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SUBJECT: STATISTICAL ANALYSES TO DETERMINE A USE CAP FOR LIMITING SEASONAL AMBIENT EXPOSURE TO METHYL BROMIDE

This memorandum summarizes decisions made by the Environmental Monitoring and Worker Health & Safety (WHS) Branches regarding a method to determine a methyl bromide use cap to protect against unacceptable intermediate-term ambient exposures.

Background

Common sense, as well as previous work, strongly suggests a relationship between use and intermediate-term air concentrations (Johnson 1995, Cryer and van Wesenbeeck 2001, Li et al. 2001). Higher use causes higher air concentrations. If the relationship between air concentration and use can be established based on regression analysis, then it may be possible to solve the fitted regression equation to find a use level that, with a specified degree of confidence, will result in average air concentrations at or below the regulatory level of 9 ppb. Such a use level can be described as a 'cap', since the purpose would be to restrict use levels to be less than the cap in order to control intermediate-term air concentrations.

Air concentrations from regional monitoring by the Air Resources Board (ARB) and possibly, pending final review, by the Alliance of the Methyl Bromide Industry (AMBI) will be used in this analysis. Measurements from both groups consist, with some exceptions, of 24-hr average concentrations for four days/week for eight weeks at each of the monitoring sites (usually six) in a region. The regions and the specific 8-week period monitored in each region were chosen on the basis of historically high methyl bromide use.

Information on methyl bromide use in the regions during the monitoring periods was obtained from the California Pesticide Use Report (PUR) database. The PUR provides the date, pounds of methyl bromide applied and the location (township-range-section) of each application.

Decisions for the regression analysis

1. Averaging time for air concentrations

The objective of the analysis is to predict (and ultimately control) the air concentrations to which people are exposed over durations of concern. The air concentration used as the dependent variable in the regression analysis should therefore be the average concentration over the duration of concern. In regions with heavy methyl bromide use, there typically are 1- or 2-month periods in which use is substantially higher than in other months. It is expected, therefore, that seasonal exposure may last one to two months. In order to set a use cap such that both 1- and 2-month exposures are below the target level, Department of Pesticide Regulation (DPR) staff will do regression analyses to predict both 4- and 8-week average air concentrations. The cap will be chosen to control exposures over both 4- and 8-week intervals.

The regression analysis to predict 8-week concentrations will be implemented using the mean of the eight weekly means at each air-monitoring site as the dependent measure. The reason for not using the simple mean of all monitoring days is that weeks frequently have different numbers of monitored days; it is not desirable to give weeks with more days monitored more weight in the overall mean. The analysis to predict 4-week concentrations will use as the dependent measure the mean of the first four weekly means and the mean of the second four weekly means at each air monitoring site (that is, each site will provide two data points for the regression). The 4-week analysis could be done using rolling averages taken over the eight weeks of monitoring. However, these concentrations would have a high degree of autocorrelation, which violates an important assumption underlying the regression analysis. Alternately, the highest 4-week concentration could be used. However, restricting the analysis to the highest concentrations could obscure the relationship between use and concentration.

2. Size of area for methyl bromide use

Clearly, use in surrounding sections contributes to air concentration; in several cases, there were positive measured air concentrations of methyl bromide in sections with no use for the month. The geometry of sectional use requires identification of a section that contains the monitoring location. Subsequent, concentric expansions in area around the monitoring section require odd number of sections along each edge of the enlarging square. The sequence of areas enclosing the monitoring section is 3x3, 5x5, 7x7, etc. The pesticide use report database identifies locations with the public land survey system, which uses sections (1x1 mile) as the smallest unit of area for most applications. Practical considerations and precedence in the regulation of 1,3-dichloropropene strongly suggest utilization of the township area, a standard unit in the public land survey system consisting of 6x6 square miles, to control methyl bromide use in order to limit intermediate-term exposures. Township use will be estimated by a weighted average of the 5x5 and 7x7-section total pounds of use. The weights will be based on the corresponding areas.

It is probable that seasonal air concentrations are influenced by applications in an area at least this large.

3. Time period for methyl bromide use

Several possibilities were considered in choosing a time interval over which to sum use in order to predict air concentrations. A basic premise of this analysis is that methyl bromide applied to soil is the source of the methyl bromide found in the air. Therefore, it would not be sensible to consider use during a shorter period than the air-averaging period, nor to consider use after the end of the air-averaging monitoring period. It could be reasonable, however, to consider use over a longer period that begins before the air-averaging period. How much longer might be based on how long the influence of an application is expected to persist in a 6x6-section area, or it might be determined empirically by trying different intervals and using that which gave the best prediction. Moreover, a use cap based on, e.g., eight weeks of use can be halved to derive a 4-week cap. Doing so would force applications to be more evenly distributed over months than they may have been in the past, the most likely effect of which would be to keep concentrations even lower than predicted. Conversely, it would be undesirable to derive an 8-week cap by doubling the cap based on four weeks; this would allow applications that had been spread over two months to be made within one month, possibly resulting in unacceptably high 4-week air concentrations.

Given these considerations, as well as that of practicality, it was decided to sum use over the same time periods as the air concentration averaging periods. Thus, in the 8-week analysis, total use during the 8-week monitoring period will be used. In the 4-week analysis, use during each of the two 4-week periods will be utilized, corresponding to the air concentration averaging periods.

4. Overall vs. regional analyses

Factors not included in this analysis may influence the relationship between amount of use and air concentration. The most important are probably weather and soil conditions, which vary region-to-region and year-to-year. DPR scientists therefore considered doing separate regression analyses for each region-year. For several reasons, it was decided instead to pool all regions and years in an overall analysis. First, the number of data points available for each region-year (6-12) is insufficient to give reliable regression estimates. Second, year-to-year variations in weather cannot be predicted, so the analysis must account for as much natural variation as possible in order that the selected cap will apply broadly. Third, while region-specific use caps are possible in principle, at present there are insufficient regional data to determine them.

5. Regression estimates

Based on guidance from DPR management, a cap will be determined from the results of the regression analysis by finding the use level corresponding to a 90-percent upper confidence limit on the 95th percentile predicted air concentration equal to 9 ppb. The interpretation of this limit is that given that level of use, we will be 90 percent certain that at least 95 percent of 4-week (or 8-week) average air concentrations at all sites will be below 9 ppb (for further explanation of these limits, see Hahn and Meeker, 1991, p.3 and p.35). The general calculation procedure is outlined in Vardeman (1994). Since DPR must be reasonably certain that all future exposures will be below an acceptable level, the upper confidence limit for an estimated upper percentile is used.

The regression equation, percentiles and confidence limits will be estimated using statistical methods for the normal distribution. While daily air concentrations are typically lognormally distributed, arithmetic means tend to be normally distributed regardless of the shape of the underlying distribution.

References

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