SENES Consultants Limited

MEMORANDUM

TO:	Michelle Vessey, NorskeCanada cc. Peter Reid, Jacques Whitford	38120
FROM:	Dan Hrebenyk	27 January 2005
SUBJ:	Supplemental Explanation of Air Quality Assessment Peer Review	

In response to your e-mail message of January 20, 2005, I have tried to provide some additional clarification of our conclusions about the significance of the surface wind data to the dispersion modelling assessment. To help illustrate some of my comments, I will be referring to the shape of plumes under various atmospheric conditions, as shown in Figure 1.

As indicated in our Peer Review report, the lack of surface meteorological data in the Crofton area would have introduced a degree of uncertainty into the modelling analysis conducted by Jacques Whitford. However, this should not be interpreted to mean that the entire analysis was invalidated by the lack of this data. The modelling was conducted using a regional scale meteorological model (MC2) which provided a good representation of wind flow above the surface. Therefore, the dispersion of emissions from the taller stacks (greater than 30 m) at the pulp mill would have been reasonably well represented by use of the MC2 data in the model.

On the other hand, dispersion of emissions from short stacks, either near the surface or on top of buildings, as well as from area sources, would have been more dependent on wind flow near the surface. Because the wind flow at the surface is influenced by topographic features such as low hills to a greater extent than winds aloft, the MC2 model, which is run on a 3.3 km resolution, may not represent the surface features with sufficient resolution to accurately estimate the direction and speed of wind flow near the surface. As an example, we showed in our report that the MC2 data did not represent outflow winds from the Cowichan Valley in the Duncan area. This does not mean that the winds from all directions in Duncan were badly represented by MC2; just that the winds from one sector were not identified by the MC2 model analysis. Consequently, it is our opinion that the MC2 model may have similarly missed some aspects of the wind flow in the Crofton area, which might have affected dispersion of emissions from the low-level sources from the Crofton mill.

TALL STACKS

Emissions from tall stacks can affect ambient pollutant concentrations at locations both near to and far from the stack source. Close to the mill, the emissions from tall stacks would add to air quality impacts from low-level sources. Figure 1 shows the various shapes of emission plumes that can be observed from tall stacks.

Some of the highest predicted ambient short-term (e.g., 1-hour average) concentrations in the Jacques Whitford report were likely the result of downward forcing of the plumes from tall stacks as illustrated in Figure 1.a (looping). Looping occurs under very unstable atmospheric conditions in the daytime (e.g., on a warm summer day), when there is a lot of thermodynamic mixing in the atmosphere. Under these conditions, there are large vertical updrafts and downdrafts which cause the “looping” behaviour of the plume. Very high ambient ground level pollutant concentrations can occur at locations where the plume reaches the surface. The plume can be forced down to the surface very near the stack source (i.e., within as little as 100m), or at varying distances from the source, even repeatedly as shown in Figure 1.a.

Very unstable conditions occur infrequently (generally less than 5% of the time), but can have a large impact on maximum short-term pollutant concentrations. Except in deep valleys, looping plume behaviour is not specific to wind direction. Because it occurs under broad regional flow conditions, this type of atmospheric condition would be well-represented in the MC2 meteorological data. The availability of surface observation data at Crofton would not likely have changed these results significantly, though such data may have slightly altered the location at which the maximum values were predicted to occur. Since the location at which maximum values can occur will vary from year to year, this is not a significant weakness in the modelling analysis conducted by Jacques Whitford.

Figure 1.b depicts the typical plume shape under neutral atmospheric conditions. Neutral conditions are the most frequent atmospheric stability class. Plumes emitted from tall stacks exhibit “coning” behaviour, such that the plumes may travel several kilometres before the pollutants reach the surface. Consequently, ambient ground level concentrations are generally lower under these conditions (due to increased dispersion over the travel distance) and occur anywhere from <1 km to 5-10 km from the stack, depending on the height of the stack, as well as the temperature and velocity of the emission plume which affect plume rise. This type of behaviour would have been well-represented in the modelling analysis by Jacques Whitford, and would have contributed a significant proportion of the long-term (i.e., annual) average concentrations used in the health risk assessment.

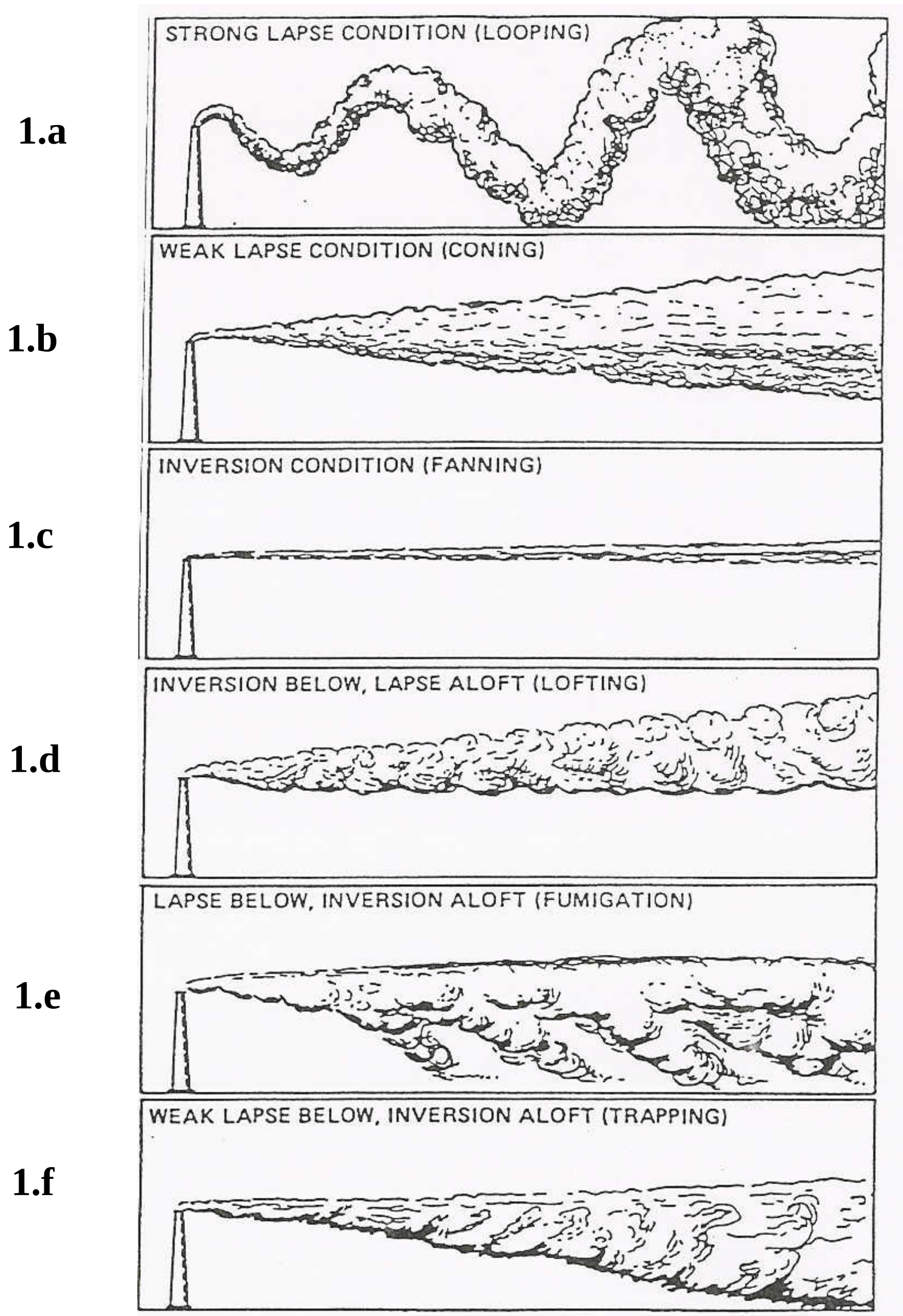
Figure 1.c shows the shape of a plume under stable atmospheric conditions in which the thermal structure of the atmosphere inhibits vertical motion. Under these types of conditions (fanning), plumes may travel over very long distances (10-100 km) in a relatively thin layer before ever reaching the surface, and contribute nothing to either short or long term ambient pollutant concentrations within a modelling domain such as that used by Jacques Whitford. This condition would also have been well-represented by the MC2 data.

Figure 1.d shows a plume that is emitted above an inversion layer. Under these conditions (lofting), the plume travels a long way (10-100 km) without ever reaching the surface, contributing nothing to ground level pollutant concentrations. The MC2 meteorological data would have accurately represented these conditions.

Figures 1.e and 1.f show two atmospheric conditions under which plumes from tall stacks can have a significant impact on ground level pollutant concentrations. ‘Fumigation’ occurs when a low level inversion layer (which may have formed overnight) starts to rise in the mid-morning due to surface heating by the sun. When the inversion layer intersects an elevated plume which has been trapped above the inversion in the preceding hours, the plume can be rapidly mixed to the surface close to the source (100-500 m or more downwind), causing very high pollutant concentrations to occur for short periods of time (i.e., 30-minutes to 1-hour) until the inversion layer either rises above the plume height or breaks up entirely. At a coastal location such as Crofton, fumigation is influenced by regional scale atmospheric conditions, and would have been well-represented by the MC2 data used in the modelling. Figure 1.f (trapping) shows a plume trapped below an inversion layer. This too can result in high pollutant concentrations to occur at the surface for distances of several kilometres, or even tens of kilometres, depending on the strength of the inversion and the amount of pollutant being released. Because the condition can persist for hours, or even several days, this type of atmospheric condition often leads to prolonged periods of elevated pollutant levels (episodes) over large areas. The MC2 meteorological data would have accounted for these effects in the assessment of emissions from the Crofton mill.

Therefore, the modelling analysis conducted by Jacques Whitford would have provided a reasonable assessment of air pollutant concentrations resulting from the releases from tall stacks (>30 m) over both short and long averaging times, and at short and long distances from the mill. I have no doubt that the human health risk assessment of emissions from these sources provides a good estimate of exposure and health risk at all distances from the mill as it relates to the elevated plume releases.

Figure 1
Profiles of Visible Plume Shape from Tall Stacks



LOW-LEVEL SOURCES

The uncertainty in the air quality modelling assessment that was identified in the SENES peer review relates mainly to emissions from short-stacks and area sources at the Crofton mill. Some of the time, the regional flow will dominate local circulation and dispersion of pollutants from low-level sources will have been well-represented by the MC2 model data, while at other times local surface circulation will be more important to the dispersal of pollutants from these sources. This means that only a portion of the dispersion modelling conducted by Jacques Whitford will have been affected by the lack of surface observation data.

It is difficult to say to what extent the analysis results were affected by the lack of such data. As presented in the Jacques Whitford report, the modelling results include the combined impacts from all emission sources at the mill, so that it is impossible to distinguish how much of the impact at a given point is due to emissions from tall stacks versus low-level emission sources. However, relying on professional judgement based on past experience with emissions from a pulp and paper mill in a coastal location, it is my opinion that the maximum impacts from low-level sources are most likely to occur close to the mill property line, and certainly within a few hundred metres of the property line. While some impacts (e.g., detectable TRS odours) from low-level sources may be carried several kilometres from the mill, the higher pollutant concentration levels from these sources will remain within less than 0.5 km of the plant.

Without re-modelling using good surface meteorological data, it is difficult to estimate the potential magnitude of uncertainty introduced to the maximum predicted pollutant concentrations by the lack of surface observation wind data. In some locations, the maximum short-term concentrations close to the mill will be determined by emissions from tall stacks (i.e., conditions in Figures 1.a and 1.e). At other locations, they may be dominated by emissions from low-level sources. This may be particularly the case for pollutants with air quality objectives based on 24-hour average levels (e.g., SO_2, NO_2 and particulate matter). Re-modelling of the plant’s emissions using good observation data for surface winds might alter the pattern of the maximum predicted concentrations, but might not change the magnitude of predicted concentrations. Alternatively, maximum predicted 24-hour average concentrations might change by a factor of 2 or 3, but it would be unrealistic to assume that the difference would be as high as a factor of 10 from the values predicted by Jacques Whitford.

For this reason, it was my opinion that the conclusions of the human health risk assessment due to long term exposure estimates (annual average concentrations) would not be altered sufficiently by any re-analysis using better surface wind data to change the conclusions about the relative harm posed by these emissions. Since the vast majority of the pollutants (66 of 70) considered in the risk analysis were evaluated in terms of the maximum annual average concentration predicted in the modelling analysis, it is the opinion of myself and Dr. Harriett Phillips at SENES that these pollutants are of no further concern for further investigation.

On the other hand, since the location and magnitude of the maximum predicted 1-hour average and 24-hour average concentrations might be affected by the emissions from low-level sources, pollutants with ambient air quality objectives for these averaging times should be re-evaluated with ambient air quality monitoring data. The pollutants with 1-hour and/or 24-hour averaging times include SO_2, NO_2, H_2S, PM_{10} and $PM_{2.5}$.

AMBIENT AIR QUALITY MONITORING LOCATIONS

Ideally, one would want to use the air dispersion modelling results as a guide to locating air quality monitoring stations in order to ensure that the samplers are placed in the locations where maximum predicted concentrations are likely to occur. In practice, one must consider the relative exposure of the site for making measurements, access and security of the equipment, as well as availability of power for the instruments.

In a small community such as Crofton, there may only be a handful of suitable locations where monitors can be placed, regardless of where the modelling analysis says they would best be located. For example, the model may suggest that, in order to determine impacts from the mill, the best place to put the monitors is in the park beside the ferry dock. However, distinguishing mill emissions from those of the ferry vessel and idling cars in the ferry line-up may be problematic. Or, the best location indicated by the model may be in someone’s back yard, but the monitors can’t be placed their if the owner does not wish it. Or, there may be tall trees in the way that would screen the air flow between the mill and the monitors.

For these types of reasons, it is often necessary to balance the purely scientific interests in locating monitors against the practical considerations of where it is feasible to place monitors. Air quality models can then be used to relate the observed air quality at the monitored locations to predicted air quality at locations where monitors cannot be placed. Presumably, a better set of meteorological data will be collected at some point in the future such that the uncertainties in the current modelling analysis can be quantified by comparison with ambient air quality monitoring data. For now, however, the most appropriate action would be to confirm predicted air quality modelling results using the current modelling analysis from Jacques Whitford and monitoring data for those pollutants (SO_2, NO_2, H_2S, PM_{10} and $PM_{2.5}$) that have 1-hour and 24-hour average objectives.

I regret that I cannot be any more specific than this in answering your question about the significance of the lack of surface meteorological data to the conclusions and recommendations of the report by Jacques Whitford. I am confident that the conclusions concerning the potential health risks from long term (annual average) exposure to the majority of pollutants emitted by the mill would not be significantly altered by the use of surface meteorological data. However, I do not have the same degree of confidence in the short term pollutant concentrations predicted by the modelling analysis. This does not mean that I believe the predicted 1-hour and 24-hour average concentrations are necessarily wrong. Rather, it is my opinion that further investigation through an ambient monitoring program would help to either increase confidence in the predicted 1-hour and 24-hour concentrations for specific pollutants, or determine the magnitude of under- or over-estimation present in the current analysis for these specific pollutants.