Normalized Methyl Bromide Dispersion Modeling Report for Ship and Log Stack Fumigation at the Port of Tauranga, NZ

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Context

Following the release of the EPA Decision Making Committee (DMC) Direction and Minute WGT27 on 03 December 2020, STIMBR engaged Sullivan Environmental Consulting (SEC) to review the report prepared by Todoroski Air Sciences (TAS) for the DMC. SEC was requested to provide recommendations to STIMBR for reducing airborne exposures associated with log and timber fumigation at the Port of Tauranga. STIMBR also engaged Cathy Nieuwenhuijsen, Golder Associates, Christchurch New Zealand to provide review and advice.

Review

In WGT23 and 24, the DMC directed TAS to conduct additional methyl bromide air dispersion modelling. The DMC identified an effective way we believe to reduce airborne exposures that is consistent with the need for log and timber fumigation, i.e., to consider meteorological factors in relation to buffer zones. The modeling recently completed by Todoroski Air Sciences (TAS) addressed this issue.

What have we done

Sullivan Environmental Consulting (SEC) reviewed the TAS report, made recommendations to STIMBR, and has completed analysis for STIMBR that is detailed in this report.

Our analysis takes the TAS modeling one step further, considering more closely the potential to adjust ventilation activities according to meteorological conditions in order to gain the full benefits of the approach identified by the DMC in WGT23 and 24.

Our further analysis shows that there is a very large difference in atmospheric dilution potential during the period from mid-morning through mid-afternoon when wind speeds tend to be higher and the dilution potential associated with atmospheric turbulence is at its peak. In contrast, early morning hours for fumigation (e.g., 7:00 A.M. through 8:00 A.M.) and later afternoon / early evening (e.g., 3:00 P.M. through 7:00 P.M.) can be less turbulent. A buffer zone that would be effective and practical at 12:00 noon would not necessarily be protective of an application at 7:00 P.M. This is especially true when the 99.9th percentile is being used as the point of compliance.

Meteorological conditions have strong cycles as a function of the time of day. Similar to the approach used by TAS for ship fumigation[1], which shows ship ventilation modeling results as a function of hour of the day, we have undertaken modeling that provides a practical way to implement the DMC directive to account for meteorological conditions when evaluating buffer zones for log stacks and ships.

Having reviewed the TAS report, SEC has expanded the TAS approach in two ways. On STIMBR's instruction we have completed analysis and report on the differences in the 99.9th percentile exposures as a function of hour of the day for the log stacks. Secondly we confirm the hypothesis, in the case of ship fumigation, that one-hour intervals between ship hold openings during a period from 9:00 A.M. to 2:00 P.M. provide a suitable solution for venting ship holds during the most favorable (i.e., most turbulent and with generally higher wind speeds) meteorological conditions. In addition, one-hour venting minimizes the period of disruption of port activities (due to buffers) when a ship is being vented.

SEC planned to use the AERMOD dispersion model to initially test the hypothesis before undertaking CALPUFF modelling to validate our findings. Unfortunately, the staff member who manages our CALPUFF modeling, Mr. Dennis Hlinka, was hospitalized in mid-January 2021 as a result of contracting the COVID 19 disease. In order to validate the AERMOD modeling results, SEC has collaborated with Golder Associates to produce CALPUFF modeling results. The outcome of that work is documented in a separate report from Golder Associates to STIMBR.

The output of the four screening-level model runs using AERMOD are provided in Figures 1-4. The raw AERMOD modeling concentration results are expressed as normalized[2] (relative) concentrations in the results section of this report. SEC has presented AERMOD results based on both the urban and rural dispersion coefficients. While it is expected that the more favorable (urban) dispersion conditions will occur at the port due to the relatively high heat capacity of the cement/asphalt surface and the respirating and heat-generating timber, we have also shown the more common rural dispersion conditions for further perspective. The advantages of considering

[1] Refer to Appendix C of the 1 December 2020 TAS report.

[2] Normalized modeling refers to relative results based on unit emissions, e.g., 1 g / sec per source.

hour of the day for log stacks and ship venting are evident in either case. It generally would be expected that the more favorable wind speeds and atmospheric turbulence, which generally occur during mid-day periods, would produce similar dilution benefits at other ports relative to early morning, late afternoon, or nighttime conditions. Some differences could occur due to differences in wind direction caused by land/sea effects, which could be evaluated, but generally speaking, the period of 9:00 A.M. through 2:00 P.M. would be expected to be relatively favorable for venting at other ports in New Zealand as well.

For both the log stacks and the ship hold venting scenarios, including both the urban and rural model runs, the period of 9:00 A.M. – 2:00 P.M. has model concentrations substantially lower than the modeling period of 7:00 A.M. – 7:00 P.M. (i.e., the hours of operation at the Port of Tauranga). Venting during the period of the day when there generally is greater turbulence and wind speed would promote reduced airborne exposures and therefore reduce the buffer distance required. Analysis of the Genera fumigation records show that this period coincides with the period when most log stacks are vented at the port, as shown in Figure 2-1 of the SEC modeling report.

Our analysis builds on the work done by TAS and demonstrates that buffer zone controls could be set based on differential windows in which to vent. For example, smaller buffer zones during the preferred dilution period of 9:00 A.M. through 2:00 P.M. for the log stacks and ship ventilation.

Figure 1: Normalized AERMOD Modeling Results (Rural Dispersion – Log Stacks)

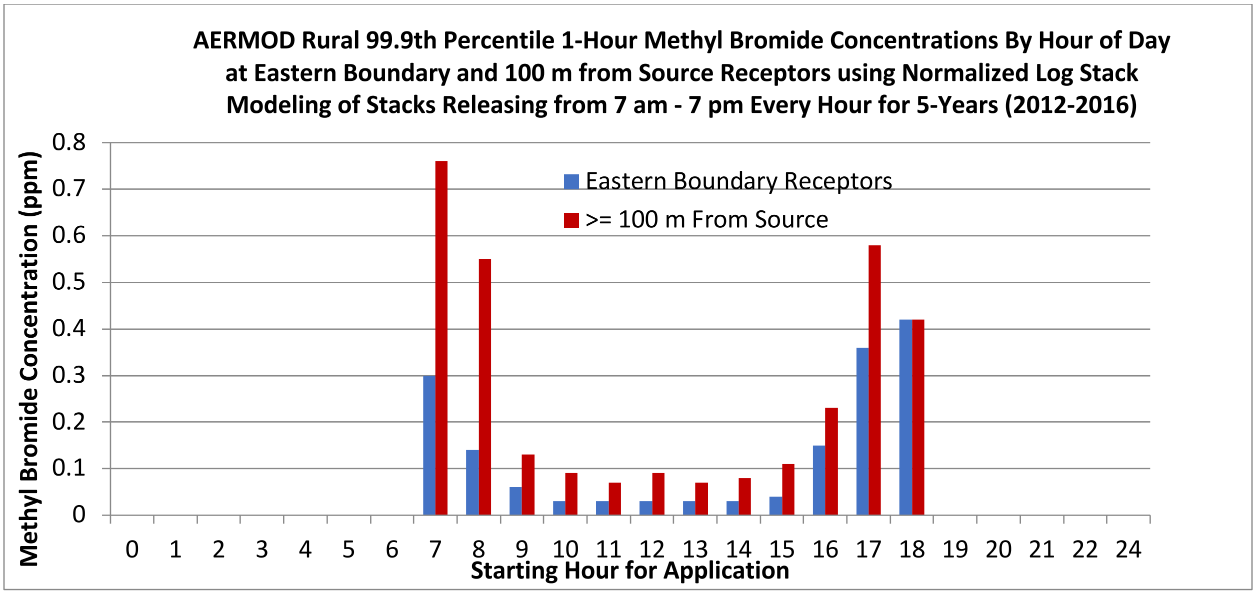


Figure 2: Normalized AERMOD Modeling Results (Urban Dispersion – Log Stacks)

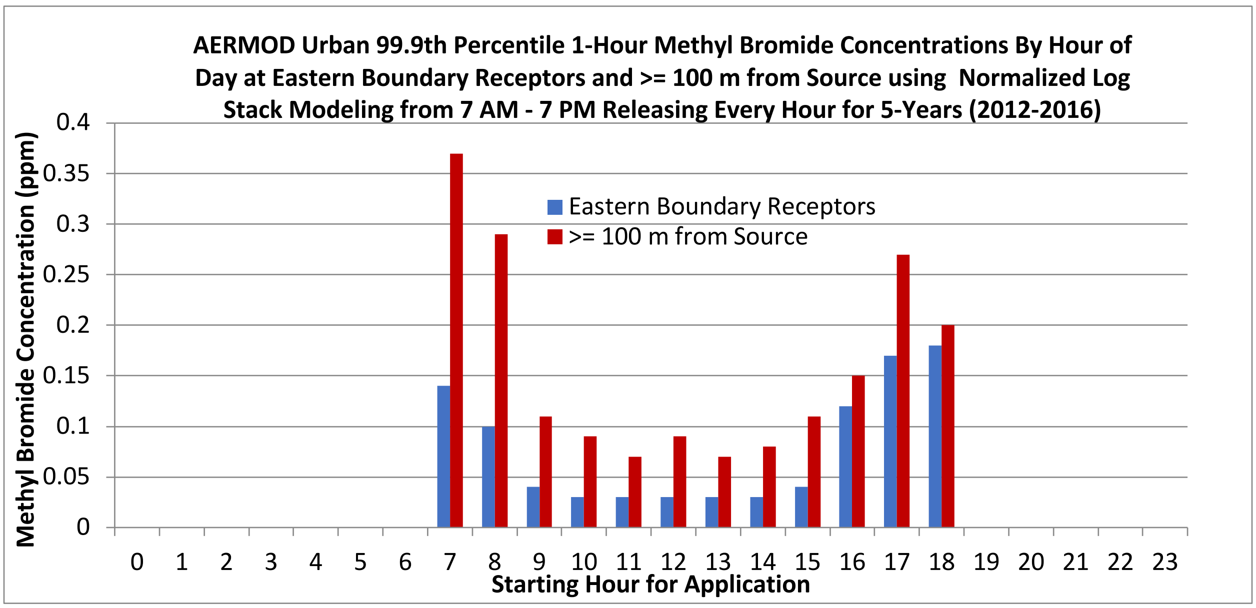


Figure 3: Normalized AERMOD Modeling Results (Rural Dispersion – Ship Holds)

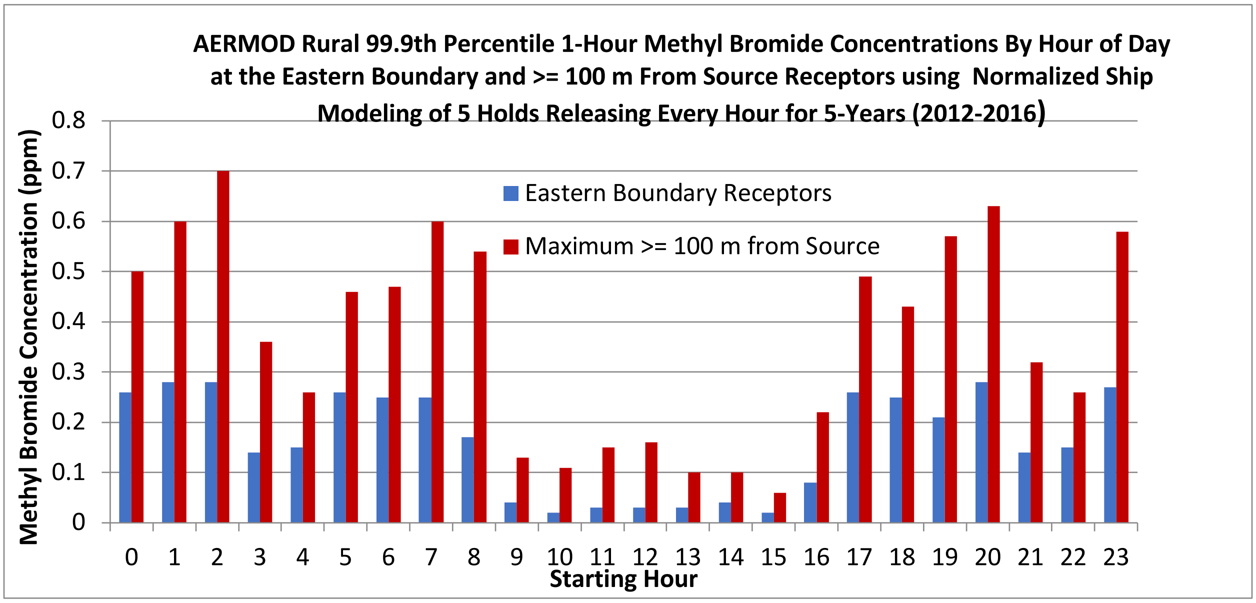
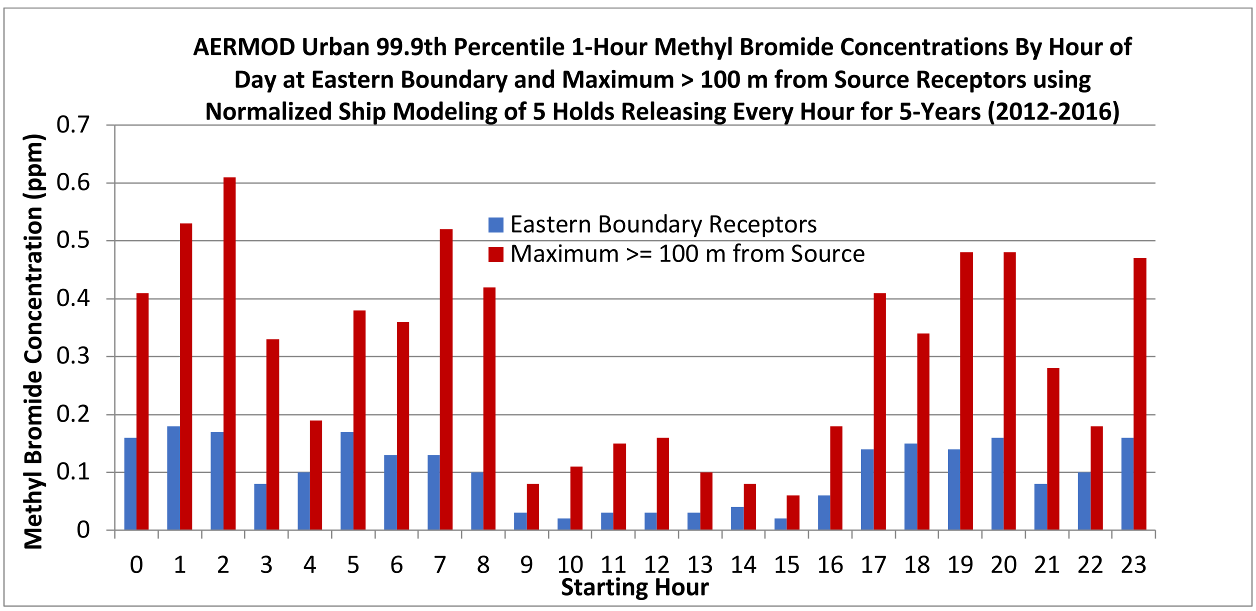


Figure 4: Normalized AERMOD Modeling Results (Urban Dispersion – Ship Holds)



Analysis and Advice

In their report to the DMC, TAS identified a range of scenarios in response to the DMC directives. Taking this approach one step further, SEC has identified an opportunity for STIMBR to consider that more fully addresses the important insight that was raised by the DMC, i.e., evaluating how meteorological conditions affect exposure. This report details that advice. SEC believes that this could be an effective way to help address concerns regarding the need to reduce potential methyl bromide exposures.

Meteorologists recognize that meteorological conditions are a strong function of the hour of the day. As the sun heats the surface, more enhanced dilution conditions generally occur. In addition, wind speeds during daytime periods are generally higher than nighttime conditions. Generally, the mid-day periods have the most favorable atmospheric conditions to dilute emissions while conditions during the night-time generally are the least favorable. TAS has provided results in Appendix C of his 1 December 2020 report of using hour of the day as a surrogate for dispersion potential. We endorse that approach. TAS showed the differences in impacts across various times of the day for the ship scenarios based on two-hour venting sequences. One limitation of the TAS analysis is that when using two-hour openings between holds, all of the venting sequences include night-time conditions during the winter season when hours of sunlight are reduced. With 99.9th percentile modeling, such conditions dominate the analysis and minimize the potential differences in atmospheric dilution potential on a diurnal basis.

In our view, the TAS modeling approach can be refined to allow for shorter ship ventilation intervals (1 hour hold openings) allowing the ventilation of up to 5 holds (the largest size of ship) entirely during the daytime period (in all seasons) when more favorable meteorological conditions exist. While 2-hour hold sequences provide advantages in terms of minimizing total emissions during any given hour, this advantage is more than offset by the limitation of having no opportunity to vent all five holds during the period of most favorable meteorological conditions. For example, even if a ship venting sequence is begun at 7:00 A.M., the final two-hour off-gassing is not complete until 5:00 P.M., i.e., in winter stable conditions are likely to occur in the latter part of the venting sequence and in some cases at the beginning of the sequence. Analysis at the 99.9th percentile shows that the cross-over into nighttime conditions will dominate the analysis and is likely to counter the benefits of having only one hold at a time off-gassing at significant levels. Secondly, also considering time of day benefits for venting log stacks provide an even greater opportunity to reduce emissions as a function of hour of the day. Our hypothesis was that the adverse meteorology associated late in the day and with nighttime conditions would overcome the benefits of avoiding two holds off-gassing at the same time. Our screening-level analysis suggests that the hypothesis is correct. Follow-up post-processing of the TAS CALPUFF modeling files as conducted by Golder Associates further confirmed this hypothesis.

Modeling Approach

To test the hypothesis, SEC ran the following subsets using AERMOD.

1. **TAS Scenario 2 (worst case log stacks)** – All modeling was conducted using AERMOD on an hourly basis. We used normalized modeling and not any specific application rate in this modeling assessment. The dimensions of the six-log stack example were approximately followed in a combined singular source with effective stack height, sigma y and sigma z (properly computed) generally consistent with the TAS model run. As a demonstration, we ran a normalized emission rate for the hours of 7:00 A.M. – 7:00 P.M. This was run for a five-year period based on Tauranga Airport meteorological data. A FORTRAN program was written to post-process the results to display a separate matrix for each hour of the day for each receptor. For each of the eastern fence line receptors and for receptors beyond approximately 100 m from the source, the 99.9th percentile was computed between 7:00 A.M. to 7:00 P.M. for the log stacks.

2. **TAS Scenario 6a (more likely ship case) -** We used normalized (relative) modeling and not any specific application rate in this modeling assessment and assumed one hour between vent openings. Every day the following sequence of one hold opening per hour was evaluated for the following periods:
    - 10:00 AM – 3:00 PM
    - 4:00 PM – 9:00 PM
    - 10:00 PM – 3:00 AM
    - 4:00 AM – 9:00 AM

The above allows for the fifth hold to go through two hours of off-gassing at peak emissions. The emission sequence then stops (without one percent carry over to the next period). This sequence was repeated through the four cycles as shown above. The holds were opened as shown in Table 1.

Table 1: Summary of Emission Sequence (% of application released per hour)

Hold #	1st hour	2nd hour	3rd hour	4th hour	5th hour	6th hour
1	21%	17.5%	1%	1%	1%	1%
2		21%	17.5%	1%	1%	1%
3			21%	17.5%	1%	1%
4				21%	17.5%	1%
5					21%	17.5%

Figures 5 and 6 present the wind rose and receptors, respectively, that were modeled in this screening-level analysis.

Figure 5: Wind Rose Presenting the Surface Wind Conditions as Modeled

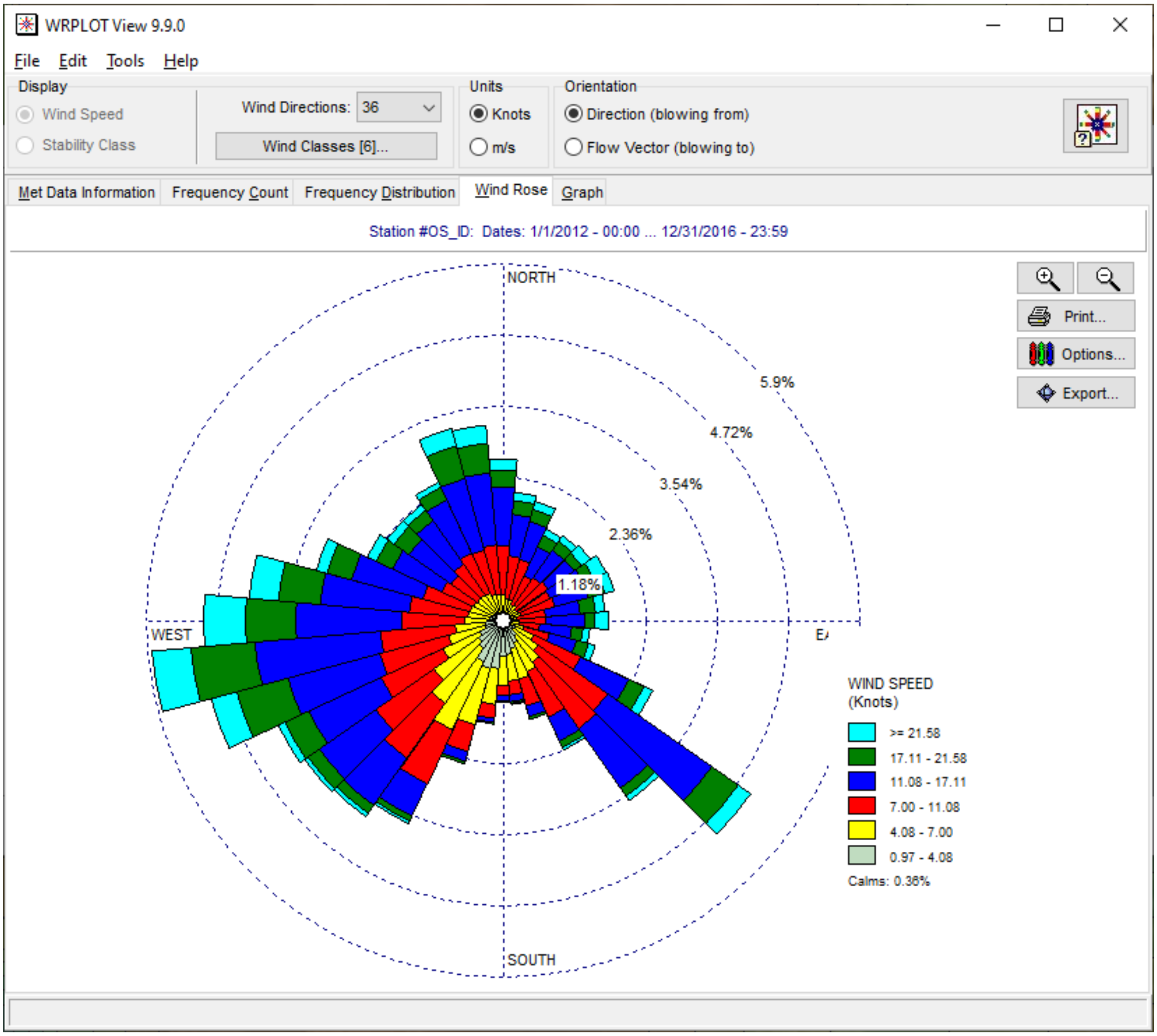


Figure 6: Port Receptors Included in the Modeling Assessment

Following the theme of diurnal dispersion differences, in our opinion the potential of having two sets of buffer zones: (1) for venting between 9:00 A.M. and 2:00 P.M. during generally favorable meteorological conditions, and (2) for venting all other hours between 7:00 A.M. and 7:00 P.M., i.e., 7:00 A.M. - 8:00 A.M. and 4:00 P.M.-7:00 P.M.

When venting between 9:00 A.M. and 2:00 P.M, permutations of buffer distances and stack sizes could be available that will meet the required health standards (e.g., venting a larger log stack, as feasible, during this window) could lead to more reasonable buffer zones during this preferred period. Conversely, venting outside of the preferred window would require larger buffer zones. This type of approach could allow the forest industry and regulators to develop appropriate controls for the use of methyl bromide that would mutually support environmental and timber production objectives.

AERMOD Modeling Post Processing Results

A FORTRAN program was developed to post process the AERMOD one-hour results to display the 99.9th maximum hourly value for each receptor. This was done for both the log stacks (from 7:00 A.M. to 7:00 P.M.) and the ship holds (four sets of ship hold emissions across a 24-hour period as described previously). Both rural and urban comparison were made to show the differences from those scenarios.

Conclusions and Recommendations

A regulatory approach that accounts for buffer zones based on time of day considerations could promote an effective balance between sound environmental management and fumigation operations required by the timber industry for export. Log stack fumigation occurs between the hours of 7:00 A.M. through 7:00 P.M. Genera records show that most of the applications at the Port of Tauranga, for example, are ventilated between mid-morning and mid-afternoon, which also coincides with the time of the day with the most favorable atmospheric dilution conditions. On this basis, buffer zones that encourage ventilation during the period with the most favorable dilution conditions can support lower buffer zones than those associated with the shoulder periods of 7:00 A.M. – 8:00 A.M. and 3:00 P.M. - 7:00 P.M. In other words, applications that are made beyond the most favorable period for dilution would require a larger buffer zone distance. Although the use of the 99.9th percentile inherently accounts for the low wind speed periods, as an additional safeguard, it is recommended that venting not begin when wind speeds are less than 1 m/sec.

Similar to the above description for log stacks, ship fumigation also could benefit from the option of ventilation during the preferred period of 9:00 A.M. through 2:00 P.M. As shown in this report, and further confirmed in the companion Golder Associates report, the use of 1 hour hold openings would allow for ship ventilation during the preferred period. The benefits of favorable dispersion conditions more than compensate for the higher emissions associated with two holds significantly emitting during a common hour. Ship hold sequences starting at 9:00 A.M. or 10:00 A.M. could support a smaller buffer zone distance than those begun at other hours of the day. As with log stacks, dual buffer zones with the 1 m / sec restriction from starting the sequence would provide an environmentally effective approach that would minimize port disruption associated with buffer zone restrictions during ship venting periods.

In our judgment, the most efficient and effective regulatory approach to implement the above recommendations would be in the form of two tables for log stacks and two tables for ship ventilation, i.e., one table that would apply for venting during the period of 9:00 A.M. through 2:00 P.M., and the other table for other hours beyond the preferred period. For each table, a matrix of buffer zones could be produced to show buffer zone as a function of volume applied and application rate. For example, Table 2 provides an example. Accounting for the differences in emission rates and associated atmospheric concentrations across the range of fumigant use rates would promote efficiency in the dual objectives of: (1) sound environmental management, and (2) maintaining the New Zealand timber industry's fumigation requirements associated with timber exports.

Table 2: Buffer Zone Distances for Log Stacks as a Function of Application Volume and Application Rate

# Log Stacks	Application Rate (g/m3)		
	40	72	120
1			
2			
3			
4			
5			
6			