements and field experiments.

Independent Weather Center

Efforts are under way by the Ministry of Forests and Range to establish a weather centre that will support wildfire fighting efforts in the summer and serve other purposes during the reminder of the year. The CVF program would fit perfectly into this framework. The Ministry of Environment should advocate for and support the creation of a collaborative weather forecasting program where all parties involved have a say about the placements and spending of resources. Other governmental agencies, which could benefit from forecast support, are the Ministry of Transportation and Infrastructure (highway and avalanche weather), the Provincial Emergency Program, the BC River Forecast Center, BC Parks and BC Ferries. Additionally, other programs (like the BC Transmission Corporation and possibly others) could benefit from such a program if it could provide services like wind power forecast, solar energy forecasts and load forecasts.

8 Acknowledgements

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The custom venting forecast service is largely a user-pay service with additional funding and logistical support from the B.C. Ministry of Environment.

The author would like to acknowledge the close co-operation on this report with the Air Quality Meteorologist of the Skeena Region, Ben Weinstein. Ben's wealth of knowledge and years of practical experience in Air Quality, both locally and B.C.-wide, is reflected on every page of this report.

The Environmental Quality Section Head of the Skeena Region, A.J. Downie, provided instrumental background information as well as a flexible guidance on the political logistics that accompany the creation of any report. His diligence and help in editing rounded out the report and contributed greatly to its completion.

Dana Clark from the Provincial Forest Fire Reporting Centre has provided the data from the provincial burn registration database that was instrumental in the analysis of the burn season.

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10 Appendix

10.1 Venting Index Computation

The computation of the venting index at Environment Canada consists primarily of the product of the average wind speed within the boundary layer and the mixing height. The result (*V*) is applied to the following formula to yield the venting index:

$$VI_{EC} = 9.0 + A \times V - B \times V^2 + C \times V^3$$

Where *A*,*B* and *C* are the following imperial constants:

$A = 0.02$, $B = 1.7 \times 10^{-6}$, $C = 6.8 \times 10^{-11}$ and

$$V = mixing\_height(agl) \times column\_wind(m/s)$$

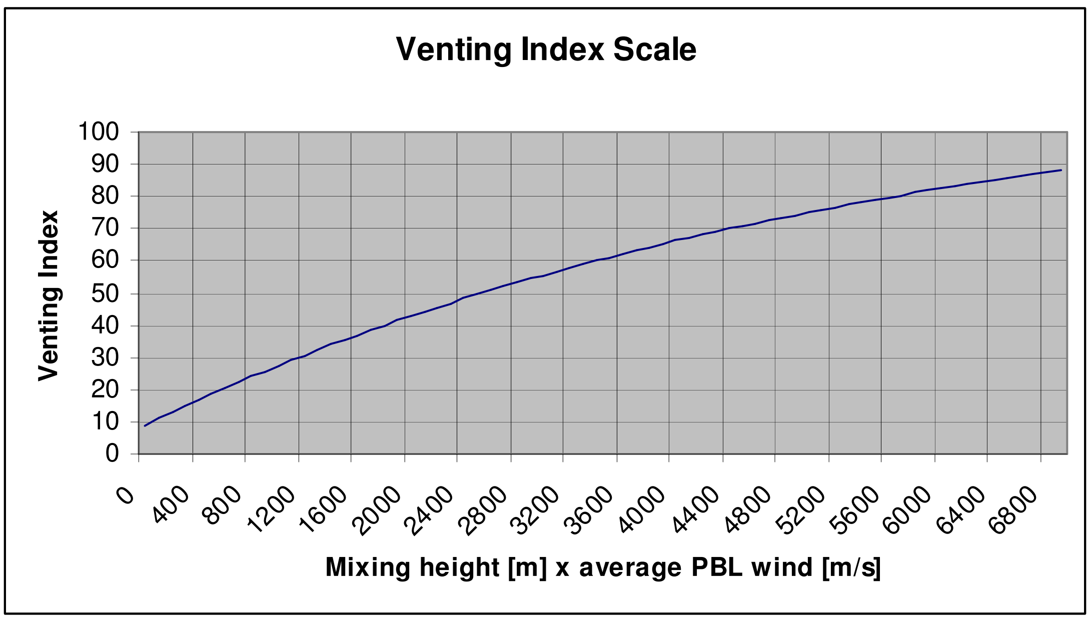

Figure 10-1 The Venting Index Scale

The resulting index is then applied to the following categorical table to yield the Ventilation Category:

Ventilation Index	**Ventilation category**
9 – 33	Poor
34 – 54	Fair
55 – 99	Good

10.2 Sample VI forecast by Environment Canada

FLCN39 CWVR 191330
SMOKE CONTROL FORECAST FOR BC AND YUKON ISSUED BY ENVIRONMENT CANADA
AT 7:00 AM PDT
TUESDAY 19 AUGUST 2008 FOR TODAY.

MIXING HEIGHTS IN METRES ABOVE SEA LEVEL. AVERAGE WINDS IN KM/H.

19-AUGUST-2008

SOUTHERN INTERIOR				TODAY				TOMORROW	
	7:00 AM			4:00 PM			4:00 PM		
	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M
FRASER CANYON	28/POOR	7	762	85/GOOD	15	1742	65/GOOD	13	1305
KAMLOOPS	20/POOR	8	615	99/GOOD	27	3016	99/GOOD	30	1957
OKANAGAN	16/POOR	7	653	63/GOOD	10	1767	67/GOOD	10	1919
CASTLEGAR	13/POOR	1	1244	64/GOOD	12	1630	55/GOOD	12	1380
CRANBROOK	27/POOR	6	1529	85/GOOD	12	2826	55/GOOD	14	1683
REVELSTOKE	13/POOR	1	654	61/GOOD	8	1997	41/FAIR	10	1119
GOLDEN	10/POOR	2	860	60/GOOD	9	2119	36/FAIR	7	1555

FORECAST UPPER WINDS FOR THIS AFTERNOON

	900M	1800M	2700M
PENTICTON	SW 14	SW 18	SW 22
CRANBROOK	SW 19	SW 25	SW 24

CENTRAL INTERIOR				TODAY				TOMORROW	
	7:00 AM			4:00 PM			4:00 PM		
	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M
QUESNEL	27/POOR	16	758	66/GOOD	12	1742	79/GOOD	19	1585
100 MILE	26/POOR	13	1200	99/GOOD	20	3027	99/GOOD	22	2784
WILLIAMS LAKE	34/FAIR	8	1569	82/GOOD	13	2554	78/GOOD	20	1894
PUNTZI MTN	43/FAIR	13	1464	99/GOOD	24	3449	56/GOOD	7	2467
PRINCE GEORGE	12/POOR	7	768	64/GOOD	12	1827	67/GOOD	11	2024
BURNS LAKE	18/POOR	6	999	60/GOOD	15	1521	28/POOR	8	1180
SMITHERS	14/POOR	7	647	99/GOOD	19	2724	42/FAIR	10	1217
MCBRIDE	16/POOR	3	1190	55/GOOD	7	2237	43/FAIR	7	1763
CLEARWATER	18/POOR	5	741	84/GOOD	10	2642	59/GOOD	13	1301

FORECAST UPPER WINDS FOR THIS AFTERNOON

	900M	1800M	2700M
PR. GEORGE	S 12	SW 15	SW 16
SMITHERS	S 22	S 15	S 8

NORTHERN BC/YUKON				TODAY				TOMORROW	
	7:00 AM			4:00 PM			4:00 PM		
	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M
FORT NELSON	11/POOR	12	412	76/GOOD	14	1675	89/GOOD	18	1763
FT ST JOHN	9/POOR	4	716	77/GOOD	11	2406	51/FAIR	20	1162
WHITEHORSE	17/POOR	12	828	64/GOOD	7	2623	57/GOOD	8	2110
DAWSON	25/POOR	8	742	68/GOOD	10	1861	31/POOR	3	1851
WATSON LAKE	10/POOR	6	732	99/GOOD	23	2664	42/FAIR	17	1096

FORECAST UPPER WINDS FOR THIS AFTERNOON

	900M	1800M	2700M
DEASE LAKE	S 12	E 8	E 6
WATSON LAKE	S 8	S 6	S 5
WHITEHORSE	S 5	SW 6	SW 5
MAYO	W 18	W 23	W 27

COAST				TODAY				TOMORROW	
	7:00 AM			4:00 PM			4:00 PM		
	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M	VI	WND KM/H	MXG HT M
VANCOUVER	53/FAIR	22	454	68/GOOD	26	585	76/GOOD	18	1017

FRASER VALLEY	42/FAIR 17	470	59/GOOD 14	892	58/GOOD 14	882
SQUAMISH	16/POOR 4	353	51/FAIR 10	983	44/FAIR 8	1000
SRN VAN ISLD	44/FAIR 25	317	49/FAIR 14	654	55/GOOD 23	474
CNTRL VAN ISLD	28/POOR 7	542	86/GOOD 23	1040	65/GOOD 17	847
NRN VAN ISLD	12/POOR 7	110	56/GOOD 34	338	51/FAIR 34	299
TERRACE	22/POOR 5	716	46/FAIR 6	1544	32/POOR 10	679
STEWART	10/POOR 5	26	13/POOR 6	122	9/POOR 4	11

FORECAST UPPER WINDS FOR THIS AFTERNOON

	900M	1800M	2700M
VANCOUVER	SW 16	SW 21	SW 16
SANDSPIT	S 19	S 20	S 22
PORT HARDY	S 24	S 25	S 25

VENTILATION GUIDELINES:
POOR: 0-33
FAIR: 34-54
GOOD: 55-100
VENTILATION INDICES NORMALLY DROP TO POOR AFTER SUNSET.

END/

10.3 Sample CVF

File Number: 21590-05/CVF

MINISTRY OF ENVIRONMENT

Custom Venting Forecast

Issued To: Nadina Woodlot Association

Company: Nadina Woodlot Association

Burn Registration Number(s): On File

Date Issued: Wednesday, 09 January 2008

nwa

Lots: **Grassy Plains, Francois Lake West**		**Lat: 53 58.317, 54 14.56**		**Long: 125 53.303, 125 50.216**	**Elevation: 850, 800m**	**Piles:**
		Venting:	Optimum Time:	Mixing Height ASL:	Wind:	
Thursday	AM	Poor	12:00 PM-1:00 PM	surface	Calm	
	PM	Poor		Near Surface	Light E	
Friday		Poor	12:00 PM-1:00 PM	Near Surface	Calm	
Saturday		Poor	12:00 PM-1:00 PM	Near 900 m	Light E	

nwa

Lots: **Cheslatta Forest**		**Lat: 53 49.218**		**Long: 126 7.439**	**Elevation: 900m**	**Piles:**
		Venting:	Optimum Time:	Mixing Height ASL:	Wind:	
Thursday	AM	Poor	12:00 PM-1:00 PM	surface	Calm	
	PM	Fair		Near 1100 m	SE 5-10 km/h	
Friday		Poor	12:00 PM-1:00 PM	Surface	Calm to light SE	
Saturday		Fair	12:00 PM-1:00 PM	Near 1200 m	S 10 km/h	

Synopsis / Remarks:

Another Pacific frontal system is approaching the coast this afternoon. It will move over the interior of BC overnight and Thursday. As the system mostly advances warm air over BC, it will stabilize the atmosphere overall keeping mixing heights very low. Light surface winds will allow for some fair venting conditions only over higher and exposed terrain as the system passes on Thursday. The system is expected to bring light precipitation to the interior mainly from early morning to noon over northern BC.

On Friday another ridge of high pressure is advancing ahead of yet another system. The ridge will be centered over western BC by Friday afternoon, giving largely low mixing heights and very slack surface winds… yet another poor venting day throughout northern BC.

The surface ridge will stay a bit stubborn over southern BC on Saturday deflecting the next system over the north coast and into the far northern interior of BC. This will give some light southerly surface winds to central and northern BC while mixing heights will slightly increase, resulting in a fair day for a lot of locations in the north.

Confidence in this forecast: Good, except moderate on Saturday: The overall pattern starts changing to more northerly flows and colder temperatures by the end of the weekend. This is not an easy scenario for the weather models, so I remain sceptical.

Current Air Quality Index:

	Burns Lake	**Houston**	**Telkwa PM 2.5**	**Smithers**	**Kitimat**	**Terrace**
PM_{10}	14	19	N/A	10	6	6
$PM_{2.5}$	18	23	24	14	4	5

Air Quality Categories: **Good: 0-25** **Fair: 26-50**
(Based on PM_{10} values) **Poor: 51-100** **Very Poor: Over 101**

Open Burning Restrictions in place: NO

U. Gramann

Uwe Gramann
Air Resources Technician
250.847.7547

10.4 Glossary

Big 5:	The largest licensees supporting the Custom Venting Forecast Program: Houston Forest Products, Babine Forest Products, Pacific Inland Resources, Canfor and Burns Lake Community Forest.
CVF:	Custom Venting Forecast; Spot forecast for smoke dispersion conditions at a location where slash burns are planned.
EC:	Environment Canada
MSC:	Meteorological Service of Canada; Division of Environment Canada that issues the Venting Index (VI).
OBSCR:	Open Burning Smoke Control Regulation
VI:	Venting Index; A smoke dispersion index issued as forecast by EC/MSC