Methyl Iodide (Iodomethane)

RISK CHARACTERIZATION DOCUMENT FOR INHALATION EXPOSURE

Volume IV - Part 2

Responses to USEPA Comments (Part b)

CH_3I

External Panel Review Draft

Department of Pesticide Regulation
California Environmental Protection Agency

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M E M O R A N D U M

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DATE: June 25, 2009

SUBJECT: RESPONSES TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY COMMENTS ON THE AIR DISPERSION MODELING SECTIONS OF THE METHYL IODIDE EXPOSURE APPRAISAL DOCUMENT (VOLUME II)

This memorandum contains the Environmental Monitoring (EM) branch responses to the U.S. Environmental Protection Agency (EPA) comments on air dispersion modeling sections of the methyl iodide exposure appraisal document, volume II of three volumes comprising the Department of Pesticide Regulation (DPR) Risk Characterization Document (RCD). Each U.S. EPA comment is in bold italics, followed by the EM response

Page 19. **"I. Introduction/Section B. Federal Regulatory History (page 4): It is indicated a draft risk assessment was completed by the EPA in 2006 and a final assessment was completed in 2007. More accurately, the 2006 was a final risk assessment and the 2007 version was a revised risk assessment based on the availability of additional data an updated analytical methods. There is also no mention about the FIFRA Scientific Advisory Panel Review of the PERFUM air model …"**

With reference to the PERFUM model, while U.S. EPA extensively used the PERFUM model for the fumigant reregistration eligibility decisions, no document was issued by EPA presenting a through quantitative evaluation. The PERFUM model concepts and basic framework was evaluated by the Scientific Advisory Panel (SAP) and found to be "scientifically sound." See <http://www.epa.gov/scipoly/SAP/meetings/2004/august1/august2425minutes.pdf> for minutes of that meeting. However, the SAP did not put the model through a detailed quantitative verification. DPR staff, during review of the methyl bromide commodity modeling discovered a significant error in the structure of the PERFUM input code related to stack releases (Barry, 2006, attached). Although this portion of the model is not related to soil fumigation, it does illustrate the importance of thoroughly evaluating models before use.

DPR staff has performed a thorough evaluation of the soil fumigant 24-hour averaging time on an older version of the PERFUM model (Barry and Johnson, 2005, attached). No other averaging times were evaluated and DPR staff has not evaluated the air concentration distribution generation portion of the model.

Appendix III includes a comparison of U.S. EPA's approach and DPR's approach. The review of the PERFUM model is mentioned there.

Page 21. **"Exposure Assessment/Section B. Bystander Exposures (Pages 32-36): The same volatility data which were included in the Agency's 2007 risk assessment were used in the DPR assessment. The calculated flux values appear reasonable and appropriate for the approaches used in the assessment. It should be noted that additional field volatility data were generated under a recent Experimental Use Permit for iodomethane (i.e., EPA MRIDs 472952-02, -03, -04) that utilized higher barrier agricultural films, reduced application rates, and a patented pulse application system (i.e. Symmetry). The results of this study indicate that emissions were greatly reduced compared to the studies used by DPR and in the 2007 Agency assessment."**

The U.S. EPA approach appears to consider risk assessment and risk mitigation in the same document. DPR's approach separates risk assessment from risk mitigation. Thus, mitigation methods are not under consideration in the Risk Assessment process. The current federal label requires a generic tarp. Thus, specialized tarps are mitigation measures and, as such, were not considered in this phase.

Page 21. **"Exposure Assessment/Section B. Bystander Exposures (Pages 32-36):… One major difference between the Agency and DPR assessments is that DPR used a deterministic modeling approach based on the use of the ISCST3 model coupled with a static weather conditions and wind vectors faced downwind 100 percent of the exposure duration. These environmental conditions are not realistic in the majority of situations."**

Screening methods are acceptable and appropriate to produce air concentration estimates. DPR has used this approach since 1992 when mitigation measures in the form of buffer zones were developed for methyl bromide. Because of the long history of use, screening methods used at DPR are well understood and characterized. In fact, the document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised (EPA-454/R-92-019)" is currently on the U.S. EPA Support Center for Regulatory Atmospheric Modeling Web site at <http://www.epa.gov/scram001/guidance_permit.htm>. This document includes methods for estimating screening level air concentrations for area sources and has an update that specifically applied to screening estimates for area sources at: <http://www.epa.gov/scram001/guidance/guide/scrupd.pdf>. Thus, it is still a U.S. EPA accepted method. Screening methods produce reasonable worst-case estimates.

DPR is interested in model results from reasonable worst case meteorological conditions. The set of screening meteorological conditions DPR has used are included in the matrix of combinations recommended in the SCREEN3 model User's Guide at: <http://www.epa.gov/scram001/userg/screen/screen3d.pdf>. Although DPR did not use

SCREEN3, because it is the screening version of the ISC model, the results would have been identical.

The U.S. EPA Screening Procedures document states: “The simple screening procedure (Phase 1) is applied to determine if the source poses a potential threat to air quality. The purpose of first applying a simple screening procedure is to conserve resources by eliminating from further analysis those sources that clearly will not cause or contribute to ambient concentrations in excess of short-term air quality standards or allowable concentration increments. A relatively large degree of “conservatism” is incorporated in that screening procedure to provide reasonable assurance that maximum concentrations will not be underestimated.”

This is exactly the stage that DPR is at with Iodomethane. DPR uses the screening method at this stage of evaluation.

As discussed above, the document “Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised (EPA-454/R-92-019)” is currently on the U.S. EPA Support Center for Regulatory Atmospheric Modeling Web site. The meteorological conditions used to product the air concentrations are not “artificial.” They are screening meteorological scenarios that can, and do, occur.

The U.S. EPA comment regarding the screening level weather: **“…a static weather conditions and wind vectors faced downwind 100 percent of the exposure duration…”** is a misunderstanding of the screening level meteorological conditions. The estimated air concentration is tied directly to the flux averaging time, not the “apparent” time step of the model. In the context of a 24-hr screening air concentration estimate based on a 24-hr time weighted average flux, the wind direction for the weather is interpreted as a predominant (or average) direction.

Page 21. **“Exposure Assessment/Section B. Seasonal Exposure (page 36): Seasonal exposures were calculated for repetitive exposures over longer intervals that "reflect the reality of changing wind directions," DPR estimated 2 week TWA concentrations by calculating average 24 hour flux over a 2 week period then "adjusting with a time-scaling factor" which was derived using peak to mean theory based on empirical and theoretical studies (Barry 2008b).”**

The two-week average is for a receptor at a particular location. The two-week air concentration incorporates expected fluctuations in plume location and atmospheric conditions over that averaging time. Peak-to-mean theory is a technique commonly used in the air pollution regulatory community. The theoretical foundation of “peak-to-mean” methods dates back to 1921 in the work of G.I. Taylor’s concepts of diffusion by continuous motion. The first major paper addressing the peak-to-mean concept was published in 1959 by Gifford. The method was further

developed by Hino in 1968 and is referenced specifically by Turner in his 1994 text entitled "Workbook of atmospheric dispersion estimates." Furthermore, the peak-to-mean adjustment concept is used by U.S. EPA in the 1992 document Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised (EPA-454/R-92-019) in the same manner as applied by DPR. This method has been used routinely to obtain long-term averages from shorter averaging time air concentrations. The Barry (2008b) document is attached for reference.

U.S. EPA. **Exposure Assessment/Section B. Seasonal Exposure (page 37): In Table 13 DPR … Additionally, as commented on above, the Agency is not using the deterministic air modeling approach used by DPR but instead completed such calculations using the PERFUM model.**

This comment is addressed in responses shown above.

Page 23. **III. Exposure Appraisal/Section C. Estimation of Application Site Air Concentrations (pages 44-46):… Finally, the factors with can potentially impact emissions have been examined in great detail by the Agency (see www.regulations.gov under docket EPA-HQ-OPP-2005-0123-0467). It is recommended that this document be considered in further revision to the DPR risk characterization document."**

DPR staff previously reviewed this document and posted comments to the appropriate dockets. The review (Sanders, 2008) is attached for reference. In addition, the EPA document includes numerous studies that DPR has reviewed and rejected for use in the DPR VOC program. Those rejected studies are not eligible for use in exposure appraisals. The reasoning and factors leading to each study rejection can be found in the memorandum Barry et al. (2007) at: <http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/emission_rating_app4.pdf>.

The DPR review of the U.S. EPA factors document and the use of studies that DPR has rejected by U.S. EPA to derive the multipliers require that DPR not consider those multipliers for reducing flux values that were actually measured in accepted field studies.

Page 25. **"Appendix III. Comparison of Calculated Air Concentrations (pages 74-75): In this section DPR commented that both ISCST3 and PERFUM were used to calculate air concentrations for various field sizes, application rates, application methods and distances from the field. A comparison was provided between the EPA estimated emission ratio values and the DPR estimated emission ratio values. Minor differences were observed except for that calculated for the Oxnard California tarped raised bed study. A few comments of note are (1) that 3 additional emissions monitoring studies were not considered (i.e., Guadalupe CA tarped raised bed application and drip irrigation application and a Camarillo CA drip irrigation application); (2) the EPA is no longer using deterministic approaches for air modeling based on ISCST3 but is using the PERFUM model with accounts for 5 years of**

weather data fluctuation; and (3) it appears DPR is apparently confusing modeling constructs which have been used by the Agency because it indicates "U.S. EPA used the whole field approach" which, in fact not true if ISCST3 is the basis for this comment because the premise of that approach is one of the worst weather condition 100 percent of the exposure duration. The "whole field" output is an aspect of the kinds of results which are available from the PERFUM model which is not referenced anywhere else in this section of the document by DPR. Finally, it should also be noted that all PERFUM outputs were considered in the ultimate decision regarding iodomethane by the Agency in order to provide for a broader consideration of the possible risks associated with its possible use. Finally, as noted above, additional data have been developed for iodomethane using reduced application rates and barrier films which greatly reduce emissions that have not been considered by DPR in their assessment that could provide additional viable agricultural production practices to growers.

(1) The three monitoring studies listed above were considered. Analysis of those studies are shown in Barry 2008a (attached).

(2) Comment regarding the use of the screening mode approach are addressed above.

(3) The meaning of this comment is not clear. However, it is clear that U.S. EPA did use the whole field output in their decision making, along with other factors. DPR staff performed an evaluation of the whole field method. That analysis is attached for reference (Barry and Johnson, 2008).

The additional data referenced by U.S. EPA are new mitigation methods, including new tarp materials. Mitigation methods not currently labeled are not under consideration in the DPR Risk Assessment process. The current federal label requires a generic tarp. Thus, specialized tarps are mitigation measures and, as such, were not considered in this phase.

Pages 25-26. **"Appendix III. Why DPR Does Not Use the PERFUM model (pages 75-76): DPR acknowledges the PERFUM model in this comment but indicates its review of the code associated with this model was incomplete at the time this assessment was completed so it was not used. The Agency has considered a code level evaluation of the PERFUM model but at this point in time has, like OPR, not completed such an effort. Over the period of the past several years the Agency has however, identified several programming errors or other fixes in PERFUM which have been presented to the developer who has subsequently modified the program and recompiled it as updated versions.**

Additionally, from a theoretical context, the FIFRA SAP has acknowledged the validity of the approach. The PERFUM model provides a variety of outputs so one would expect a concurrence of the ISCST3 approach at outputs which represent the highest percentiles of

exposure and this is in fact observed. This is another indication that PERFUM is adequate as a tool for calculating buffer estimates. Finally, the Agency is aware that some level of review of the PERFUM code has been completed by DPR but no acknowledgement of this process has been included in the DPR RCD even though it may be still somewhat incomplete. It would be a more balanced consideration of the modeling approaches if the preliminary results of this analysis was included in the RCD especially if no major issues were identified or, conversely, if DPR had identified substantive issues at the code level for PERFUM."

While U.S. EPA extensively used the PERFUM model for the fumigant reregistration eligibility decisions, no document was issued by EPA presenting a through quantitative evaluation. The PERFUM model concepts and basic framework was evaluated by the SAP and found to be "scientifically sound." See <http://www.epa.gov/scipoly/SAP/meetings/2004/august1/august2425minutes.pdf> for minutes of that meeting. However, the SAP did not put the model through a detailed quantitative verification. DPR staff, during review of the methyl bromide commodity modeling discovered a significant error in the structure of the PERFUM input code related to stack releases (Barry, 2006). Although this portion of the model is not related to soil fumigation, it does illustrate the importance of thoroughly evaluating models before use.

DPR staff has performed a thorough evaluation of the soil fumigant 24-hour averaging time on an older version of the PERFUM model (Barry and Johnson, 2005, attached). Thus, DPR staff has confidence in the results when using the PERFUM model in this context. No other averaging times were evaluated and DPR staff has not evaluated the air concentration distribution generation portion of the model.

The risk characterization document objective is to identify unacceptable risks. DPR believes that the additional information obtainable with the use of PERFUM is more appropriately implemented at the mitigation phase.

Page 26. **"Appendix III. Buffer Zones (page 76). A discussion was provided by DPR describing how PERFUM outputs contain both whole and maximum buffer distances. The comments provided also indicate that the Agency based its determination of buffer distances solely on the whole field buffer statistics provided by PERFUM. They also present failure rates for other chemicals including methyl bromide, metam sodium, and chloropicrin but it is not clear how they were determined. In fact, the Agency did consider the whole field buffer statistic for iodomethane but other criteria were considered as well including other PERFUM outputs (i.e., maximum buffer statistic and the air concentration outputs by distance rings), incident rates for similar chemicals where the anticipated use of iodomethane might fill a niche (e.g., methyl bromide), and the available monitoring data itself. The probability of a series of sequential factors which could lead to severe deleterious**

health effects (e.g., possibility of fetal loss) was also considered in the determination of the ultimate buffer distances which were applied to iodomethane. The latter factor was also acknowledged by DPR in their risk characterization piece as described above. In summary, the deterministic approach for calculating buffer distances is legitimate but does not provide as broad of a information base for risk managers to consider in the formulation of their decisions as opposed to the use of PERFUM which provides a variety of outputs which can be considered by risk managers including results for the highest percentiles of exposure that emulate those calculated by DPR (e.g., maximum buffer distances at the highest percentiles of exposure).”

It is noted that U.S. EPA acknowledges the deterministic approach (screening approach) is legitimate. DPR’s reasoning for justification of the screening approach at this stage of a analysis concerning methyl iodide is explained in responses above.

The analysis, Barry and Johnson (2008), is attached to answer questions related to the failure rates in this comment. However, a discussion of buffer zones or other mitigation measures is inappropriate for an exposure assessment. The buffer zone section has been deleted.

Page 26. **“Appendix III. Intermediate and Annual Bystander Expsoure Estimates (page 76): The consideration of seasonal exposures is presented in this section. DPR indicates that U.S. EPA "did not include an estimate of potential community exposures" but that it did compare "iodomethane to the ambient air levels that were quantified for methyl bromide." DPR utilized a modeling approach instead to estimate the exposure of an individual at a 152 meter buffer zone over the course of a 2 week period. The Agency does not concur with this approach for the reasons outlined above in responses focused on Sections II.B & II.C (pages 36 & 38 of the document).”**

The portions of these comments pertaining to the model estimated air concentrations were addressed in the responses above.

Page 30. **“Attachment C: US EPA Review Comments on DPR Iodomethane Environmental Fate Assessment. … 1. p 35 (Tables 12 and 13) – Utilization of time-averaged flux, as listed in Table 12, to determine estimated exposure concentrations in air is not consistent with present EPA policy regarding risk assessments. The flux profile, measures at specific time intervals over time, is used in dispersion models to predict estimated exposure concentrations in air. Although a short-term averaging period (e.g., 4 hours) is often selected corresponding to the exposure time in an acute toxicity study in the concentration profile, the measured flux at each sampling period is complied from the field study and matched sequentially to 5 years worth of hourly meteorological data using the PERFUM model in order to obtain estimate exposure concentrations in air. This process was established in the 2004 SAAP, “Fumigant Bystander Exposure Model Review: Probabilistic Exposure and**

Risk model for FUMigants (PERFUM) Using Iodomethane as a Case Study." While CALDPR's approach using ISCST3 with static meteorological data provides a conservative estimated exposure concentration in air, the Office of Air Quality Planning and Standard's Guideline on Air Quality Models (Appendix W) recommends that additional refinement by way of 5-years worth of metorological data in the determination of estimated exposure concentrations. Therefore, CALDPR should incorporate this type of method into the ISCST3 model and the health risk assessment."

DPR uses screening level methods at the initial risk assessment stage. Additional refinements are made during the mitigation stage.

Screening methods are acceptable and appropriate to produce air concentration estimates. DPR has used this approach since 1992 when mitigation measures in the form of buffer zones were developed for methyl bromide. Because of the long history of use, screening methods used at DPR are well understood and characterized. In fact, the document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised (EPA-454/R-92-019)" is currently on the U.S.EPA Support Center for Regulatory Atmospheric Modeling Web site at: <http://www.epa.gov/scram001/guidance_permit.htm>. This document includes methods for estimating screening level air concentrations for area sources and has an update that specifically applied to screening estimates for area sources at: <http://www.epa.gov/scram001/guidance/guide/scrupd.pdf>. Thus, it is still a U.S. EPA accepted method. Screening methods produce reasonable worst-case estimates.

DPR is interested in model results from reasonable worst case meteorological conditions. The set of screening meteorological conditions DPR has used are included in the matrix of combinations recommended in the SCREEN3 model User's Guide at: <http://www.epa.gov/scram001/userg/screen/screen3d.pdf>. Although DPR did not use SCREEN3, because it is the screening version of the ISC model, the results would have been identical.

The U.S. EPA Screening Procedures document states: "The simple screening procedure (Phase 1) is applied to determine if the source poses a potential threat to air quality. The purpose of first applying a simple screening procedure is to conserve resources by eliminating from further analysis those sources that clearly will not cause or contribute to ambient concentrations in excess of short-term air quality standards or allowable concentration increments. A relatively large degree of "conservatism" is incorporated in that screening procedure to provide reasonable assurance that maximum concentrations will not be underestimated."

This is exactly the stage that DPR is at with Iodomethane. DPR uses the screening method at this stage of evaluation.

As discussed above, the document “Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised (EPA-454/R-92-019)” is currently on the U.S. EPA Support Center for Regulatory Atmospheric Modeling Web site. The meteorological conditions used to product the air concentrations are not “artificial.” They are screening meteorological scenarios that can, and do, occur.

The use of five years of meteorological data is not required in the screening phase, it is a refinement that will be considered in the mitigation phase.

Attachments

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SUBJECT: DEVELOPMENT OF SUB-CHRONIC AIR CONCENTRATION ESTIMATES ASSOCIATED WITH A SINGLE FUMIGANT APPLICATION

Background

The Worker Health and Safety (WHS) branch previously requested air concentration estimates associated with a single fumigant for various sample averaging times less than or equal to 24 hours (hrs) (Barry, 2008). Estimates for iodomethane and chloropicrin were produced for use in the WHS exposure appraisals. The exposure appraisals also include sub-chronic exposure scenarios. Thus, two-week air concentration estimates were requested. For both chloropicrin and iodomethane. In addition, 30-day iodomethane air concentration estimates were requested for comparison with the Air Resources Board (ARB) ambient air concentration data for methyl bromide because the use pattern of iodomethane is expected to be similar to methyl bromide. Thus, the ARB methyl bromide ambient monitoring results can be used as a surrogate for the eventual iodomethane ambient air concentrations.

Methods

The sub-chronic exposure air concentration estimates were produced by extension of the 24 hr air concentration estimates (see Barry, 2008). The same single study flux profiles were used to produce flux profiles of 2-week (chloropicrin and iodomethane) and 30-day duration (iodomethane only). The chloropicrin study flux profiles were based on two-week field studies and were adequate without fitting or extrapolation. Flux profiles for five application methods are available: broadcast/untarp, bed/untarp, bed/tarp, broadcast/tarp, and bed/drip/tarp. (Beard et al., 1996; Rotandardo, 2004). The broadcast/tarp application method has three flux profiles from three separate field studies in Arizona, Washington, and Florida (Table 1).

For iodomethane WHS requested both 2-week and 30-day estimates (Table 2). As part of the registration process the registrant conducted eight studies to characterize the flux profile of iodomethane following application to soil by three different methods: broadcast/tarp, bed/tarp, and drip/tarp (Baker et al., 2001; Baker et al., 2002a; Baker et al., 2002b; Baker et al., 2003; Baker et al., 2004a; Baker et al., 2004b; Baker et al, 2004c). In contrast to the chloropicrin studies, the iodomethane studies were conducted to 10 or 11 days. Consequently, in order to estimate 2-weeks or 30-days, a three parameter lognormal function was fit to the 10 or 11 days

iodomethane flux profiles. This function was integrated from the end of measured values out to 14 days or 30 days and the resulting integration added to the measured flux in order to extend the flux estimates out to 2-weeks or 30-days (Table 3).

The procedure to estimate the 2-week and 30-day average air concentration was a follows:

1. Simulate the generic 24-hr centerline downwind air concentrations based on the 100ug/m^2sec generic flux.
2. Adjust the generic 24-hr air concentration to 2-week or 30-day average air concentration. This is the averaging time adjustment factor (development of this adjustment factor will be presented below).
3. Develop each application method flux profile so that it extends for the 2-week or 30-day interval. This is the flux profile development.
4. Calculate the average 24-hr flux over that period and divide by 100. This number represents the average flux on any given day over the 2-week or 30-day interval scaled to the 100ug/m^2sec generic flux.
5. Multiply the 2-week or 30-day average air concentration by the scaled average 24-hr flux to obtain the estimated 2-week or 30-day air concentration for a particular study. This estimates represents the 2-week or 30-day air concentration for an application made at the application rate used in the study.
6. Adjust the 2-week or 30-day air concentration estimate for a particular study to obtain estimates for application rates other than that used in the study.

These steps are illustrated in the EXCEL spreadsheets for iodomethane and chloropicrin in Appendix A.

1. Simulate the generic 24-hour centerline downwind air concentrations

These generic 24-hour centerline downwind air concentration estimates are produced using the 100ug/m^2sec generic flux and the Department of Pesticide Regulation (DPR) standard weather conditions of 1.4 m/s and C stability. See Barry (2008) for method details.

2. Averaging time adjustment factor

The adjustment factors to obtain the 2-week and 30-day average air concentrations from the generic 24-hr air concentrations were derived based upon the U.S. Environmental Protection Agency (EPA) Modeling Guidelines. The 2-week and 30-day average air concentration is the air concentration that would be measured by an air sampler at a particular spot if that air sampler continually drew air over the 2-week or 30-day sampling period.

The basic equation relating air concentrations averaged over different sampling times can be found in Turner (1994) and was reviewed in Barry (2000):

$$\chi_s = \chi_k \left(t_k / t_s \right)^p$$

where:

χ_κ = base concentration
χ_s = desired concentration
t_k = base averaging interval (shorter interval)
t_s = desired averaging interval (longer interval)
p = power law exponent

The adjustment factor, or multiplier is the portion of the equation shown below:

$$\left(t_k / t_s \right)^p$$

The value of p, the power law exponent varies, depending upon the range of averaging times of interest. For example, in U.S. EPA air toxics modeling guidelines (U.S. EPA, 1992a; U.S. EPA, 1992b) the value of p is between 0.096 and 0.29 to obtain the recommended multiplier for adjusting a 1 hr air concentration to between a 3 hr and an annual air concentration. The progression of the values of p and resulting multipliers for adjusting a 1 hour air concentration are shown below:

Averaging Time	Exponent	Multiplier
3 hr	p = 0.096	0.9
8 hr	p = 0.17	0.7
24 hr	p = 0.28	0.4
annual	p = 0.28	0.08

For the sub-chronic exposure assessment an average 24 hr air concentration will be adjusted to a 2 week or a 30 day air concentration. Based upon the above relationships, p = 0.28 is the appropriate exponent value for these adjustments. The multipliers are 0.48 for 2 weeks and 0.39 for 30 days. The justification for this exponent value and the multipliers is shown below.

First, to conform to the U.S. EPA exponent values, adjustment of the 1 hr to 24 hr is as follows:

$$multiplier_{1hr \rightarrow 24hr} = \left(1/24 \right)^{0.28} = 0.41$$

The 1 hr to 2 weeks (336 hrs) multiplier:

$$multiplier_{1hr \rightarrow 336hr} = \left(1/336 \right)^{0.28} = 0.196$$

The 1 hr to 30 days (720 hrs) multiplier:

$$multiplier_{1hr \rightarrow 720hr} = \left(1/720 \right)^{0.28} = 0.158$$

By extension of the equation -

The 24 hr to 2 weeks (336 hrs) multiplier:

$$multiplier_{24hr \rightarrow 336hr} = \left(24/336 \right)^{0.28} = 0.48$$

The 24 hr to 30 day (720 hr) multiplier:

$$multiplier_{24hr \rightarrow 720hr} = \left(24/720 \right)^{0.28} = 0.39$$

The ratio of the 24 hr multiplier to the 2 week multiplier and the 24 hr multiplier to the 30 day multiplier illustrates that p = 0.28 is the appropriate multiplier for adjusting a 24 hr air concentration to averaging times between 24 hrs and annual:

$$1hr \rightarrow 336hr : 1hr \rightarrow 24hr = 0.196 / 0.41 = 0.48$$

$$1hr \rightarrow 720hr : 1hr \rightarrow 24hr = 0.158 / 0.41 = 0.39$$

3. Flux profile development

Table 3 shows a summary of the subchronic flux estimates for iodomethane. Two of the studies (Guadalupe, drip/tarp and Oxnard, bed/tarp) measured flux that projected 100 percent loss of the applied mass within the 10 days of the application. These measured flux profiles were used "as is" and zeros were used to fill in the remaining days out to 30 days.

For the remaining iodomethane studies a 3 parameter log-normal function was fit to the measured daily flux and used to extend the flux profiles to 30 days. The function was integrated from the end of measured values to 14 days. The resulting flux was added to the measured flux to estimate the 2-week cumulative flux. Similarly, the function was integrated from the end of measured values to 30 days and the result was added to the measured flux to estimate the 30 day cumulative flux.

4. Calculate the average 24-hr flux over the desired period

This number represents the average flux on any given day during the 2-week or 30-day interval. Where necessary the 2-week and 30-day average 24-hr flux estimates were adjusted to prevent projected mass loss from exceeding applied mass. Final flux estimates are shown in Table 3.

5. Multiply the 2-week or 30-day average air concentration by the scaled average 24-hr flux to obtain the estimates 2-week or 30-day air concentration for a particular study

This adjustment scales the generic 2-week or 30-day average air concentration from the 100 ug/m^{2}sec generic flux to the flux observed for the actual study application rate. It is accomplished by dividing the average 2-week or 30-day flux by the 100ug/m^{2}sec generic flux to get a scaled flux value. The generic concentrations are multiplied by the scaled flux value to estimate the 2-week or 30-day air concentration for an application made at the application rate used in the study.

6. Adjust the 2-week or 30-day air concentration estimate for a particular study to obtain estimates for application rates other that that use in the study

Since air concentrations are assumed to be proportional to flux and flux is assumed to be proportional to application rate, 2-week or 30-day air concentration estimates for other application rates can be obtained by applying an adjustment factor that expresses the desired application rate as a proportion of the study application rate.

Results

Appendix A shows results of the procedure for both Chloropicrin and Iodomethane. Appendix B shows the 3 parameter log-normal fits to develop the Iodomethane flux profiles. Appendix C contains the Chloropicrin and Iodomethane flux profiles used to calculate the average 24-hr flux values.

References

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Table 1. Summary of application rates and flux estimates from chloropicrin studies used to estimate off-site air concentrations.

Study Location	Application Method	Study Application Rate[a] (lb/acre)	Study Effective Broadcast Application Rate (lb/acre)	2-week 24 hr average flux (ug/m^2sec)
Arizona	Broadcast/Untarp	171	171	10.39
Arizona	Bed/Untarp	149	86	5.39
Arizona	Broadcast/Tarp	332	332	12.37
Arizona	Bed/Tarp	377	189	21.45
Washington	Broadcast/Tarp	343	343	9.54
Florida	Broadcast/Tarp	346	346	12.33
California	Bed/Drip/Tarp	300	156	2.24

[a] This application rate is the "treated acre" rate. For broadcast application methods the Study Application Rate and the Study Effective Broadcast Application Rate will be the same. For bed type applications an adjustment must be made to the Study Application Rate to account for the portions of the field that are untreated

Table 2. Iodomethane studies used to estimate off-site air concentrations.

Study	Application Method	Study Treated Acre Application Rate[a]	Study Effective Broadcast Application Rate	175 lb/acre Adjustment Factor	87.5 lb/acre Adjustment Factor
Watsonville, California	Broadcast/Tarp	252	252	0.69	0.35
Manteca, California	Broadcast/Tarp	242	242	0.72	0.36
LaSelva Beach, California	Drip/Tarp	235	162	1.08	0.54
Camarillo, California	Drip/Tarp	175	119	1.47	0.74
Guadalupe, California	Drip/Tarp	174	139	1.26	0.63
Oxnard, California	Bed/Tarp	244	171	1.02	0.51
Guadalupe, California	Bed/Tarp	179	143	1.22	0.61

a. This application rate is the “treated acre” rate which is only the treated soil area excluding nontreated areas such as furrows. For broadcast application methods the Study Application Rate and the Study Effective Broadcast Application Rate will be the same. For bed type applications an adjustment must be made to the Study Application Rate to account for the portions of the field that are untreated.

Appendix A

Iodomethane - 2 week concentrations

				vol 52875-026 Manteca Field Study		vol 52875-007 Watsonville Field Study		vol 52875-056 LaSelva Beach Field Study			vol 52875-063 Camarillo Field Study			vol 52875-089 Guadalupe Field Study			vol 52875-046 Oxnard Field Study			vol 52875-064 Guadalupe Field Study		
		24hr	2 week																			
feet	meters	generic con	generic conc	242 lbs/ac	175 lbs/ac	252 lbs/ac	175 lbs/ac	162 lbs/ac	175 lbs/ac	87.5 lbs/ac	119 lbs/ac	175 lbs/ac	87.5 lbs/ac	139 lbs/ac	175 lbs/ac	87.5 lbs/ac	171 lbs/ac	175 lbs/ac	87.5 lbs/ac	143 lbs/ac	175 lbs/ac	87.5 lbs/ac
10	3.04	2589.13	1242.78	274.65	197.75	168.77	116.45	90.35	97.58	48.79	114.09	167.71	84.42	160.07	201.69	100.84	196.98	200.92	100.46	157.58	192.25	96.13
50	15.2	2350.75	1128..6	249.37	179.54	153.23	105.73	82.03	88.59	44.30	103.58	152.27	76.65	145.33	183.12	91.56	178.85	182.42	91.21	143.08	174.55	87.28
100	30.4	2018.72	968.98	214.15	154.18	131.59	90.80	70.45	76.08	38.04	88.95	130.76	65.83	124.81	157.25	78.63	153.58	156.66	78.33	122.87	149.90	74.95
300	91.2	1373.99	659.52	145.75	104.94	89.56	61.80	47.95	51.78	25.89	60.54	89.00	44.80	84.95	107.03	53.52	104.53	106.62	53.31	83.63	102.02	51.01
500	152	1083.24	519.96	114.91	82.74	70.61	48.72	37.80	40.82	20.41	47.73	70.17	35.32	66.97	84.38	42.19	82.41	84.06	42.03	65.93	80.43	40.22
###	760	379.24	182.04	40.23	28.97	24.72	17.06	13.23	14.29	7.15	16.71	24.56	12.37	23.45	29.54	14.77	28.85	29.43	14.71	23.08	28.16	14.08
		2 week adj*	0.48																			
			flux adjustment	0.221		0.1358		0.0727			0.0918			0.1288			0.1585			0.1268		
			app rate multiplier#		0.72		0.69		1.08	0.54		1.47	0.74		1.26	0.63		1.02	0.51		1.22	0.61

* this adjustment converts the generic 24hr conc to a generic 2week conc

** this adjustment converts the 2 week generic air concentration (based on 100ug/m2sec) to an air concentration based on average 24hr flux over the 2 week flux profile from the study. e.g. from Table 3: 0.221=(22.1ug/m2sec)/(100ug/m2sec) and (0.221)*(1242.78) = 274.65ug/m3

\# this multiplier scales the concentrations from the study to the desired application rate e.g.: (0.72)*(274.655) = 197.75

the multiplier is calculated as: 175/242 = 0.72 and scales the application rate from 242lb/ac to 175lb/ac

Any additional broadcast application rates can be obtained by calculating the app rate multiplier.

Concentrations shown are model results and 2 decimal places are retained to minimized rounding differences in calculations

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Appendix A
Iodomethane - 30 day concentrations

				vol 52875-026 Manteca Field Study		vol 52875-007 Watsonville Field Study		vol 52875-056 LaSelva Beach Field Study			vol 52875-063 Camarillo Field Study			vol 52875-089 Guadalupe Field Study			vol 52875-046 Oxnard Field Study			vol 52875-064 Guadalupe Field Study		
		24hr	30 day																			
feet	**meters**	**generic con**	**generic conc**	**242 lbs/ac**	**175 lbs/ac**	**252 lb/ac**	**175 lb/ac**	**162 lbs/ac**	**175 lbs/ac**	**87.5 lb/ac**	**119 lb/ac**	**175 lbs/ac**	**87.5 lbs/ac**	**139 lbs/ac**	**175 lbs/ac**	**87.5 lbs/ac**	**171 lbs/ac**	**175 lbs/ac**	**87.5 lbs/ac**	**143 lbs/ac**	**175 lbs/ac**	**87.5 lbs/ac**
10	3.04	2589.13	1009.76	105.72	76.12	65.43	45.15	34.33	37.08	18.54	43.32	63.68	32.06	60.99	76.85	38.42	74.72	76.22	38.11	59.88	73.05	36.53
50	15.2	2350.75	916.79	95.99	69.11	59.41	40.99	31.17	33.66	16.83	39.33	57.82	29.10	55.37	69.77	34.89	67.84	69.20	34.60	54.37	66.33	33.16
100	30.4	2018.72	787.30	82.43	59.35	51.02	35.20	26.77	28.91	14.45	33.78	49.65	24.99	47.55	59.92	29.96	58.26	59.43	29.71	46.69	56.96	28.48
300	91.2	1373.99	535.86	56.10	40.39	34.72	23.96	18.22	19.68	9.84	22.99	33.79	17.01	32.37	40.78	20.39	39.65	40.45	20.22	31.78	38.77	19.38
500	152	1083.24	422.46	44.23	31.85	27.38	18.89	14.36	15.51	7.76	18.12	26.64	13.41	25.52	32.15	16.08	31.26	31.89	15.94	25.05	30.56	15.28
###	760	379.24	147.90	15.49	11.15	9.58	6.61	5.03	5.43	2.72	6.35	9.33	4.70	8.93	11.26	5.63	10.94	11.16	5.58	8.77	10.70	5.35
		30 Day adj*	0.39																			
			flux adjustment**	0.1047		0.0648		0.0340			0.0429			0.0604			0.0740			0.0593		
			app rate multiplier#		0.72		0.69		1.08	0.54		1.47	0.74		1.26	0.63		1.02	0.51		1.22	0.61

* this adjustment converts the generic 24hr conc to a generic 30 Day conc
** this adjustment converts the 30 day generic air concentration (based on 100ug/m2sec) to an air concentration based on average 24hr flux over the 30 day flux profile from the study. e.g. from Table 3: 0.1047=(10.47ug/m2sec)/(100ug/m2sec) and (0.1047)*(1009.7607) = 105.72ug/m3
# this multiplier scales the concentrations from the study to the desired application rate e.g.: (0.720)*(105.72) = 75.12
the multiplier is calculated as: 175/242 = 0.72 and scales the application rate up from 242lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.

Concentrations shown are model results and 2 decimal places are retained to minimized rounding differenced in calculations
Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Appendix A
Chloropicrin 2 week averages

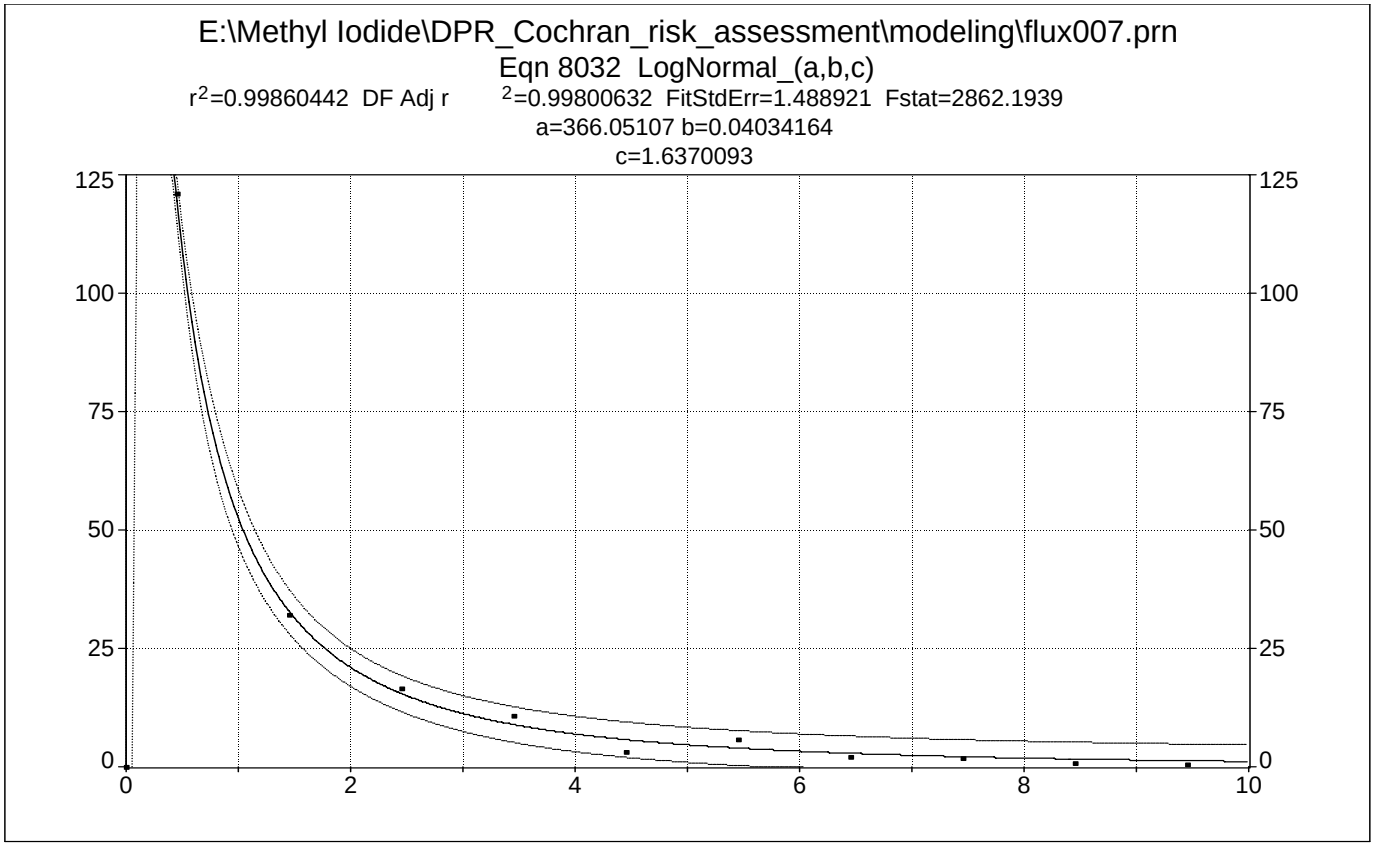
		24hr	2 week	AZ broad/untarp			AZ bed/untarp			AZ bed/tarp			AZ broad/tarp			WA broad/tarp			FL broad/tarp			CA bed/drip/tarp	
feet	**meter**	**generic con**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	2589.13	1242.78	129.13	132.09	377.56	66.99	136.32	194.73	266.58	493.17	706.43	153.73	162.03	232.14	118.56	120.93	173.10	153.24	155.07	221.42	27.84	53.53
50	15.2	2350.75	1128.6	117.24	119.93	342.80	60.82	123.77	176.80	242.03	447.76	641.39	139.58	147.12	210.76	107.65	109.80	157.16	139.13	140.80	201.04	25.28	48.60
100	30.4	2018.72	968.98	100.68	102.99	294.38	52.23	106.28	151.83	207.85	384.52	550.80	119.86	126.34	180.99	92.44	94.29	134.96	119.48	120.91	172.64	21.71	41.74
300	91.2	1373.99	659.52	68.52	70.10	200.36	35.55	72.34	103.34	141.47	261.71	374.88	81.58	85.99	123.19	62.92	64.18	91.86	81.32	82.29	117.50	14.77	28.41
500	152	1083.24	519.96	54.02	55.27	157.96	28.03	57.03	81.47	111.53	206.33	295.56	64.32	67.79	97.12	49.60	50.60	72.42	64.11	64.88	92.64	11.65	22.40
###	760	379.24	182.04	18.91	19.35	55.30	9.81	19.97	28.52	39.05	72.24	103.47	22.52	23.73	34.00	17.37	17.71	25.35	22.44	22.71	32.43	4.08	7.84
		2 week adj*	0.48																				
			flux adjustment	0.1039			0.0539			0.2145			0.1237			0.0954			0.1233			0.0224	
			app rate multiplier#		1.023	2.924		2.035	2.907		1.85	2.65		1.054	1.51		1.02	1.46		1.012	1.445		1.923

* this adjustment converts the generic 24hr conc to a generic 2week conc
** this adjustment converts the 2 week generic air concentration (based on 100ug/m2sec) to an air concentration based on average 24hr flux over the 2 week flux profile from the study. e.g. from Table 1: 0.1039=(10.39ug/m2sec)/(100ug/m2sec) and (0.1039)*(1242.78) = 129.3ug/m3
# this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.023)*(129.13) = 132.09
the multiplier is calculated as: 175/171 = 1.023 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations shown are model results and 4 decimal placed are retained to minimized rounding differenced in calculations
Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Appendix B. Iodomethane 30-Day Flux Profile Development

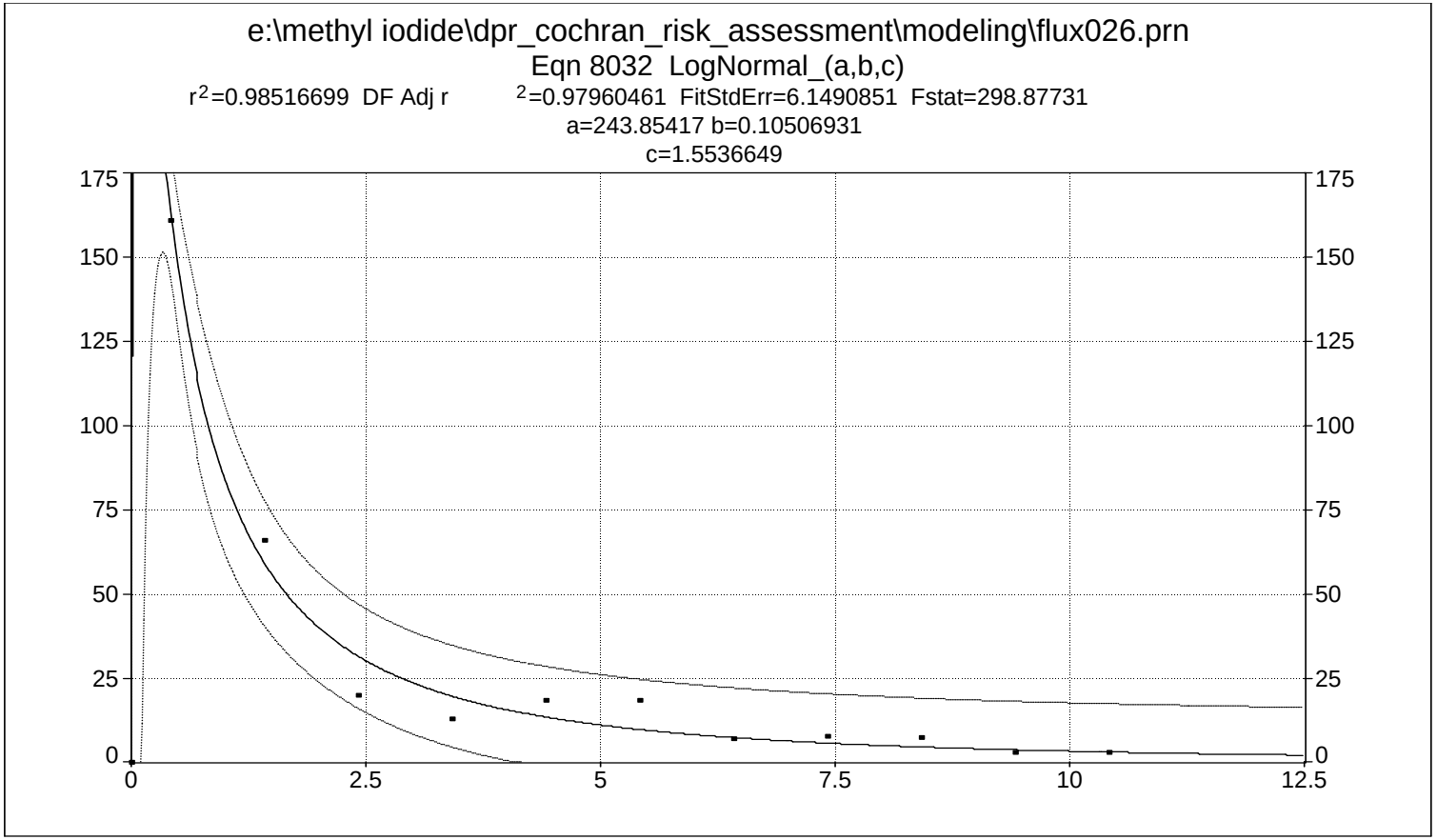
007 Watsonville, California
Broadcast/tarp



Rank 1 Eqn 8032 LogNormal_(a,b,c)

XY	*	X Value	Y Value	Y Predict	Residual	Residual%	95% Confidence Limits		95% Prediction Limits		Weights
1		0.0000000	0.0000000								1
2		0.4600000	121.30000	121.21224	0.0877648	0.0723535	117.77941	124.64506	116.35704	126.06743	1
3		1.4600000	32.200000	33.105312	-0.905312	-2.811529	29.919536	36.291089	28.421531	37.789093	1
4		2.4600000	16.800000	15.645902	1.1540984	6.8696332	13.941254	17.350550	11.812567	19.479237	1
5		3.4600000	11.000000	9.0727609	1.9272391	17.520355	7.5096807	10.635841	5.3002481	12.845274	1
6		4.4600000	3.3000000	5.8797181	-2.579718	-78.17328	4.4127679	7.3466683	2.1460100	9.6134262	1
7		5.4600000	5.9000000	4.0904287	1.8095713	30.670700	2.7560509	5.4248065	0.4067895	7.7740678	1
8		6.4600000	2.3000000	2.9902720	-0.690272	-30.01183	1.7961628	4.1843812	-0.644908	6.6254515	1
9		7.4600000	1.9000000	2.2679552	-0.367955	-19.36606	1.2058527	3.3300576	-1.326025	5.8619355	1
10		8.4600000	1.0000000	1.7698504	-0.769850	-76.98504	0.8259742	2.7137267	-1.790983	5.3306840	1
11		9.4600000	0.5600000	1.4129763	-0.852976	-152.3172	0.5727308	2.2532217	-2.121800	4.9477528	1

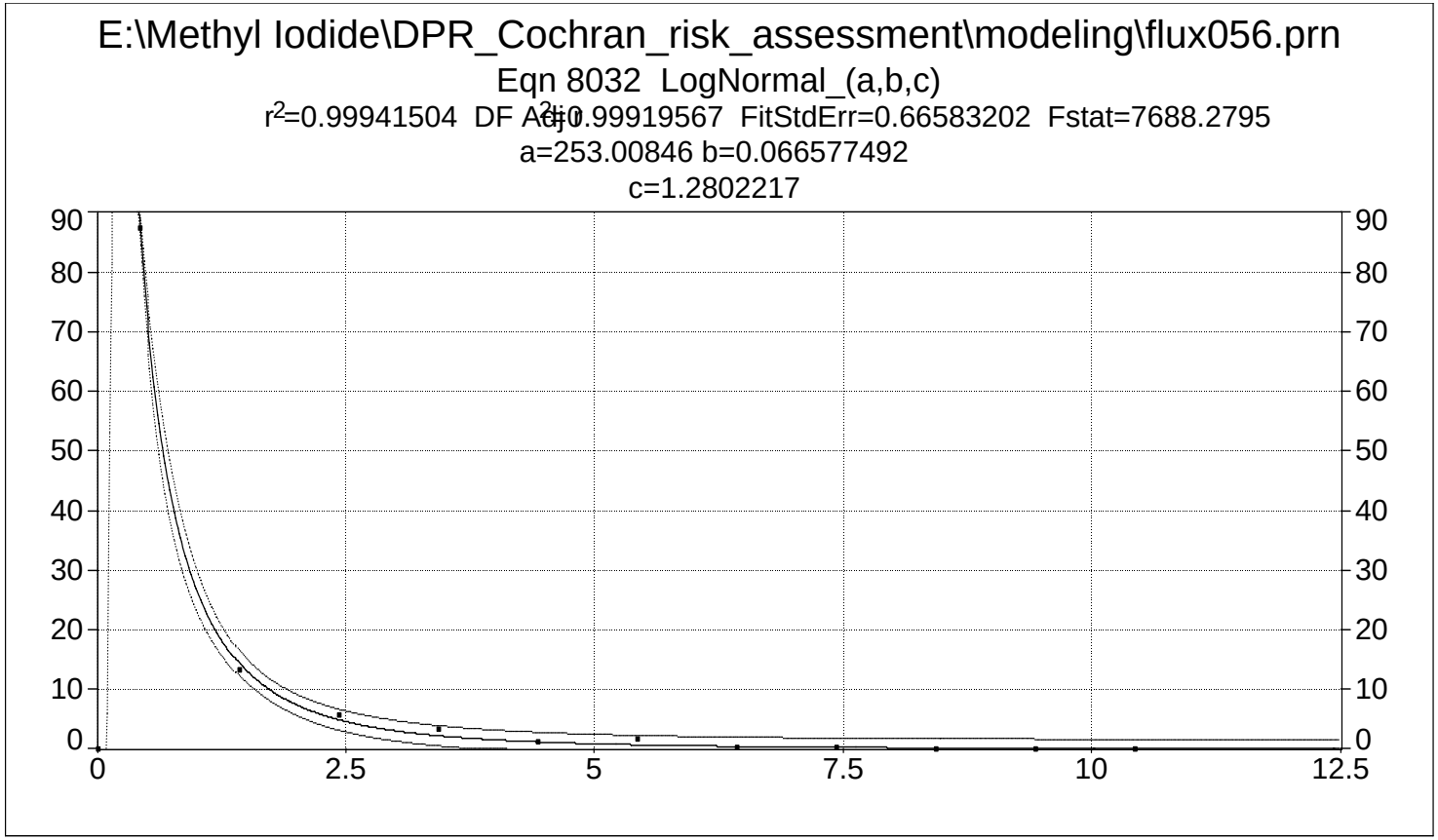
026 Manteca
Broadcast/tarp



Rank 1 Eqn 8032 LogNormal_(a,b,c)

XY	*	X Value	Y Value	Y Predict	Residual	Residual%	95% Confidence Limits		95% Prediction Limits		Weights
1		0.0000000	0.0000000								1
2		0.4300000	161.20000	161.62053	-0.420527	-0.260873	147.71704	175.52401	141.95328	181.28777	1
3		1.4300000	66.000000	59.422012	6.5779885	9.9666492	46.921775	71.922248	40.720421	78.123602	1
4		2.4300000	20.000000	31.593718	-11.59372	-57.96859	24.755255	38.432182	16.093455	47.093982	1
5		3.4300000	13.000000	19.684956	-6.684956	-51.42274	13.734926	25.634986	4.5556325	34.814280	1
6		4.4300000	18.500000	13.421508	5.0784921	27.451308	7.7227323	19.120284	-1.610778	28.453794	1
7		5.4300000	18.500000	9.7064289	8.7935711	47.532817	4.3461762	15.066682	-5.200814	24.613672	1
8		6.4300000	7.0000000	7.3199966	-0.319997	-4.571380	2.3698197	12.270173	-7.444753	22.084746	1
9		7.4300000	8.0000000	5.6968555	2.3031445	28.789307	1.1713012	10.222410	-8.931002	20.324713	1
10		8.4300000	7.5000000	4.5441430	2.9558570	39.411427	0.4255713	8.6627146	-9.962966	19.051252	1
11		9.4300000	3.0000000	3.6972963	-0.697296	-23.24321	-0.045840	7.4404328	-10.70773	18.102318	1
12		10.430000	3.0000000	3.0578933	-0.057893	-1.929778	-0.345569	6.4613560	-11.26262	17.378408	1

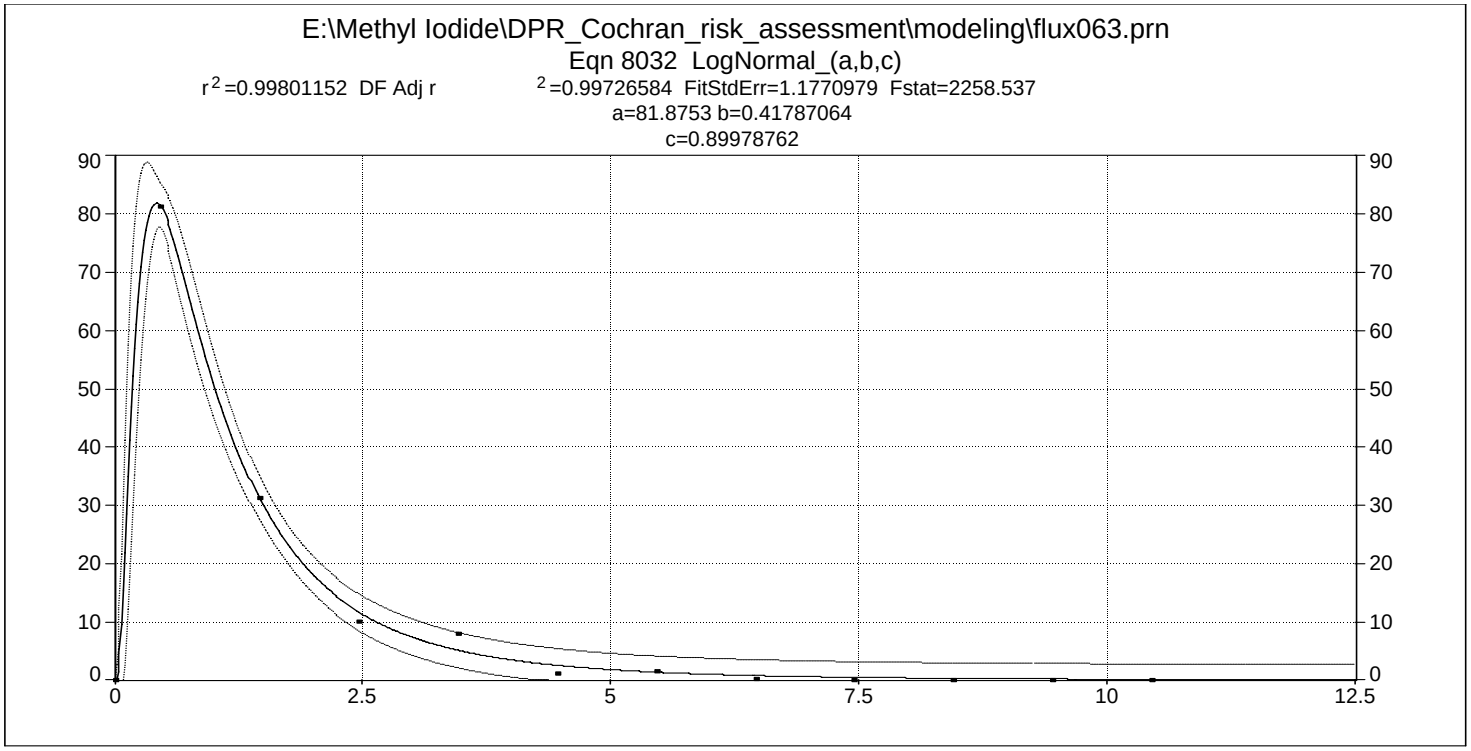
056 LaSelva Beach, California
Drip/Tarp



Rank 1 Eqn 8032 LogNormal_(a,b,c)

XY	*	X Value	Y Value	Y Predict	Residual	Residual%	95% Confidence Limits		95% Prediction Limits		Weights
1		0.0000000	0.0000000								1
2		0.4300000	87.600000	87.517959	0.0820408	0.0936539	86.011767	89.024151	85.387864	89.648054	1
3		1.4300000	13.400000	14.348797	-0.948797	-7.080578	12.876518	15.821077	12.242546	16.455049	1
4		2.4300000	5.7000000	4.8826428	0.8173572	14.339599	3.9656399	5.7996458	3.1192419	6.6460438	1
5		3.4300000	3.3500000	2.2099065	1.1400935	34.032641	1.4168010	3.0030120	0.5076418	3.9121712	1
6		4.4300000	1.3700000	1.1707592	0.1992408	14.543124	0.5537230	1.7877954	-0.456945	2.7984638	1
7		5.4300000	1.7000000	0.6863966	1.0136034	59.623728	0.2172734	1.1555199	-0.891185	2.2639787	1
8		6.4300000	0.2500000	0.4321646	-0.182165	-72.86585	0.0742734	0.7900559	-1.115987	1.9803167	1
9		7.4300000	0.2700000	0.2869597	-0.016960	-6.281369	0.0108052	0.5631142	-1.244363	1.8182827	1
10		8.4300000	0.0950000	0.1985869	-0.103587	-109.0388	-0.017364	0.4145373	-1.323032	1.7202055	1
11		9.4300000	0.1120000	0.1420635	-0.030063	-26.84237	-0.029065	0.3131923	-1.373843	1.6579704	1
12		10.430000	0.0500000	0.1044352	-0.054435	-108.8704	-0.032879	0.2417489	-1.408028	1.6168980	1

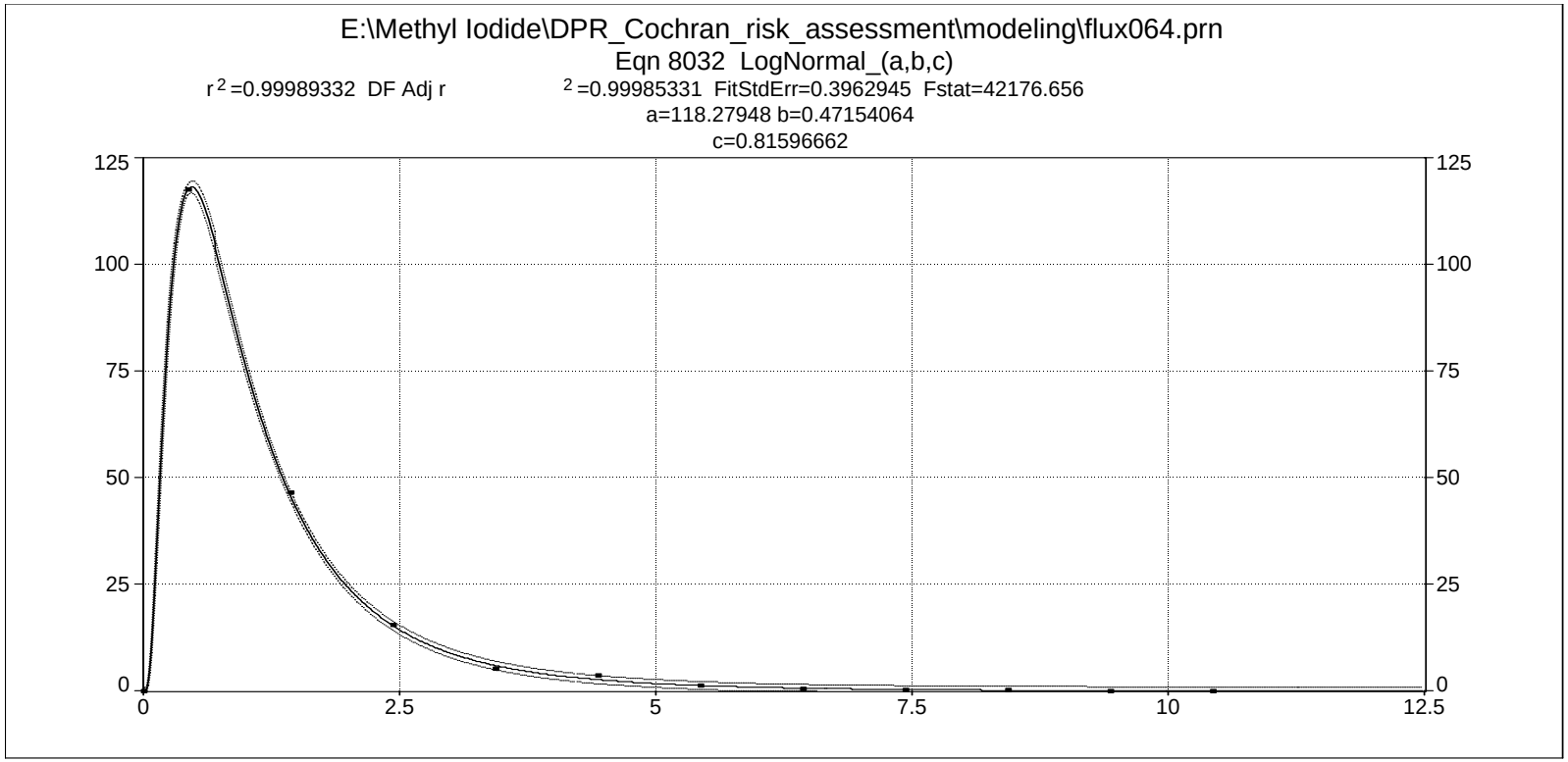
063 Camarillo, California
Drip/Tarp



Rank 1 Eqn 8032 LogNormal_(a,b,c)

XY	*	X Value	Y Value	Y Predict	Residual	Residual%	95% Confidence Limits		95% Prediction Limits		Weights
1		0.0000000	0.0000000								1
2		0.4600000	81.400000	81.410097	-0.010097	-0.012404	78.747555	84.072639	77.644525	85.175668	1
3		1.4600000	31.400000	31.145217	0.2547834	0.8114122	28.544839	33.745594	27.423340	34.867093	1
4		2.4600000	10.200000	11.756312	-1.556312	-15.25796	10.034303	13.478320	8.5852371	14.927386	1
5		3.4600000	8.0000000	5.1843372	2.8156628	35.195785	3.7144208	6.6542536	2.1427828	8.2258916	1
6		4.4600000	1.3000000	2.5676056	-1.267606	-97.50812	1.4893233	3.6458879	-0.305214	5.4404251	1
7		5.4600000	1.7000000	1.3855146	0.3144854	18.499139	0.6268568	2.1441725	-1.383233	4.1542618	1
8		6.4600000	0.3700000	0.7983049	-0.428305	-115.7581	0.2666348	1.3299750	-1.917035	3.5136450	1
9		7.4600000	0.1600000	0.4844065	-0.324407	-202.7541	0.1084439	0.8603691	-2.204784	3.1735973	1
10		8.4600000	0.1100000	0.3065380	-0.196538	-178.6709	0.0371015	0.5759745	-2.369839	2.9829152	1
11		9.4600000	0.0800000	0.2008490	-0.120849	-151.0613	0.0049367	0.3967613	-2.469129	2.8708267	1
12		10.460000	0.0500000	0.1355201	-0.085520	-171.0402	-0.008982	0.2800221	-2.531178	2.8022184	1

064 Guadalupe. California
Bed/Tarp



Rank 1 Eqn 8032 LogNormal_(a,b,c)

XY	*	X Value	Y Value	Y Predict	Residual	Residual%	95% Confidence Limits		95% Prediction Limits		Weights
1		0.0000000	0.0000000								1
2		0.4350000	117.70000	117.70300	-0.003004	-0.002553	116.80657	118.59944	116.43522	118.97079	1
3		1.4350000	46.700000	46.660998	0.0390019	0.0835158	45.776674	47.545322	45.401750	47.920246	1
4		2.4350000	15.600000	15.627740	-0.027740	-0.177821	14.988843	16.266637	14.526892	16.728588	1
5		3.4350000	5.5000000	6.1211787	-0.621179	-11.29416	5.6289493	6.6134080	5.0984535	7.1439039	1
6		4.4350000	3.7000000	2.7200787	0.9799213	26.484361	2.3978679	3.0422894	1.7674523	3.6727050	1
7		5.4350000	1.5000000	1.3299475	0.1700525	11.336832	1.1256154	1.5342796	0.4104755	2.2494195	1
8		6.4350000	0.5500000	0.7001924	-0.150192	-27.30770	0.5698866	0.8304981	-0.205709	1.6060934	1
9		7.4350000	0.3000000	0.3909902	-0.090990	-30.33008	0.3064695	0.4755110	-0.509466	1.2914462	1
10		8.4350000	0.3000000	0.2290643	0.0709357	23.645248	0.1731325	0.2849960	-0.669159	1.1272878	1
11		9.4350000	0.1500000	0.1396659	0.0103341	6.8893972	0.1019019	0.1774299	-0.757610	1.0369414	1
12		10.435000	0.1000000	0.0880843	0.0119157	11.915697	0.0620959	0.1140727	-0.808773	0.9849413	1

Appendix C – Chloropicrin (2-week) and Iodomethane (30-Day) Flux Profiles

Chloropicrin daily integrated flux profiles (ug/m^{2}sec - day)

Day	AZ broad/untarp 171 lb/ac	AZ bed/untarp 86 lb/ac	AZ bed/tarp 189 lb/ac	AZ broad/tarp 332 lb/ac	WA broad/tarp 343 lb/ac	FL broad/tarp 346 lb/ac	CA bed/drip/tarp 156 lb/ac
1	85.700	66.320	79.90	79.450	4.83	16.110	22.250
2	38.470	6.820	91.47	71.960	10.15	24.910	4.770
3	11.300	1.720	59.66	11.600	13.31	25.490	0.980
4	5.970	0.350	29.96	3.500	4.93	17.870	0.350
5	2.380	0.100	14.22	1.125	4.54	17.150	0.550
6	1.050	0.015	6.20	1.580	4.48	17.640	0.130
7	0.195	0.035	3.96	0.910	33.93	20.230	0.064
8	0.165	0.015	3.97	0.920	31.48	18.230	0.036
9	0.035	0.015	6.56	0.560	11.44	10.160	0.050
10	0.095	0.015	2.58	0.520	5.73	2.290	0.970
11	0.015	0.015	0.51	0.595	3.66	0.552	0.520
12	0.000	0.015	0.60	0.160	1.90	0.993	0.240
13	0.020	0.015	0.47	0.175	1.78	0.619	0.240
14	0.030	0.015	0.22	0.170	1.33	0.394	0.240
Proportion Applied Mass Lost	0.6246	0.6138	0.6864	0.6264	0.3379	0.3650	0.1520

007 Watsonville, California
Broadcast/Tarp

Day Midpoint	Proportion of 24hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.46	0.92	111.596	85.9289
1.46	1.00	32.200	24.7940
2.46	1.00	16.800	12.9360
3.46	1.00	11.000	8.4700
4.46	1.00	3.300	2.5410
5.46	1.00	5.900	4.5430
6.46	1.00	2.300	1.7710
7.46	1.00	1.900	1.4630
8.46	1.00	1.000	0.7700
9.46	1.00	0.560	0.4312
10.46	1.00	1.150	0.8855
11.46	1.00	0.950	0.7315
12.46	1.00	0.790	0.6083
13.46	1.00	0.670	0.5159
14.46	1.00	0.580	0.4466
15.46	1.00	0.500	0.3850
16.46	1.00	0.430	0.3311
17.46	1.00	0.380	0.2926
18.46	1.00	0.330	0.2541
19.46	1.00	0.300	0.2310
20.46	1.00	0.260	0.2002
21.46	1.00	0.240	0.1848
22.46	1.00	0.210	0.1617
23.46	1.00	0.190	0.1463
24.46	1.00	0.170	0.1309
25.46	1.00	0.160	0.1232
26.46	1.00	0.140	0.1078
27.46	1.00	0.130	0.1001
28.46	1.00	0.120	0.0924
29.46	1.00	0.110	0.0847

026 Manteca

Broadcast/tarp

Day Midpoint	Proportion of 24hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.43	0.86	161.20	106.747
1.43	1.00	66.00	50.820
2.43	1.00	20.00	15.400
3.43	1.00	13.00	10.010
4.43	1.00	18.50	14.245
5.43	1.00	18.50	14.245
6.43	1.00	7.00	5.390
7.43	1.00	8.00	6.160
8.43	1.00	7.50	5.775
9.43	1.00	3.00	2.310
10.43	1.00	3.00	2.310
11.43	1.00	2.56	1.971
12.43	1.00	2.17	1.671
13.43	1.00	1.86	1.432
14.43	1.00	1.61	1.240
15.43	1.00	1.40	1.078
16.43	1.00	1.23	0.947
17.43	1.00	0.00	0.000
18.43	1.00	0.00	0.000
19.43	1.00	0.00	0.000
20.43	1.00	0.00	0.000
21.43	1.00	0.00	0.000
22.43	1.00	0.00	0.000
23.43	1.00	0.00	0.000
24.43	1.00	0.00	0.000
25.43	1.00	0.00	0.000
26.43	1.00	0.00	0.000
27.43	1.00	0.00	0.000
28.43	1.00	0.00	0.000
29.43	1.00	0.00	0.000

056 LaSelva Beach, California

Drip/Tarp

Day Midpoint	Proportion of 24hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.43	0.86	75.336	58.0087
1.43	1.00	13.400	10.3180
2.43	1.00	5.700	4.3890
3.43	1.00	3.350	2.5795
4.43	1.00	1.370	1.0549
5.43	1.00	1.700	1.3090
6.43	1.00	0.250	0.1925
7.43	1.00	0.270	0.2079
8.43	1.00	0.095	0.0732
9.43	1.00	0.112	0.0862
10.43	1.00	0.050	0.0385
11.43	1.00	0.078	0.0601
12.43	1.00	0.060	0.0462
13.43	1.00	0.047	0.0362
14.43	1.00	0.037	0.0285
15.43	1.00	0.030	0.0231
16.43	1.00	0.024	0.0185
17.43	1.00	0.020	0.0154
18.43	1.00	0.016	0.0123
19.43	1.00	0.014	0.0108
20.43	1.00	0.011	0.0085
21.43	1.00	0.010	0.0077
22.43	1.00	0.008	0.0062
23.43	1.00	0.007	0.0054
24.43	1.00	0.006	0.0046
25.43	1.00	0.005	0.0039
26.43	1.00	0.005	0.0031
27.43	1.00	0.004	0.0031
28.43	1.00	0.003	0.0023
29.43	1.00	0.003	0.0023

063 Camarillo, California

Drip/Tarp

Day Midpoint	Proportion of 24hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.46	0.92	74.888	57.6638
1.46	1.00	31.400	24.1780
2.46	1.00	10.200	7.8540
3.46	1.00	8.000	6.1600
4.46	1.00	1.300	1.0010
5.46	1.00	1.700	1.3090
6.46	1.00	0.370	0.2849
7.46	1.00	0.160	0.1232
8.46	1.00	0.110	0.0847
9.46	1.00	0.080	0.0616
10.46	1.00	0.050	0.0385
11.46	1.00	0.094	0.0724
12.46	1.00	0.066	0.0508
13.46	1.00	0.048	0.0370
14.46	1.00	0.035	0.0270
15.46	1.00	0.026	0.0200
16.46	1.00	0.020	0.0154
17.46	1.00	0.015	0.0116
18.46	1.00	0.012	0.0092
19.46	1.00	0.009	0.0069
20.46	1.00	0.007	0.0054
21.46	1.00	0.006	0.0046
22.46	1.00	0.005	0.0039
23.46	1.00	0.004	0.0031
24.46	1.00	0.003	0.0023
25.46	1.00	0.002	0.0015
26.46	1.00	0.002	0.0015
27.46	1.00	0.002	0.0015
28.46	1.00	0.001	0.0008
29.46	1.00	0.001	0.0008

90 Guadalupe, California

Drip/Tarp

Day Midpoint	Proportion of 24hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.48	0.96	125.856	96.80
1.48	1.00	26.000	20.10
2.48	1.00	9.520	7.34
3.48	1.00	5.700	4.36
4.48	1.00	5.400	4.16
5.48	1.00	4.500	3.46
6.48	1.00	2.100	1.64
7.48	1.00	1.200	0.90
8.48	1.00	0.630	0.49
9.48	1.00	0.210	0.16
10.48	1.00	0.150	0.11
11.48	1.00	0.000	0.00
12.48	1.00	0.000	0.00
13.48	1.00	0.000	0.00
14.48	1.00	0.000	0.00
15.48	1.00	0.000	0.00
16.48	1.00	0.000	0.00
17.48	1.00	0.000	0.00
18.48	1.00	0.000	0.00
19.48	1.00	0.000	0.00
20.48	1.00	0.000	0.00
21.48	1.00	0.000	0.00
22.48	1.00	0.000	0.00
23.48	1.00	0.000	0.00
24.48	1.00	0.000	0.00
25.48	1.00	0.000	0.00
26.48	1.00	0.000	0.00
27.48	1.00	0.000	0.00
28.48	1.00	0.000	0.00
29.48	1.00	0.000	0.00

046 Oxnard, California

Bed/Tarp

Day Midpoint	Proportion of 24hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.43	0.86	186.4	74.4
1.43	1.00	71.0	53.8
2.43	1.00	29.0	22.4
3.43	1.00	11.0	8.9
4.43	1.00	7.0	5.4
5.43	1.00	8.0	6.3
6.43	1.00	0.0	0.0
7.43	1.00	0.0	0.0
8.43	1.00	0.0	0.0
9.43	1.00	0.0	0.0
10.43	1.00	0.0	0.0
11.43	1.00	0.0	0.0
12.43	1.00	0.0	0.0
13.43	1.00	0.0	0.0
14.43	1.00	0.0	0.0
15.43	1.00	0.0	0.0
16.43	1.00	0.0	0.0
17.43	1.00	0.0	0.0
18.43	1.00	0.0	0.0
19.43	1.00	0.0	0.0
20.43	1.00	0.0	0.0
21.43	1.00	0.0	0.0
22.43	1.00	0.0	0.0
23.43	1.00	0.0	0.0
24.43	1.00	0.0	0.0
25.43	1.00	0.0	0.0
26.43	1.00	0.0	0.0
27.43	1.00	0.0	0.0
28.43	1.00	0.0	0.0
29.43	1.00	0.0	0.0

064 Guadalupe, California

Bed/Tarp

Day Midpoint	Proportion of 24 hr (day)	Daily integrated flux (ug/m^{2}sec - day)	Daily mass loss (lb/acre)
0.435	0.87	78.8472	74.4
1.435	1.00	35.9590	53.8
2.435	1.00	12.0120	22.4
3.435	1.00	4.2350	8.9
4.435	1.00	2.8490	5.4
5.435	1.00	1.1550	6.3
6.435	1.00	0.4235	0.0
7.435	1.00	0.2310	0.0
8.435	1.00	0.2310	0.0
9.435	1.00	0.1155	0.0
10.435	1.00	0.0770	0.0
11.435	1.00	0.0439	0.0
12.435	1.00	0.0293	0.0
13.435	1.00	0.0200	0.0
14.435	1.00	0.0139	0.0
15.435	1.00	0.0100	0.0
16.435	1.00	0.0069	0.0
17.435	1.00	0.0054	0.0
18.435	1.00	0.0039	0.0
19.435	1.00	0.0031	0.0
20.435	1.00	0.0023	0.0
21.435	1.00	0.0015	0.0
22.435	1.00	0.0015	0.0
23.435	1.00	0.0010	0.0
24.435	1.00	0.0008	0.0
25.435	1.00	0.0008	0.0
26.435	1.00	0.0006	0.0
27.435	1.00	0.0005	0.0
28.435	1.00	0.0004	0.0
29.435	1.00	0.0003	0.0

Table 3. Summary of the iodomethane 2-week and 30-day factors to estimate the sub-chronic air concentrations.

Study (Application Method)	Study Effective Broadcast Application Rate (lb/ac)	3 Parameter Log-Normal Function R^2	First Sampling Interval Duration (hrs)	First Sampling Interval Proportion of 24 hrs	Study Reported Measured Proportion Mass Lost	2-week 24 hr average flux (ug/m^{2}sec)	2-week Mass lost (lb/ac)	2-week Proportion of Mass Applied	30-Day 24hr average flux (ug/m^{2}sec)	30-Day Mass Lost (lb/ac)	30-Day Proportion of Mass Applied
Watsonville, California (broadcast/tarp)	252	99.7 percent	22	0.92	0.58	13.58	146.0	0.58	6.48	150.0	0.59
Manteca, California (broadcast/tarp)	242	98.5 percent	19	0.86	0.94	22.1	238.0	0.98	10.47	242.0	1.00
LaSelva Beach, California (drip/tarp)	162	99.9 percent	19	0.86	0.45	7.27	78.4	0.48	3.40	78.5	0.48
Camarillo, California (drip/tarp)	119	99.8 percent	22	0.92	0.83	9.18	98.9	0.83	4.29	99.0	0.83
Guadalupe, California (drip/tarp)	139	-[1]	23	0.96	1.00	12.88	139.0	1.00	6.04	139.0	1.00
Oxnard, California (bed/tarp)	171	-[1]	19	0.86	1.00	15.85	171.0	1.00	7.40	171.0	1.00
Guadalupe, California (bed/tarp)	143	99.9%	21	0.87	0.97	12.68	136.8	0.96[2]	5.93	136.9	0.96[2]

[1] These two studies measured flux that results in 100 percent mass loss within the first 10 days.
[2] This mass loss differs slightly from 0.97 due to rounding difference between the study report and calculations in this memorandum.

Appendix A. Estimated Chloropicrin 2-week and Iodomethane 2-week and 30-Day Sub-chronic Off-site Air Concentrations.

Mary-Ann Warmerdam
Director

Department of Pesticide Regulation

Arnold Schwarzenegger
Governor

M E M O R A N D U M

TO: Randy Segawa, Environmental Program Manager I
Environmental Monitoring Branch

FROM: Terrell Barry, Ph.D., Research Scientist III *Original signed by*
Environmental Monitoring Branch
(916) 324-4140

DATE: August 21, 2008

SUBJECT: SCREENING LEVEL AIR CONCENTRATION ESTIMATES FOR WORKER HEALTH AND SAFETY EXPOSURE APPRAISALS

Background

The Department of Pesticide Regulation (DPR) exposure appraisals have relied exclusively on air concentrations measured in monitoring studies. However, measured air concentrations are limited in the context of estimating exposure because a measured air concentration results from a unique combination of application and meteorological conditions. The maximum air concentration associated with an application is unknown because it is unlikely that the highest air concentration present was captured by the finite set of air samplers. In addition, due to the dependence of measured air concentrations on specific application conditions, it is not possible to apply results obtained from a single study directly to other conditions. Methods have been develop using air dispersion models to generalize results from single monitoring studies so that results can be applied to other conditions.

Air dispersion models are mathematical models that describe and quantify the dispersal of pollutants in the atmosphere following release from point, line, volume, or area sources. Thus, the atmospheric processes known to disperse pollutants emitted from sources are characterized in an air dispersion model, allowing the estimation (prediction) of air concentrations at receptors located off-site around a source. In the case of soil fumigants it is only necessary to consider areas sources. More complex considerations are required to model commodity and structural fumigants.

The U.S. Environmental Protection Agency (U.S. EPA) Office of Air and Radiation and Office of Air Quality Planning and Standards administers the program which reviews and accepts candidate models as “preferred,” “alternative,” or “screening,” and maintains air dispersion model codes. This process insures uniformity in the models and modeling procedures among users. The “preferred” model status is required for State Implementation Plan revisions for existing sources and for New Source Review and Prevention of Significant Deterioration programs (40 CFR 51, Federal Register, 2005). The “preferred” models related to DPR applications are the AMS/EPA Regulatory Model (AERMOD) (U.S. EPA, 2004) and CALPUFF (Scire et al., 2000). The “alternative” model status allows for reviewed models to be used in

regulatory applications with case-by-case justification (Section 3.2, Appendix W, 40 CFR 51, Federal Register 2005). The reviewing authority in this case is DPR and the "alternative" model related to DPR applications is Industrial Source Complex Short Term Version 3 (ISCST3) air dispersion model (U.S. EPA, 1995). The ISCST3 model was a "preferred" model prior to the promulgation of the AERMOD model in December 2006 (40 CFR 51, Federal Register, 2005).

Since the 1990's, DPR has used the ISCST3 air dispersion model extensively (Johnson et al, 1999; Barry, 2000a, Johnson and Barry, 2005) to estimate off-site fumigant air concentrations. For the purposes of this project, DPR is not required to shift to either AERMOD or CALPUFF because these applications are not related to the State Implementation Plan or the Prevention of Significant Deterioration programs. In addition, the improvements gained by use of AERMOD are not implemented in the area source portion of that model. Use of CALPUFF has been considered. However, CALPUFF is a complex model that requires extensive meteorological inputs that are not readily available. While it is likely CALPUF will be integrated into the DPR modeling program in the future, at this time it is not in use.

The ISCST3 model uses a steady-state Gaussian plume dispersion equation to estimate downwind air concentrations from point, volume, and area pollutant sources. For fixed meteorological conditions, the Gaussian plume algorithm produces downwind air concentrations that are directly proportional to the emission rate (flux) of a pollutant. In addition, DPR has assumed that flux is directly proportional to the application rate (Segawa et al., 2000). The resulting proportional linkage between application rate and concentration simplifies calculations under fixed meteorological conditions.

The ISCST3 model can be used in three distinct ways: (1) the screening mode, (2) the PERFUM model, and (3) the FEMS model. For a chosen emission scenario, the screening mode produces a single air concentration estimate at a receptor (a point location at a specified distance from the source) using a single set of worst-case meteorological conditions. This means that a single downwind centerline set of air concentration estimates at various distances is the result of the analysis. Although there are differences in their approaches, the PERFUM and FEMS models are "probabilistic" in the sense that for a chosen emission scenario, historical weather data is used to produce multiple air concentration estimates at each receptor. This produces a distribution of air concentrations at a given receptor over the span of the meteorological data. Use of these distributions requires defining one or more key percentiles (e.g. 95th percentile) concentrations corresponding to key percentiles identified by risk managers.

The Worker Health and Safety (WHS) branch has chosen the screening mode for this project. This memorandum describes the method employed by DPR using air dispersion modeling to estimate screening level worst case air concentrations under the range of application methods

and rates expected for a given chemical. The fumigants, iodomethane, and chloropicrin will provide examples of this method.

Throughout this memorandum the air concentrations and flux represent time weighted averages (TWA) that are either measured over a single sampling interval or are composites of shorter time intervals. Air concentration results are dependent upon sample interval duration. If fumigant air concentrations at a fixed location were measured at 1 minute intervals for 24 hours (hrs) the resulting 24 point plot would show a sharply fluctuating function with many peaks and valleys due to the intermittency with which the fumigant plume contacted the air sampler. Fumigant application site monitoring seldom uses 1 minute sampling intervals. Instead, sampling intervals of 2 to 12 hrs are employed. An air sampler at a fixed location accumulates intermittent deposits of fumigant mass during a sampling interval. The total mass collected is divided by the total volume of air pulled through the sampler during the sampling interval and this quotient become the air concentration for that sampling interval. Flux measurements are based upon air concentration measurements so the same properties apply. Thus, a single sampling interval concentration measurement represents a TWA of the peaks and valley in the hidden, high frequency concentration function during the sampling interval. The same TWA properties apply to composites of several shorter intervals of varying duration into a longer average. The longer average is constructed as an average weighted according to the individual sampling interval durations.

Methods

There are two components to the process of obtaining air concentration estimates for use in a screening level exposure appraisal: (1) generic ISCST3 simulation results which can be adapted to the specifics of an exposure scenario and (2) specific elements in the exposure scenario which are utilized to adapt the generic simulation results. The generic ISCST3 simulation results consist of downwind air concentration estimates generated using fixed meteorological conditions and using a nominal flux of 100 ug/m^2s. Sets of generic concentration estimates are produced for different acreages and meteorological condition combinations. Exposure scenario elements are used to choose appropriate acreage and meteorological conditions and to adjust the downwind air concentrations. Exposure scenario elements consist of four, interrelated kinds of parameters: (1) expected application parameters (chemical, application size, application method and rate), (2) flux estimates from field studies, (3) health threshold averaging time and possibly concentration, and (4) meteorological conditions. Each input class will be discussed below.

(1) Expected Application Parameters

These parameters are either available from use patterns for registered pesticides, or must be specified for a new pesticide that is in the registration process. Typically, the largest single day application acreage labeled or expected is simulated as a square field. The largest single day application acreage may reflect label conditions or physical limitations on the size of an application that can be made in a single day. Although other field geometries may be more common in practice, for simulation and comparison purposes the square field presents a uniform case across chemicals, application methods and rates. In addition to the largest single day application acreage, the largest allowed application rate is also used. The largest allowed application rate may be smaller than the maximum labeled rate.

The application method must be adequately described and studied in at least one reviewed field study so that a flux profile can be developed. The flux profile characterizes the progression of flux values over time following the application. The application rate used for air dispersion modeling is the "effective broadcast application rate" (Barry et al., 2004) defined as the total mass of chemical applied to a field divided by the size of the field. This method of designating the application rate removes the consideration of "treated" versus "broadcast" acres. It makes no difference whether the total mass is applied to rows or broadcast because the application is modeled as a uniform area source.

(2) Flux Estimates from Field Studies

The flux profile is typically presented as a plot or table showing the flux value observed for each averaging period of the field study. The flux profile for an application method must be developed before air dispersion modeling to estimate air concentrations under various use scenarios can be conducted. The flux profile can be developed using either the back-calculation method (Johnson et al., 1999), or a direct flux estimation method (e.g., Majewski, et al., 1995). The fully characterized flux profile will have averaging intervals that match the sampling intervals used in the field study. These averaging intervals may not match the Health Threshold averaging time. In that case additional analysis is required to obtain the flux estimates used to adjust the generic centerline concentrations. The analysis method used to obtain the centerline adjustment flux values must be fully described. The relationship between the flux profile averaging times and the time of day should be preserved in the process of adjusting the generic centerline concentrations. Thus, a day flux is used only with the day conditions centerline and a night flux is used only with the night conditions centerline. In cases of averaging intervals that span sunrise or sunset, both day and night air concentration estimates should be calculated.

(3) Health Threshold Averaging Time and Concentration

The Health Threshold averaging time must be specified in order to designate the proper averaging time for the air concentration estimates. The health threshold concentration is not always used directly in the air dispersion modeling but it is required if the exposure appraisal includes distances to specific air concentrations. If the Health Threshold averaging time is significantly shorter than the sampling intervals in the field study and the fumigant of interest has very short-term irritant properties then it may be necessary to apply a peak-to-mean adjustment (Barry, 2000b) to the estimated air concentrations. Application of the peak-to-mean adjustment can be viewed as a component of risk management and should be discussed with the exposure assessment team. Thus, the peak-to-mean adjustment is not necessarily applied simply because the flux sampling interval is longer than the desired Health Threshold Averaging Time.

(4) Meteorological Conditions

The meteorological data is considered screening level and represents reasonable worst case. The choice of screening level meteorological conditions depend upon the Health Threshold averaging time and, for averaging times shorter than 24 hrs, night versus day. For a Health Threshold averaging time of 24 hrs (e.g. methyl bromide) the screening conditions are wind speed of 1.4 m/s and atmospheric stability of slightly unstable (Class C in the Pasquill-Gifford classification scheme) (Johnson and Barry, 2005). For Health Threshold averaging times shorter than 24 hrs, day screening conditions are wind speed of 1.0 m/s and atmospheric stability class of neutral (Class D in the Pasquill-Gifford classification scheme) (Barry et al., 2004) and night screening conditions are wind speed of 1.0 m/s and atmospheric stability moderately stable (Class F in the Pasquill-Gifford classification scheme) (Barry, 2000c, Barry et al. 2004).

Example 1: Estimated Iodomethane Air Concentrations

The U.S. EPA recently granted iodomethane a conditional registration (U.S. EPA, 2007). As part of the registration process the registrant conducted eight studies to characterize the flux profile of iodomethane following application to soil by three different methods: broadcast/tarp, bed/tarp, and drip/tarp (Baker et al., 2001; Baker et al., 2002 a; Baker et al., 2002b; Baker et al., 2003; Baker et al., 2004a; Baker et al., 2004b; Baker et al, 2004c).

Iodomethane is under review for registration in California. The DPR iodomethane exposure appraisal will use off-site air concentrations that were estimated using screening air dispersion modeling. The process to produce those air concentration estimates is described and illustrated in this section. The full set of air concentration estimates developed for the WHS chloropicrin exposure appraisal are shown in Appendix A. Table 1 shows the iodomethane field studies conducted, the treated area application rate, the effective broadcast application rate, and the proportional factor needed to adjust from the effective broadcast rate in the study to the expected

label application rates. Some of the field studies were conducted at application rates higher than those now labeled under the federal conditional registration. The proportion of the study effective broadcast rate can be used to adjust air concentrations to the desired effective broadcast application rate for various use scenarios. The 175 lb/acre adjustment factor is calculated by dividing 175 lb/ac by the study effective broadcast application rate.

Table 2 shows the flux estimates for three averaging times obtained from each study flux profile. The three averaging times shown (24, 8, and 1 hr) are those requested by WHS and included in the DPR iodomethane exposure appraisal. The flux estimates in Table 2 are the highest flux values obtained using the study flux profiles and a rolling average method where necessary to obtain the highest flux for each of the desired Health Threshold averaging periods (24, 8, and 1 hr). The total interval of time associated with each TWA flux is shown in parentheses in Table 2. The TWA intervals vary because studies do not always have sampling interval durations that match the Health Threshold averaging time. Ideally, the TWA flux should be over a period equal to or shorter than the desired Health Threshold averaging time. For a constant flux, an air concentration measured at a particular receptor is a function of averaging time. Under those conditions, air concentrations taken over shorter intervals will be higher relative to those taken over longer intervals. This phenomenon is well described in air dispersion theory literature (Csanady, 1973; Pasquill, 1974)

To calculate the 24 hr screening air concentration estimates the appropriate flux estimates were obtained by taking rolling weighted averages until the largest 24 hr flux was obtained. The interval durations for the 24 hr flux were between 19 and 24 hrs. In all cases the first 24 hrs yielded the highest 24 hr TWA flux. For the 8 hr air concentration estimates the flux estimates were obtained by taking rolling weighted averages of sampling periods between 2 and 4 hrs duration. Thus, the 8 hr flux estimates are based on 6 hr to and 8 hr weighted averages.

To calculate 1 hr screening air concentrations it is necessary to estimate maximum 1 hr flux. Obtaining 1 hr flux estimates can be problematic. In most studies the sampling intervals will be longer than 1 hr, and commonly no smaller than 4 hrs. However, several of the Iodomethane studies had early sampling intervals of 2 or 3 hrs. Thus, the 1 hr air concentration estimates flux estimates measured in sampling intervals ranging from 2 to 4 hrs were used directly. An alternative is to use a “peak-to-mean” adjustment to account for estimating a shorter duration concentration from longer duration concentrations (Barry, 2000b). WHS has opted not to use the peak to mean adjustments for the 1 hr modeled air concentrations because iodomethane is not an acute irritant (unlike chloropicrin or other irritants) and the averaging times of the sampling intervals were judged close enough to 1 hr to use directly from the study results.

The process of producing the 24 hr screening air concentration estimates for the Manteca broadcast/tarp application method and a 40 acre square field is illustrated in Table 3. The

remaining estimates for other application methods and locations can be found in Appendix A. The third column of Table 3 shows the generic downwind centerline air concentrations at 6 distances between 3.04 m (10 ft) and 760 m (2500 ft) from the application edge. These air concentrations were produced at a receptor height of 1.2 m representing the human breathing zone using the ISCST3 model with inputs of a 40 acre square source, generic flux (100 ug/m^2sec), the standard weather data for 24 hrs (1.4 m/s wind speed and C stability; see Johnson and Barry, 2005). These generic downwind centerline air concentrations can be used for any fumigant that uses a 24 hr Health Threshold averaging time. Only the fumigant/application method combination specific adjustment for the flux and application rate is needed to produce scenario specific air concentration estimates.

For this Manteca Broadcast/Tarp application method iodomethane study, the adjustment factors are as follows (see Table 2, row 2):

The field study has a 24 hr TWA flux estimate = 160.2 ug/m^2s

The flux adjustment factor (multiplier) for the generic air concentrations is calculated as:

$$(160.2 \text{ ug/m}^2\text{s}) / (100 \text{ ug/m}^2\text{s}) = 1.602$$

This multiplier is applied to the downwind centerline concentrations as follows:

3.04 m generic downwind centerline air concentration = 2589.13 ug/m^3

3.04 m 242 lb/ac broadcast/tarp downwind centerline air concentration =

$$(1.602)(2589.13 \text{ ug/m}^3) = 4147.8 \text{ ug/m}^3$$

The 4147.8 ug/m^3 result is shown in column 4 of Table 3.

The next application rate factor is calculated.

The 175 lb/ac application rate adjustment =

$$(175/242) = 0.72$$

The 3.04 m 175 lb/ac broadcast/tarp downwind centerline concentration =

$$(0.72)(4147.8) = 2986.4$$

It is recommended that the air concentration estimates be rounded to 2 significant figures for use in the exposure appraisals.

The generic downwind centerline air concentrations for averaging times shorter than 24 hrs use the standard weather conditions for day (1.0 m/s and D stability) and night (1.0 m/s and F stability). The relationship between the flux profile as it was developed in the field study and the diurnal cycle is preserved. Thus, to produce the estimates, the highest day averaging time flux is matched with the day standard weather conditions, while the highest night averaging time flux is matched with the night standard weather conditions. The scenario producing the highest off-site air concentration is emphasized in the air concentration estimation. As an example of the shorter averaging time, Tables 4 and 5 show the day 1 hr TWA and the day 8 hr TWA (respectively) iodomethane air concentration estimates for the Manteca study.

The Generic day 1 hr air concentrations (Table 4) are produced with the standard day meteorological conditions (D-stability and 1 m/s wind speed) and generic flux of 100 ug/m^{2}sec.

The calculations are as follows:

The Manteca broadcast/tarp field study has a 1 hr TWA flux estimate = 481.0 ug/m^{2}sec (Table 2).

The flux adjustment factor (multiplier) is calculated as:

$$(481.0 \text{ ug/m}^2\text{s}) / (100 \text{ ug/m}^2\text{s}) = 4.810$$

This multiplier is applied to the downwind centerline concentrations as follows:

3.04 m generic downwind centerline air concentration = 5181.70 ug/m^3

3.04 m 242 lb/ac broadcast/tarp downwind centerline air concentration =

$$(4.810)(5181.70 \text{ ug/m}^3) = 24924.0 \text{ ug/m}^3$$

The 24924.000 ug/m^3 result is shown in column 4 of Table 4.

The results for the 175 lb/ac application rate are shown in column 5 of Table 4.

The 175 lb/ac application rate adjustment =

$$(175/242) = 0.72$$

The 3.04 m 175 lb/ac broadcast/tarp downwind centerline concentration =

$$(0.72)(24924.0) = 17945.3$$

The Generic day 8 hr air concentrations are produced with the standard day meteorological conditions (D-stability and 1 m/s wind speed) and generic flux of 100 ug/m^{2}sec. The Generic Day 8 hr air concentrations are the same as the Generic Day 1 hr TWA concentrations because the meteorological conditions and the generic flux are the same. The difference in final screening air concentrations is accounted for in the flux estimates, which are measured over different averaging times. The calculations are as follows:

The field study has an 8 hr flux estimate = 313.7 ug/m^{2}sec (Table 2).

The flux adjustment factor (multiplier) for the generic air concentrations is calculated as:

$$(313.7 \text{ ug/m}^2\text{s}) / (100 \text{ ug/m}^2\text{s}) = 3.14$$

This multiplier is applied to the downwind centerline concentrations as follows:

3.04 m generic downwind centerline air concentration = 5181.700 ug/m^3

3.04 m 242 lb/ac broadcast/tarp downwind centerline air concentration =

$$(3.14)(5181.70\text{ug/m}^3) = 16270.5 \text{ ug/m}^3$$

The 16270.500 ug/m^3 result is shown in column 4 of Table 5.

The next application rate factor is calculated.

The 175lb/ac application rate adjustment =

$$(175/242) = 0.72$$

The 3.04m 175lb/ac broadcast/tarp downwind centerline concentration =

$$(0.72)(16270.5) = 11714.8$$

Estimated air concentrations for all 8 iodomethane field studies under all meteorological and averaging time scenarios can be found in Appendix A.

Example 2: Chloropicrin

The full set of air concentration estimates developed for the WHS chloropicrin exposure appraisal are shown in Appendix B. Flux profiles for 5 application methods are available: broadcast/untarp, bed/untarp, bed/tarp, broadcast/tarp, and bed/drip/tarp. (Beard, 1996; Rotandardo, 2004). The broadcast/tarp application method has three flux profiles from three separate field studies in Arizona, Washington, and Florida. The Health Threshold averaging times for the chloropicrin exposure appraisal are 24, 6, and 1 hr. A summary of the field study application methods and rates and the flux estimates used for the chloropicrin exposure appraisal are shown in Table 6.

The process of producing the night 1 hr chloropicrin air concentration estimates for the Arizona broadcast/tarp application method and a 40 acre square field is illustrated in Table 7. The estimates for other application methods and locations can be found in Appendix B. The shortest sampling interval in the Arizona broadcast/tarp field study was 6 hrs. Consequently the 1 hr air concentration estimation will begin with results for the 6 hr averaging time. Then the peak-to-mean adjustment is made to the 6 hr air concentrations to obtain the 1 hr air concentration estimates. The WHS branch has requested the use of the peak-to-mean adjustment because chloropicrin is an irritant at low concentrations.

The third column of Table 7 shows the generic night 6 hr downwind centerline air concentrations at 6 distances between 3.04 m (10 ft) and 760 m (2500 ft) from the application edge. These air concentrations were produced at a receptor height of 1.2 m (representing the human breathing zone) using the ISCST3 model with inputs of a 40 acre square source, generic flux (100 ug/m^{2}sec), the standard weather data for 6 hr night conditions (1 m/s wind speed and F stability). These generic downwind centerline air concentrations can be used for any fumigant that uses a 6 hr threshold averaging time, and, in fact were used to produce the chloropicrin night 6 hr air concentration estimates (see Appendix B). These concentrations are considered 6 hr concentrations because the averaging time on the flux estimate is 6 hours. The 6 hr sampling interval is the shortest interval in the Beard et al. (1996) study. Hence, in this case it is used as the basis to generate 1 hr air concentrations using peak-to-mean adjustment methods (Barry, 2000b).

For this Arizona Broadcast/Tarp application method chloropicrin study, the adjustment factors are as follows (see Table 7):

The field study has a night 6 hr flux estimate = 30.15 ug/m^{2}sec

The 332 lb/acre application rate flux adjustment factor (multiplier) for the generic air concentrations is calculated as:

$$(30.15\ ug/m^2s) / (100\ ug/m^2s) = 0.3015\ (Table\ 6).$$

This flux adjustment multiplier is applied to the 6 hr generic downwind centerline concentrations as follows:

3.04 m generic downwind centerline 6 hr air concentration = 8329.80 ug/m^3

3.04 m 332 lb/ac broadcast/tarp downwind centerline air concentration =

$$(0.3015)(8329.80\ ug/m^3) = 2511.4\ ug/m^3$$

The night 6 hr air concentration estimate of 2511.4 ug/m^3 is shown for the downwind distance of 3.04 m in column 4 of Table 7. The next step is to develop the 1 hr air concentration estimate for this application rate by applying the peak-to-mean adjustment to the 6 hr estimates as follows:

The peak-to-mean adjustment for 6 hrs to 1 hr = 2.45

This multiplier is applied to the 6 hr air concentration estimates in column 4 of Table 7 as follows:

$$(2.45)*(2511.4) = 6153.0$$

Results of this adjustment are shown in column 5 of Table 7.

The next application rate is calculated.

The estimates for 350 lb/ac application rates are made as follows:

$$\text{application rate adjustment} = (350/332) = 1.0542$$

This adjustment is applied to the 332 lb/ac 6 hr TWA concentrations in column 4 of Table 7:

$$(1.0542)*(2511.4) = 2647.6$$

Results are shown in Column 6 of Table 7. The peak-to-mean adjustment of 2.45 is then applied to the 350 lb/acre 6 hr air concentration estimates shown in Column 6 to produced the 1 hr air concentration estimates:

$$(2.45)*(2647.6) = 6486.5$$

The 1 hr air concentration estimates for 350 lb/ac are shown in Column 7 or Table 7.

It is recommended that the air concentration estimates be rounded to 2 significant figures for use in the exposure appraisals.

Summary

These air dispersion modeling methods can be used to produce worst case exposure appraisal air concentration estimates for any fumigant that has a developed flux profile. The Health Threshold averaging time, application rates, and maximum field size are fumigant specific. However, the basic procedures would be similar.

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Table 1. Iodomethane studies used to estimate off-site air concentrations.

Study	Application Method	Study Treated Acre Application Rate[a]	Study Effective Broadcast Application Rate	175 lb/acre Adjustment Factor	87.5 lb/acre Adjustment Factor
Watsonville, California	Broadcast/Tarp	252	252	0.69	0.35
Manteca, California	Broadcast/Tarp	242	242	0.72	0.36
Oxnard, California	Bed/Tarp	244	171	1.02	0.51
Guadalupe, California	Bed/Tarp	179	143	1.22	0.61
LaSelva Beach, California	Drip/Tarp	235	162	1.08	0.54
Camarillo, California	Drip/Tarp	175	119	1.47	0.74
Guadalupe, California	Drip/Tarp	174	139	1.26	0.63

a. This application rate is the "treated acre" rate which is only the treated soil area excluding nontreated areas such as furrows. For broadcast application methods the Study Application Rate and the Study Effective Broadcast Application Rate will be the same. For bed type applications an adjustment must be made to the Study Application Rate to account for the portions of the field that are untreated. See the text for details of the calculation.

Table 2. Flux estimates for iodomethane studies used to estimate off-site air concentrations. With the exception of LaSelva Beach, the 8 hr and 1 hr scenarios both exhibited the highest flux and highest air concentrations during the day. Both day and night air concentrations were provided for the LaSelva Beach study (See Appendix A). The remainder of the studies focused on the day scenario.

Study Location	Application Method	Study Application Rate[a]	Study Effective Broadcast Application Rate	24 hr flux (ug/m^{2}sec) (hrs)[b]	8 hr flux (day) (ug/m^{2}sec) (hrs)	1 hr flux (day) (ug/m^{2}sec) (hrs)
Watsonville, California	Broadcast/ Tarp	252	252	120.9 (22.0)[b]	234.2 (8.1)	N/A[c]
Manteca, California	Broadcast/ Tarp	242	242	160.2 (19.0)	313.7 (8.0)	481.0 (3.3)
Oxnard, California	Bed/Tarp	244	171	186.4 (18.9)	265.6 (8.2)	535.0 (2.6)
Guadalupe, California	Bed/Tarp	179	143	117.7 (21.0)	153.1 (7.0)	171.4 (3.0)
LaSelva Beach, California	Drip/Tarp	235	162	87.6 (19.0)	187.5 (7.0)	198.0 (3.0)
Camarillo, California	Drip/Tarp	175	119	81.4 (22.0)	153.4 (8.0)	242.1 (4.0)
Guadalupe, California	Drip/Tarp	174	139	131.1 (23.0)	296.1 (7.0)	429.8 (3.0)

a. This application rate is the "treated acre" rate. For broadcast application methods the Study Application Rate and the Study Effective Broadcast Application Rate will be the same. For bed type applications an adjustment must be made to the Study Application Rate to account for the portions of the field that are untreated. See the text for details of the calculation.

b. The number in parentheses is the sampling interval duration in hrs.

c. It was not possible to estimate a 1 hr flux for this study.

Table 3. Screening 24 hr air concentration estimates for a square 40 acre iodomethane Manteca broadcast/tarp application. The generic 24 hr air concentrations are produced with the standard 24 hr meteorological conditions (C-stability and 1.4 m/s wind speed) and generic flux of 100 ug/m^{2}sec. The direct proportionality of air concentrations to flux and flux to application rate allows a simple adjustment of the generic 24 hr air concentrations to obtain air concentrations for other application rates and flux values. In this case, the field study had an effective broadcast application rate of 242 lb/ac with a flux of 160.2 ug/m^{2}sec. The first step adjusts for the flux by using the multiplier (160.2/100) = 1.602. Thus, for example, (1.602)(2589.13) = 4147.8. The second step adjusts for application rate. The 175 lb/ac application rate adjustment is (175/242) = 0.72 and the final screening air concentration estimate is obtained by (0.72)(4147.8) = 2986.4. Air concentration estimates should be rounded to two significant figures. Small rounding differences may occur.

Distance (ft)	Distance (m)	Generic 24 hr Air concentration (ug/m^3)	242 lb/ac application rate Air concentration (ug/m^3)	175 lb/ac application rate Air concentration (ug/m^3)
10	3.04	2589.13	4147.8	2986.4
50	15.2	2350.75	3765.9	2711.5
100	30.4	2018.72	3234.0	2328.5
300	91.2	1373.99	2201.1	1584.8
500	152	1083.24	1735.4	1249.5
2500	760	379.24	607.6	437.4

Table 4. Screening day 1 hr air concentration estimates for a square 40 acre iodomethane Manteca broadcast/tarp application. The generic day 1hr air concentrations are produced with the standard day meteorological conditions (D-stability and 1 m/s wind speed) and generic flux of 100 ug/m^{2}sec. The direct proportionality of air concentrations to flux and flux to application rate allows a simple adjustment of the generic day 1hr air concentrations to obtain air concentrations for other application rates and flux values. In this case, the field study had an effective broadcast application rate of 242 lb/ac with a 1 hr flux of 481.0 ug/m^{2}sec. The first step adjusts for the flux by using the multiplier (481.0/100) = 4.81. Thus, for example, (4.81)(5181.70) = 24924.00. The second step adjusts for application rate. The 175 lb/ac application rate adjustment is (175/242) = 0.72 and the final screening air concentration estimate is obtained by (0.72)(24924.0) = 17945.3. Air concentration estimates should be rounded to two significant figures. Small rounding differences may occur.

Distance (ft)	Distance (m)	Generic Day 1 hr Air Concentration (ug/m^3)	242 lb/ac application rate Air concentration (ug/m^3)	175 lb/ac application rate Air concentration (ug/m^3)
10	3.04	5181.700	24924.00	17945.30
50	15.2	4838.100	23271.30	16755.30
100	30.4	4444.500	21378.00	15392.20
300	91.2	3178.900	15290.50	11009.20
500	152	2560.200	12314.60	8866.50
2500	760	1044.900	5026.00	3618.70

Table 5. Screening day 8 hr air concentration estimation for a square 40 acre iodomethane Manteca broadcast/tarp application. The generic day 8 hr air concentrations are produced with the standard day meteorological conditions (D-stability and 1 m/s wind speed) and generic flux of 100 ug/m^{2}sec. The generic day 8 hr air concentrations are the same as the generic day 1 hr air concentrations because the meteorological conditions and the generic flux are the same. The difference in air concentrations is accounted for in the flux estimates, which are measured over different averaging times. The direct proportionality of air concentrations to flux and flux to application rate allows a simple adjustment of the generic day 8 hr air concentrations to obtain air concentrations for other application rates and flux values. In this case, the field study had an effective broadcast application rate of 242 lb/ac with a day 8 hr flux of 313.7 ug/m^{2}sec. The first step adjusts for the flux by using the multiplier (313.7/100) = 3.14. Thus, for example, (3.14)(5181.70) = 16270.5. The second step adjusts for application rate. The 175 lb/ac application rate adjustment is (175/242) = 0.72 and the final screening air concentration estimate is obtained by (0.72)(16270.5) = 11714.8. Air concentration estimates should be rounded to two significant figures. Small rounding differences may occur.

Distance (ft)	Distance (m)	Generic Day 8 hr Air Concentration (ug/m^3)	242 lb/ac application rate Air concentration (ug/m^3)	175 lb/ac application rate Air concentration (ug/m^3)
10	3.04	5181.70	16270.5	11714.8
50	15.2	4838.10	15191.6	10938.0
100	30.4	4444.50	13955.7	10048.1
300	91.2	3178.90	9981.7	7186.9
500	152	2560.20	8039.0	5788.1
2500	760	1044.90	3281.0	2362.3

Table 6. Flux estimates for chloropicrin studies used to estimate off-site air concentrations. With the exception of the California Bed/Drip/Tarp study, all sampling intervals were either 6 or 12 hrs.

Study Location	Application Method	Study Application Rate[a] (lb/acre)	Study Effective Broadcast Application Rate (lb/acre)	24 hr flux (ug/m^2sec)	6 hr flux (day) (ug/m^2sec)[b]	6 hr flux (night) (ug/m^2sec)[b]
Arizona	Broadcast/Untarp	171	171	86	50	180
Arizona	Bed/Untarp	149	86	66	114	113
Arizona	Bed/Tarp	377	189	108	132	142
Arizona	Broadcast/Tarp	332	332	111	211	30
Washington	Broadcast/Tarp	343	343	34	70	20
Florida	Broadcast/Tarp	346	346	28	58	22
California	Bed/Drip/Tarp	300	156	22	47[c]	5[c]

a. This application rate is the "treated acre" rate. For broadcast application methods the Study Application Rate and the Study Effective Broadcast Application Rate will be the same. For bed type applications an adjustment must be made to the Study Application Rate to account for the portions of the field that are untreated
b. For 1 hr concentrations, the 6 hr flux was used to estimate 6 hr air concentrations. Then a peak-to-mean adjustment was made to the 6 hr air concentrations to derive the 1 hr air concentrations.
c. These two flux estimates are 8 hr due to the sampling intervals in the study

Table 7. Screening night 6 hr and night 1 hr air concentration estimates for a square 40 acre chloropicrin Arizona broadcast/tarp application. In this field study (Beard, 1996) the shortest sampling interval averaging time was 6 hrs. So, the generic night 1 hr air concentrations were produced starting with the standard 6 hr meteorological conditions (F-stability and 1 m/s wind speed) and generic flux of 100 ug/m^{2}sec. A peak-to-mean adjustment (Barry, 2000b) is made to obtain 1 hr generic air concentration estimates. Direct proportionality of air concentrations to flux and flux to application rate allows a simple adjustment of the generic night 6 hr air concentrations to obtain air concentrations for other application rates and flux values. In this case, the field study had an effective broadcast application rate of 332 lb/ac with a flux of 30.15 ug/m^{2}sec. The first step adjusts for application rate by using the multiplier (30.15/100) = 0.3015. Thus, for example, (0.3015)(8329.80) = 2511.4. The 350lb/ac application rate adjustment is (350/332) = 1.0542 and the air concentration estimate is obtained by (1.0542)(2511.4) = 2647.6. The peak-to-mean adjustment was made to the 6-hr estimates: for the 332 lb/acre application rate (2.45)(2511.4) = 6153.0 and for the 350 lb/acre application rate (2.45)(2647.6) = 6486.5. Air concentration estimates should be rounded to 2 significant figures. Small rounding differences may occur.

Distance (ft)	Distance (m)	Generic Night 6 hr Air Concentration (ug/m^3)	332 lb/ac Application Rate Night 6 hr Air Concentration (ug/m^3)	332 lb/ac Application Rate Peak-to-Mean Adjusted Night 1 hr Air Concentration (ug/m^3)	350 lb/ac Application Rate Night 6 hr Air Concentration (ug/m^3)	350 lb/ac Application Rate Peak-to-Mean Adjusted Night 1 hr Air Concentration (ug/m^3)
10	3.04	8329.8	2511.4	6153.0	2647.6	6486.5
50	15.2	8285.1	2498.0	6120.0	2633.3	6451.7
100	30.4	8058.3	2429.6	5952.5	2561.3	6275.1
300	91.2	6419.2	1935.4	4741.7	2040.3	4998.7
500	152	5341.6	1610.5	3945.7	1697.8	4159.6
2500	760	2377.9	716.9	1756.5	755.8	1851.7

Iodomethane
40ac 1hr day

All Concentrations are ug/m3**
Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

			vol 52875-007 Watsonville broad/tarp		**vol 52875-026 Manteca broad/tarp**		**vol 52875-046 Oxnard bed/tarp**			**vol 52875-056 LaSelva Beach drip/tarp**			**vol 52875-063 Camarillo drip/tarp**			**vol 52875-064 Guadalupe bed/tarp**			**vol 52875-089 Guadalupe drip/tarp**		
distance (	**distance (r**	**Nominal flux concentration 100ug/m**2/sec**	**252 lb/ac**	**175 lb/ac**	**242 lb/ac**	**175 lb/ac**	**171 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**162 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**119 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**143 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**139 lb/ac**	**175 lb/ac**	**87.5 lb/ac**
10	3.04	5181.70	N/A	N/A	24924.0	17945.3	27722.1	28276.5	14138.3	10259.8	11080.5	5540.3	12539.7	18433.4	9279.4	8860.7	10810.1	5405.0	22281.3	28074.5	14037.2
50	15.2	4838.10			23271.3	16755.3	25883.8	26401.5	13200.8	9579.4	10345.8	5172.9	11708.2	17211.1	8664.1	8273.2	10093.2	5046.6	20803.8	26212.8	13106.4
100	30.4	4444.50			21378.0	15392.2	23778.1	24253.6	12126.8	8800.1	9504.1	4752.1	10755.7	15810.9	7959.2	7600.1	9272.1	4636.1	19111.3	24080.3	12040.2
300	91.2	3178.90			15290.5	11009.2	17007.1	17347.3	8673.6	6294.2	6797.8	3398.9	7692.9	11308.6	5692.8	5435.9	6631.8	3315.9	13669.3	17223.3	8611.6
500	152	2560.20			12314.6	8866.5	13697.1	13971.0	6985.5	5069.2	5474.7	2737.4	6195.7	9107.7	4584.8	4377.9	5341.1	2670.5	11008.9	13871.2	6935.6
2500	760	1044.90			5026.0	3618.7	5590.2	5702.0	2851.0	2068.9	2234.4	1117.2	2528.7	3717.1	1871.2	1786.8	2179.9	1089.9	4493.1	5661.3	2830.6
		flux adjustment*			4.81		5.35			1.98			2.42			1.71			4.3		
		app rate multiplier#				0.72		1.02	0.51		1.08	0.54		1.47	0.74		1.22	0.61		1.26	0.63

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (4.81)*(5181.7) = 24924
# this multiplier scales the concentrations from the study to the desired application rate e.g.: (0.72)*(24924) = 17945
the application rate multiplier is calculated as: 175/242 = 0.72 and scales the application rate down from 242lb/ac to 175lb/ac
Any additional effective broadcast application rates can be obtained by calculating the app rate multiplier.
Example: drip/tarp 87.5 app rate multiplier = 87.5/171 = 0.51
the concentrations in the "drip/tarp 171" column multipled by 0.51 gives estimated concentration for 87.5lb effective broadcast
this scenario would be 175lbs in the beds and beds 50% of the field area.

Chloropicrin
40ac 1hr night

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
		24hr	**AZ broad/untarp**			**AZ bed/untarp**			**AZ bed/tarp**			**AZ broad/tarp**			**WA broad/tarp**			**FL broad/tarp**			**CA bed/drip/tarp**	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	8329.800	36793.6	37654.6	107584.5	23020.2	46846.2	66919.8	29005.9	53716.0	76735.1	6153.0	6486.5	9266.4	4063.2	4146.1	5923.0	4428.5	4479.9	6399.7	1071.4	2060.4
50	15.2	8285.100	36596.2	37452.5	107007.2	22896.7	46594.8	66560.7	28850.3	53427.8	76323.3	6120.0	6451.7	9216.7	4041.4	4123.9	5891.2	4404.8	4455.9	6365.3	1065.7	2049.4
100	30.4	8058.300	35594.4	36427.3	104077.9	22269.9	45319.3	64738.7	28060.5	51965.2	74234.0	5952.5	6275.1	8964.4	3930.8	4011.0	5729.9	4284.2	4333.9	6191.1	1036.5	1993.3
300	91.2	6419.200	28354.3	29017.8	82907.9	17740.1	36101.1	51570.5	22352.8	41395.2	59134.4	4741.7	4998.7	7141.0	3131.3	3195.1	4564.4	3412.8	3452.4	4931.8	825.7	1587.8
500	152	5341.600	23594.4	24146.5	68990.0	14762.0	30040.8	42913.3	18600.4	34446.2	49207.5	3945.7	4159.6	5942.2	2605.6	2658.8	3798.2	2839.9	2872.8	4103.9	687.1	1321.3
2500	760	2377.900	10503.4	10749.2	30712.0	6571.6	13373.1	19103.5	8280.3	15334.3	21905.5	1756.5	1851.7	2645.3	1159.9	1183.6	1690.8	1264.2	1278.9	1826.9	305.9	588.2
		flux adjustment**	1.8029			1.128			1.4213			0.3015			0.1991			0.217			0.0525	
		peak-to-mean adjustment***	2.450			2.450			2.450			2.450			2.450			2.450			2.450	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* These estimated air concentrations involve 2 adjustments to the 6hr TWA air concentrations: 1) flux and 2) peak-to-mean for 6 hr to 1 hr.
** this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (1.8029)**(8330) = 15018.16
*** note that the Peak-to-Mean 100ug/m**2/sec concentrations were obtained by adjusting the 6hr air concentrations with the peak-to-mean adjustment of 2.45:
(15018.16)*(2.45) = 36794.49

this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(36794) = 37655
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Chloropcirin
40ac 6hr day

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
		24hr	AZ broad/untarp			AZ bed/untarp			AZ bed/tarp			AZ broad/tarp			WA broad/tarp			FL broad/tarp			CA bed/drip/tarp	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	5181.7	2567.5	2627.6	7507.5	5912.8	12032.6	17188.6	6823.3	12636.0	18050.9	10933.9	11526.5	16466.5	3649.0	3723.4	5319.1	2995.0	3029.8	4328.1	2419.9	4653.6
50	15.2	4838.1	2397.3	2453.4	7009.6	5520.8	11234.7	16048.8	6370.8	11798.1	16854.0	10208.9	10762.2	15374.6	3407.0	3476.5	4966.4	2796.4	2828.9	4041.1	2259.4	4345.0
100	30.4	4444.5	2202.2	2253.8	6439.4	5071.6	10320.7	14743.2	5852.5	10838.3	15482.8	9378.3	9886.6	14123.8	3129.8	3193.7	4562.3	2568.9	2598.7	3712.3	2075.6	3991.6
300	91.2	3178.9	1575.1	1612.0	4605.7	3627.4	7381.8	10545.0	4186.0	7752.0	11074.0	6707.8	7071.4	10101.9	2238.6	2284.2	3263.2	1837.4	1858.7	2655.2	1484.5	2854.9
500	152	2560.2	1268.6	1298.3	3709.3	2921.4	5945.1	8492.6	3371.3	6243.3	8918.7	5402.3	5695.1	8135.8	1802.9	1839.7	2628.1	1479.8	1497.0	2138.5	1195.6	2299.3
2500	760	1044.9	517.7	529.9	1513.9	1192.3	2426.4	3466.1	1375.9	2548.1	3640.0	2204.8	2324.3	3320.5	735.8	750.8	1072.6	604.0	611.0	872.8	488.0	938.4
		flux adjustment*	0.4955			1.1411			1.3168			2.1101			0.7042			0.578			0.467	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (0.4955)*(5182) = 2568
# this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(2568) = 2628
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Iodomethane
40ac 24hr

All Concentrations are ug/m3**
Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

			vol 52875-007		vol 52875-026		vol 52875-046			vol 52875-056			vol 52875-063			vol 52875-064			vol 52875-089		
		Nominal flux	Watsonville		Manteca		Oxnard			LaSelva Beach			Camarillo			Guadalupe			Guadalupe		
		concentration	broad/tarp		broad/tarp		bed/tarp			drip/tarp			drip/tarp			bed/tarp			drip/tarp		
distance (	distance (r	100ug/m**2/sec	252 lb/ac	175 lb/ac	242 lb/ac	175 lb/ac	171 lb/ac	175 lb/ac	87.5 lb/ac	162 lb/ac	175 lb/ac	87.5 lb/ac	119 lb/ac	175 lb/ac	87.5 lb/ac	143 lb/ac	175 lb/ac	87.5 lb/ac	139 lb/ac	175 lb/ac	87.5 lb/ac
10	3.04	2589.13	3130.3	2159.9	4147.8	2986.4	4826.1	4922.7	2461.3	2268.1	2449.5	1224.8	2107.6	3098.1	1559.6	3047.4	3717.8	1858.9	3394.4	4276.9	2138.4
50	15.2	2350.75	2842.1	1961.0	3765.9	2711.5	4381.8	4469.4	2234.7	2059.3	2224.0	1112.0	1913.5	2812.9	1416.0	2766.8	3375.5	1687.8	3081.8	3883.1	1941.6
100	30.4	2018.72	2440.6	1684.0	3234.0	2328.5	3762.9	3838.2	1919.1	1768.4	1909.9	954.9	1643.2	2415.6	1216.0	2376.0	2898.8	1449.4	2646.5	3334.6	1667.3
300	91.2	1373.99	1661.2	1146.2	2201.1	1584.8	2561.1	2612.3	1306.2	1203.6	1299.9	650.0	1118.4	1644.1	827.6	1617.2	1973.0	986.5	1801.3	2269.6	1134.8
500	152	1083.24	1309.6	903.7	1735.4	1249.5	2019.2	2059.6	1029.8	948.9	1024.8	512.4	881.8	1296.2	652.5	1275.0	1555.5	777.7	1420.1	1789.4	894.7
2500	760	379.24	458.5	316.4	607.6	437.4	706.9	721.1	360.5	332.2	358.8	179.4	308.7	453.8	228.4	446.4	544.6	272.3	497.2	626.5	313.2
		flux adjustment*	1.209		1.602		1.864			0.876			0.814			1.177			1.311		
		app rate multiplier#		0.69		0.72		1.02	0.51		1.08	0.54		1.47	0.74		1.22	0.61		1.26	0.63

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (1.209)*(2517.4) = 3043.5
\# this multiplier scales the concentrations from the study to the desired application rate e.g.: (0.69)*(3043.5) = 2100.0
the application rate multiplier is calculated as: 175/252 = 0.69 and scales the application rate down from 252lb/ac to 175lb/ac
Any additional effective broadcast application rates can be obtained by calculating the app rate multiplier.
Example: drip/tarp 87.5 app rate multiplier = 87.5/171 = 0.51
the concentrations in the "drip/tarp 171" column multipled by 0.51 gives estimated concentration for 87.5lb effective broadcast
this scenario would be 175lbs in the beds and beds 50% of the field area.

Chloropicrin
40ac 1hr day

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
		24hr	AZ broad/untarp			AZ bed/untarp			AZ bed/tarp			AZ broad/tarp			WA broad/tarp			FL broad/tarp			CA bed/drip/tarp	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	5181.7	6290.5	6437.7	18393.3	14486.5	29479.9	42112.1	16717.0	30958.2	44224.8	26788.1	28240.0	40342.8	8939.9	9122.3	13031.7	7337.8	7422.9	10603.9	5928.6	11401.4
50	15.2	4838.1	5873.3	6010.8	17173.6	13525.9	27525.1	39319.7	15608.5	28905.4	41292.2	25011.7	26367.4	37667.7	8347.1	8517.4	12167.6	6851.2	6930.7	9900.7	5535.5	10645.3
100	30.4	4444.5	5395.5	5521.8	15776.5	12425.5	25285.8	36120.8	14338.7	26553.8	37932.9	22976.9	24222.3	34603.3	7668.1	7824.5	11177.7	6293.9	6366.9	9095.3	5085.2	9779.3
300	91.2	3178.9	3859.1	3949.4	11284.0	8887.2	18085.5	25835.2	10255.6	18992.4	27131.3	16434.1	17324.8	24749.8	5484.5	5596.4	7994.8	4501.6	4553.9	6505.3	3637.1	6994.6
500	152	2560.2	3108.0	3180.7	9087.8	7157.5	14565.6	20807.0	8259.6	15296.0	21850.8	13235.6	13952.9	19932.8	4417.1	4507.2	6438.8	3625.5	3667.6	5239.2	2929.3	5633.2
2500	760	1044.9	1268.5	1298.2	3709.0	2921.2	5944.7	8492.0	3371.0	6242.8	8918.0	5401.9	5694.6	8135.2	1802.8	1839.5	2627.9	1479.7	1496.8	2138.3	1195.5	2299.1
		flux adjustment*	0.4955			1.1411			1.3168			2.1101			0.7042			0.578			0.467	
		peak-to-mean adjustment***	2.450			2.450			2.450			2.450			2.450			2.450			2.450	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* These estimated air concentrations involve 2 adjustments to the 6hr TWA air concentrations: 1) flux and 2) peak-to-mean for 6 hr to 1 hr.
** this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (0.4955)*(5181.7) = 2567.532
*** note that the Peak-to-Mean 100ug/m**2/sec concentrations were obtained by adjusting the 6hr air concentrations with the peak-to-mean adjustment of 2.45:
(2567.532)*(2.45) = 6290.45

this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(6290) = 6438
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Chloropicrin
40ac 1hr night

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
		24hr	**AZ broad/untarp**			**AZ bed/untarp**			**AZ bed/tarp**			**AZ broad/tarp**			**WA broad/tarp**			**FL broad/tarp**			**CA bed/drip/tarp**	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	8329.800	36793.6	37654.6	107584.5	23020.2	46846.2	66919.8	29005.9	53716.0	76735.1	6153.0	6486.5	9266.4	4063.2	4146.1	5923.0	4428.5	4479.9	6399.7	1071.4	2060.4
50	15.2	8285.100	36596.2	37452.5	107007.2	22896.7	46594.8	66560.7	28850.3	53427.8	76323.3	6120.0	6451.7	9216.7	4041.4	4123.9	5891.2	4404.8	4455.9	6365.3	1065.7	2049.4
100	30.4	8058.300	35594.4	36427.3	104077.9	22269.9	45319.3	64738.7	28060.5	51965.2	74234.0	5952.5	6275.1	8964.4	3930.8	4011.0	5729.9	4284.2	4333.9	6191.1	1036.5	1993.3
300	91.2	6419.200	28354.3	29017.8	82907.9	17740.1	36101.1	51570.5	22352.8	41395.2	59134.4	4741.7	4998.7	7141.0	3131.3	3195.1	4564.4	3412.8	3452.4	4931.8	825.7	1587.8
500	152	5341.600	23594.4	24146.5	68990.0	14762.0	30040.8	42913.3	18600.4	34446.2	49207.5	3945.7	4159.6	5942.2	2605.6	2658.8	3798.2	2839.9	2872.8	4103.9	687.1	1321.3
2500	760	2377.900	10503.4	10749.2	30712.0	6571.6	13373.1	19103.5	8280.3	15334.3	21905.5	1756.5	1851.7	2645.3	1159.9	1183.6	1690.8	1264.2	1278.9	1826.9	305.9	588.2
		flux adjustment**	1.8029			1.128			1.4213			0.3015			0.1991			0.217			0.0525	
		peak-to-mean adjustment***	2.450			2.450			2.450			2.450			2.450			2.450			2.450	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* These estimated air concentrations involve 2 adjustments to the 6hr TWA air concentrations: 1) flux and 2) peak-to-mean for 6 hr to 1 hr.
** this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (1.8029)**(8330) = 15018.16
*** note that the Peak-to-Mean 100ug/m**2/sec concentrations were obtained by adjusting the 6hr air concentrations with the peak-to-mean adjustment of 2.45:
(15018.16)*(2.45) = 36794.49

this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(36794) = 37655
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Iodomethane
40ac 8hr day

All Concentrations are ug/m3**
Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

			vol 52875-007		**vol 52875-026**		**vol 52875-046**			**vol 52875-056**			**vol 52875-063**			**vol 52875-064**			**vol 52875-089**		
		Nominal flux concentration	**Watsonville broad/tarp**		**Manteca broad/tarp**		**Oxnard bed/tarp**			**LaSelva Beach drip/tarp**			**Camarillo drip/tarp**			**Guadalupe bed/tarp**			**Guadalupe drip/tarp**		
distance (	**distance (r**	**100ug/m**2/sec**	**252 lb/ac**	**175 lb/ac**	**242 lb/ac**	**175 lb/ac**	**171 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**162 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**119 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**143 lb/ac**	**175 lb/ac**	**87.5 lb/ac**	**139 lb/ac**	**175 lb/ac**	**87.5 lb/ac**
10	3.04	5181.70	12125.2	8366.4	16270.5	11714.8	13783.3	14059.0	7029.5	9689.8	10465.0	5232.5	7928.0	11654.2	5866.7	7928.0	9672.2	4836.1	15337.8	19325.7	9662.8
50	15.2	4838.10	11321.2	7811.6	15191.6	10938.0	12869.3	13126.7	6563.4	9047.3	9771.0	4885.5	7402.3	10881.4	5477.7	7402.3	9030.8	4515.4	14320.8	18044.2	9022.1
100	30.4	4444.50	10400.1	7176.1	13955.7	10048.1	11822.4	12058.8	6029.4	8311.2	8976.1	4488.1	6800.1	9996.1	5032.1	6800.1	8296.1	4148.1	13155.7	16576.2	8288.1
300	91.2	3178.90	7438.6	5132.7	9981.7	7186.9	8455.9	8625.0	4312.5	5944.5	6420.1	3210.1	4863.7	7149.7	3599.2	4863.7	5933.7	2966.9	9409.5	11856.0	5928.0
500	152	2560.20	5990.9	4133.7	8039.0	5788.1	6810.1	6946.3	3473.2	4787.6	5170.6	2585.3	3917.1	5758.1	2898.7	3917.1	4778.9	2389.4	7578.2	9548.5	4774.3
2500	760	1044.90	2445.1	1687.1	3281.0	2362.3	2779.4	2835.0	1417.5	1954.0	2110.3	1055.1	1598.7	2350.1	1183.0	1598.7	1950.4	975.2	3092.9	3897.1	1948.5
		flux adjustment*	2.34		3.14		2.66			1.87			1.53			1.53			2.96		
		app rate multiplier#		0.69		0.72		1.02	0.51		1.08	0.54		1.47	0.74		1.22	0.61		1.26	0.63

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (2.34)*(5181.7) = 12125
\# this multiplier scales the concentrations from the study to the desired application rate e.g.: (0.69)*(12125) = 8366
the application rate multiplier is calculated as: 175/252 = 0.69 and scales the application rate down from 252lb/ac to 175lb/ac
Any additional effective broadcast application rates can be obtained by calculating the app rate multiplier.
Example: drip/tarp 87.5 app rate multiplier = 87.5/171 = 0.51
the concentrations in the "drip/tarp 171" column multipled by 0.51 gives estimated concentration for 87.5lb effective broadcast
this scenario would be 175lbs in the beds and beds 50% of the field area.

Chloropcirin
40ac 6hr day

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
		24hr	AZ broad/untarp			AZ bed/untarp			AZ bed/tarp			AZ broad/tarp			WA broad/tarp			FL broad/tarp			CA bed/drip/tarp	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	5181.7	2567.5	2627.6	7507.5	5912.8	12032.6	17188.6	6823.3	12636.0	18050.9	10933.9	11526.5	16466.5	3649.0	3723.4	5319.1	2995.0	3029.8	4328.1	2419.9	4653.6
50	15.2	4838.1	2397.3	2453.4	7009.6	5520.8	11234.7	16048.8	6370.8	11798.1	16854.0	10208.9	10762.2	15374.6	3407.0	3476.5	4966.4	2796.4	2828.9	4041.1	2259.4	4345.0
100	30.4	4444.5	2202.2	2253.8	6439.4	5071.6	10320.7	14743.2	5852.5	10838.3	15482.8	9378.3	9886.6	14123.8	3129.8	3193.7	4562.3	2568.9	2598.7	3712.3	2075.6	3991.6
300	91.2	3178.9	1575.1	1612.0	4605.7	3627.4	7381.8	10545.0	4186.0	7752.0	11074.0	6707.8	7071.4	10101.9	2238.6	2284.2	3263.2	1837.4	1858.7	2655.2	1484.5	2854.9
500	152	2560.2	1268.6	1298.3	3709.3	2921.4	5945.1	8492.6	3371.3	6243.3	8918.7	5402.3	5695.1	8135.8	1802.9	1839.7	2628.1	1479.8	1497.0	2138.5	1195.6	2299.3
2500	760	1044.9	517.7	529.9	1513.9	1192.3	2426.4	3466.1	1375.9	2548.1	3640.0	2204.8	2324.3	3320.5	735.8	750.8	1072.6	604.0	611.0	872.8	488.0	938.4
		flux adjustment*	0.4955			1.1411			1.3168			2.1101			0.7042			0.578			0.467	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (0.4955)*(5182) = 2568
# this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(2568) = 2628
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Chloropicirn
40ac 6hr night

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
		24hr	AZ broad/untarp			AZ bed/untarp			AZ bed/tarp			AZ broad/tarp			WA broad/tarp			FL broad/tarp			CA bed/drip/tarp	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	8329.8	15017.8	15369.2	43912.0	9396.0	19120.9	27314.2	11839.1	21924.9	31320.5	2511.4	2647.6	3782.2	1658.5	1692.3	2417.5	1807.6	1828.5	2612.1	437.3	841.0
50	15.2	8285.1	14937.2	15286.7	43676.4	9345.6	19018.3	27167.6	11775.6	21807.3	31152.4	2498.0	2633.3	3761.9	1649.6	1683.2	2404.6	1797.9	1818.7	2598.1	435.0	836.5
100	30.4	8058.3	14528.3	14868.3	42480.8	9089.8	18497.7	26423.9	11453.3	21210.3	30299.6	2429.6	2561.3	3658.9	1604.4	1637.1	2338.7	1748.7	1768.9	2527.0	423.1	813.6
300	91.2	6419.2	11573.2	11844.0	33840.0	7240.9	14735.1	21049.2	9123.6	16896.0	24136.5	1935.4	2040.3	2914.7	1278.1	1304.1	1863.0	1393.0	1409.1	2013.0	337.0	648.1
500	152	5341.6	9630.4	9855.7	28159.2	6025.3	12261.5	17515.6	7592.0	14059.7	20084.7	1610.5	1697.8	2425.4	1063.5	1085.2	1550.3	1159.1	1172.6	1675.1	280.4	539.3
2500	760	2377.9	4287.1	4387.4	12535.5	2682.3	5458.4	7797.4	3379.7	6258.9	8941.0	716.9	755.8	1079.7	473.4	483.1	690.1	516.0	522.0	745.7	124.8	240.1
		flux adjustment*	1.8029			1.128			1.4213			0.3015			0.1991			0.217			0.0525	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (1.8029)*(8330) = 15018
\# this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(15018) = 15369
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Chloropicrin
40ac 24hr

All Concentrations are ug/m3**

			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			vol 199-073			Vol 199-112	
			AZ			AZ			AZ			AZ			WA			FL			CA	
		24hr	AZ broad/untarp			AZ bed/untarp			AZ bed/tarp			AZ broad/tarp			WA broad/tarp			FL broad/tarp			CA bed/drip/tarp	
feet	**meters**	**generic conc**	**171 lb/ac**	**175 lb/ac**	**500 lb/ac**	**86 lb/ac**	**175 lb/ac**	**250 lb/ac**	**189 lb/ac**	**350 lb/ac**	**500 lb/ac**	**332 lb/ac**	**350 lb/ac**	**500 lb/ac**	**343 lb/ac**	**350 lb/ac**	**500 lb/ac**	**346 lb/ac**	**350 lb/ac**	**500 lb/ac**	**156 lb/ac**	**300 lb/ac**
10	3.04	2589.1	2218.9	2270.8	6488.0	1717.1	3494.3	4991.7	2787.2	5161.6	7373.5	2869.5	3025.1	4321.5	878.5	896.4	1280.6	712.0	720.3	1028.9	576.1	1107.9
50	15.2	2350.7	2014.6	2061.7	5890.7	1559.0	3172.6	4532.1	2530.6	4686.4	6694.6	2605.3	2746.5	3923.6	797.6	813.9	1162.7	646.5	654.0	934.2	523.0	1005.9
100	30.4	2018.7	1730.0	1770.5	5058.7	1338.8	2724.5	3891.9	2173.2	4024.5	5749.1	2237.3	2358.6	3369.4	685.0	698.9	998.5	555.1	561.6	802.2	449.2	863.8
300	91.2	1374.0	1177.5	1205.1	3443.0	911.2	1854.4	2649.0	1479.1	2739.1	3913.0	1522.8	1605.3	2293.3	466.2	475.7	679.6	377.8	382.2	546.0	305.7	587.9
500	152	1083.2	928.3	950.1	2714.5	718.4	1462.0	2088.4	1166.1	2159.5	3084.9	1200.6	1265.6	1808.0	367.5	375.0	535.8	297.9	301.3	430.5	241.0	463.5
2500	760	379.2	325.0	332.6	950.3	251.5	511.8	731.2	408.3	756.0	1080.0	420.3	443.1	633.0	128.7	131.3	187.6	104.3	105.5	150.7	84.4	162.3
		flux adjustment*	0.857			0.6632			1.0765			1.1083			0.3393			0.275			0.2225	
		app rate multiplier#		1.0234	2.924		2.035	2.907		1.8519	2.6455		1.0542	1.506		1.0204	1.4577		1.0116	1.4451		1.9231

* this adjustment converts the 100ug.m**2/sec to the flux from the study e.g.: (0.857)*(2589.132) = 2218.886
# this multiplier scales the concentrations from the study to the desired application rate e.g.: (1.0234)*(2218.886) = 2270.808
the multiplier is calculated as: 175/171 = 1.0234 and scales the application rate up from 171lb/ac to 175lb/ac
Any additional broadcast application rates can be obtained by calculating the app rate multiplier.
Example: bed/tarp 250 app rate multiplier = 250/189 = 1.323
the concentrations in the "bed/tarp 189" column multipled by 1.323 gives estimated concentration for 250lb effective broadcast
this scenario would be 500lbs in the beds and beds 50% of the field area.

Concentrations should be rounded to 2 significant figures for use in the Exposure Appraisal

Mary-Ann Warmerdam
Director

Department of Pesticide Regulation

Arnold Schwarzenegger
Governor

M E M O R A N D U M

TO: Randy Segawa, Agriculture Program Supervisor IV
Environmental Monitoring Branch

FROM: Terrell Barry, Ph.D., Research Scientist III
Environmental Monitoring Branch
(916) 324-4140

Original signed by

DATE: November 21, 2006

SUBJECT: REVIEW OF THE DOCUMENTS IN THE AUGUST 9, 2006 AND SEPTEMBER 29, 2006 ENVIRONMENTAL PROTECTION AGENCY POSTINGS ON THE METHYL BROMIDE E-DOCKET OPP-2005–123

Documents Reviewed:

The August 9, 2006, Environmental Protection Agency (EPA) posting on the Methyl Bromide E-Docket #OPP-2005–123 the includes:

0229 – Federal Register Notice Vol 71 No. 153 P45400 Inorganic Bromide: Tolerance Actions

0230 – The Readers Guide to the Methyl Bromide E-Docket #OPP-2005-0123

0231 – EPA 738-R-06-026 Report of Food Quality Protection Act (FQPA) Tolerance Reassessment and Risk Management Decision (TRED) for Methyl Bromide, and Reregistration Eligibility Decision (RED) for Methyl Bromide's Commodity Uses

0232 – Appendices to 0231

0233 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide for Plant Protection an Quarantine (PPQ) Purpose in Support of the Reregistration Eligibility Decision (RED)

0234 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide on Non-Quarantine Commodities in Support of the Reregistration Eligibility Decision (RED)

0235 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide on Dry Cured Pork Product Facilities in Support of the Reregistration Eligibility Decision (RED)

0236 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide in Structural and Food Processing Facilities in Support of the Reregistration Eligibility Decision (RED)

0237 – Agency Responses to Phase 5 Public Comments Related to Methyl Bromide's Commodity Risk Assessments and Risk Mitigation Options Proposal

0238 – Federal Register Notice Vol 71 No. 153 P45546 Methyl Bromide Tolerance Reassessment and Risk Management Decision (TRED) for Methyl Bromide, and Reregistration Eligability Decision (RED) for Methyl Bromide's Commodity Uses: Notice of Availability

The September 29, 2006 Environmental Protection Agency (EPA) posting on the Methyl Bromide E-Docket #OPP-2005–123 includes the documents:

0240 – Impact Assessments for Postharvest Use of Methyl Bromide

0241 – Federal Register Notice Vol 71 No. 189 P57505 Methyl Bromide: Tolerance Reassessment and Risk Management Decision for Methyl Bromide and Reregistration Eligibility Decision for Methyl Bromide's Commodity Uses: Extension of Comment Period

0242 – Buffer Zone Look-up Tables for Methyl Bromide's Commodity Uses

0243 – Updated Rates and Exposure Times for Methyl Bromide's TRED/RED Label Table.

Review:

My review will only pertain to the sections of these documents that are related to producing the air concentrations and buffer zones used in the RED. I previously reviewed the Methyl Bromide: Phase 5 Health Effects Division (HED) Human Health Risk Assessment of Commodity Uses. PC Code: 053201, DP Bar Code: D304623 March 10, 2006 (See comments submitted to the Docket by R. Segawa on 5/30/2006 EPA-HQ-OPP-2005-0123-0222).

This risk assessment was not revised and re-issued. Instead, an Addendum to Phase 5 Health Effects Division (HED) Human Health Risk Assessment for Commodity Uses. PC Code: 053201, DP Barcode: D304619 was issued. This addendum addresses comments that required specific clarifications or model re-runs. These documents are part of 0232 – Appendices to 0231.

Review of each of the documents are listed below.

0229 – Federal Register Notice Vol 71 No. 153 P45400 Inorganic Bromide: Tolerance Actions

This document states that EPA is revoking 12 specific inorganic bromide tolerances resulting from MeBr soil fumigations because EPA has classified MeBr as a non-food use pesticide with regard to soil fumigant uses. This document does not need to be reviewed in the context of MeBr inhalation exposures.

0230 – The Readers Guide to the Methyl Bromide E-Docket #OPP-2005-0123

No review is necessary. This document simply lists the contents of the August 8, 2006 posting.

0231 – EPA 738-R-06-026 Report of Food Quality Protection Act (FQPA) Tolerance Reassessment and Risk Management Decision (TRED) for Methyl Bromide, and Reregistration Eligibility Decision (RED) for Methyl Bromide's Commodity Uses

Only Sections directly related to modeled air concentrations were reviewed.

The main conclusion of this document is: "The Agency has determined that MeBr's commodity uses are eligible for reregistration provided that the risk mitigation measures outlined in this document are adopted and label amendments are made to reflect these measures" (page 9). The risk mitigation measures include the same types of measures CDPR has implemented for MeBr commodity and space fumigations. The main exception is the allowance of the horizontal aeration of PPQ facilities. Although CDPR regulations do not allow this method of aeration, much of my review will discuss this particular aeration technique because it poses a high potential for acute exposure. Thus, the modeling employed to characterize this aeration method must be carefully reviewed.

Pages 24–26. IV. Risk Management, Reregistration, and Tolerance Reassessment Decision. D. Regulatory Rationale. 2. Residential Risks. It is stated that the acute inhalation exposure level of concern (LOC) is 1ppm as an 8-hr Time Weighted Average (TWA). This is in contrast to CDPR 0.630ppm 8hr TWA LOC. Examination of the model input files shows that the LOC used to develop the buffer zones is 1ppm 4hr TWA. EPA is proposing buffer zoned based upon the 1ppm 4hr TWA. This LOC will results in longer required buffer zones.

Examples of mitigation techniques to reduce potential exposure, and thus buffer zone size, are given in this section. The list of mitigation techniques is reasonable and consistent with discussions with EPA staff.

Pages 27–33. IV. Risk Management, Reregistration, and Tolerance Reassessment Decision. E. Residential Bystander and Occupational Risk Mitigation. This section describes the rationale for risk management decisions. CDPR EM staff participated in discussions and submitted comments that were part of the development of this section. The Site-specific Fumigation Management Plan (FMP) is similar in concept to the Site Plan in California Regulations. The buffer zones are included in the FMP, the required size will be specified in Agency look-up tables or by other alternative methods. EPA has decided to use the 99th percentile "whole field" distance outputs from the PERFUM model to specify the required buffer zones. EPA states on Page 30: "…an analysis by the Agency has determined that the distances for scenarios modeled using the 99th percentile whole field distance outputs are in many cases is similar to the distances currently required by California's permit conditions for MeBr commodity fumigations." I have not reviewed this analysis and thus I cannot judge the extent to which this analysis compared the buffer zone results. However, any similarity of buffer zone size between the proposed EPA tables and the California tables is likely due to chance rather than equivalent risk mitigation conditions. The LOC's used by EPA and CDPR are different: EPA using 1ppm 4hr TWA (EPA states they are using a 1ppm 8hr TWA but the modeling uses a 1ppm 4 hr TWA to establish the buffer zones) versus California using 0.630ppm 8hr TWA (effective 1.26ppm 4hr TWA) so it is impossible to perform a direct comparison of maximum direction and whole field results.

Page 30 – availability of Buffer Zone Tables. The TRED states: " The Agency will provide information in the form of look-up tables for commodity fumigators to follow to ensure that workers and bystanders are protected. These table will be available on the Agency's internet website…" However, the buffer zone tables are not available now so there is no opportunity for review. We can use the partial results in the Phase 5 risk assessment and the Phase 5 Addendum but this assumes that nothing changes in the interim.

Page 30 – It should be clarified that the "ground level local exhaust ventilation" is a horizontal release. This type of aeration simply lays a conduit on the ground and directs the flow parallel to and along the ground rather than vertically. Although not impossible, this aeration scenario is a significant challenge to model as will be discussed later in this review.

0232 – Appendices to 0231

There are 9 Appendices to 0231. Only Appendix I contains air concentration estimation methods and results. The appendices are listed below:

Appendix A: Methyl Bromide Commodity Use Patterns Eligible for Registration

Appendix B: Table of Generic Data Requirements and Studies Used to Make the Reregistration Decision for Methyl Bromide

Appendix C: Bibliography

Appendix D: Technical Support Documents

Appendix E: Generic Data Call-In (to be inserted after approval) – this appendix is currently empty

Appendix F: Product-Specific Data Call-In (to be inserted after approval) – this appendix is currently empty

Appendix G: EPA's Batching of Methyl Bromide Products for Meeting Acute Toxicity Data Requirements for Reregistration – Product batching was not developed for methyl bromide products

Appendix H: List of Registrants Sent Data Call-Ins – this appendix is empty

Appendix I: List of Available Related Documents and Electronically Available Forms –

The "Methyl Bromide: Phase 5 Health Effect Division (HED) Human Health Risk Assessment for Commodity Uses: PC Code: 053201, DP Barcode: D304623" and the "Methyl Bromide: Addendum to Phase 5 Health Effect Division (HED) Human Health Risk Assessment for Commodity Uses: PC Code: 053201, DP Barcode: D304619" are contained in this appendix.

The Phase 5 risk assessment was previously reviewed. However, no PERFUM input files were available at the time of the review. This review of the TRED/RED included examination of the PERFUM input files.

PERFUM simulation Scenarios:

General comment: the risk assessment specifies the LOC as 1ppm 8hr TWA however, for all the scenarios the averaging time is 4 hours. Therefore the effective LOC is 1ppm 4hr TWA. This is a more stringent LOC that the EPA specified LOC, therefore, the buffer zone results are larger than needed. This is also more stringent than the CDPR LOC of 0.210ppm 24hr TWA.

Scenario 1 – Chamber During Treatment

The model setup for the enclosure is consistent with how CDPR modeled the treatment period. However, the assumed leakage rate during the holding period is very different. EPA uses the PERFUM input files from Scenario 2 – Aeration with No Stack to produce this scenario. This method of specifying the flux releases all the mass lost during treatment in 1 hour followed by

3 hours of 0 flux. While this is an appropriate method to simulate the Aeration with No Stack scenario, it is not the best method to simulate the treatment period. This is not how leakage occurs during the treatment period. This flux profile structure will cause buffer zones for the treatment period to be significantly larger that if a more realistic, lower steady loss is assumed.

The CDPR modeling has used either 30% or 75% loss in 24 hours. The flux is assumed to be steady over the 24hr period (e.g., 3% per hour). With a steady loss, if the holding period is less than 24 hours, less than 30% or 75% will be lost.

A comparison of flux profile and percent loss maximum direction buffer zone (meters) results are shown below. This comparison shows for 50000 cubic feet volume the EPA results for the 10% loss from Table 8 page 40 and the 75% loss from Table 7, no stack aeration page 39. Only 10% and 75% loss can be easily compared because those are the results available in the Phase 5 risk assessment.

Max Direction Percentile	10% loss in 24 hours		75% loss in 24 hours	
	EPA[1]	Steady[2]	EPA	Steady
95	205	0	755	120
99	230	0	855	145
99.9	240	0	890	190

[1] 4hr TWA air concentration produced assuming a large 1hour flux followed by zero flux for the remaining 3 hrs of the averaging period.
[2] 4hr TWA air concentration produced assuming a steady flux for 24 hours. Therefore, each of the 4 hours in the averaging period has the same, nonzero flux.

EPA 99th percentile proposed Whole Field Buffers (m) from Table 7, page 39 and Table 8, page 40, of Phase 5 risk assessment*

$1000ft^3$			$10000ft^3$			$50000ft^3$			$100000ft^3$		
75%	10%	1%	75%	10%	1%	75%	10%	1%	75%	10%	1%
15	0	0	95	15	0	260	75	0	385	120	0

*these buffers are calculated using the 1 hour flux followed by 3 hours zero flux

The effect of releasing all the mass lost in one hour on buffer zone length is readily apparent. Even the Whole Field buffers are larger than those required under the maximum direction when a steady flux is used.

Scenario 2 – Aeration with No Stack

This model setup of the enclosure is consistent with how CDPR modeled this scenario. I was able to reproduce the EPA results shown in Table 7 of the Phase 5 risk assessment for this scenario. However, as discussed above, the averaging time and LOC are different and appropriate comparison to California regulations is difficult.

EPA 99th percentile proposed Whole Field Buffers (m) from Table 7. Application rate is 4lb/1000ft3. Page 39-40 of Phase 5 risk assessment

$1000ft^3$		$10000ft^3$		$50000ft^3$		$100000ft^3$	
95% loss	75% loss	95% loss	75% loss	95% loss	75% loss	95% loss	75% loss
20	15	115	95	295	260	440	385

These buffers were produced by modeling 4-hour periods where the flux all occurs in the first hour followed by 3 hours of zero flux. So, for the 95% loss scenario, the loss will be 3.8lb/1000ft3 in 1 hour.

Scenario 3 – Aeration with Stack (building downwash included)

This scenario assumes that the stack will be influenced by building downwash. Therefore, it is similar to CDPR short stack scenario. I was able to reproduce the EPA results shown in Table 7 of the Phase 5 risk assessment for this scenario. However, as discussed above, the averaging time and LOC are different and appropriate comparison to California regulations is difficult.

EPA 99th percentile proposed Whole Field Buffers (m) from Table 7. Application rate is 4lb/1000ft3. Page 39-40 of Phase 5 risk assessment

$1000ft^3$ sd[1] =0.24m		$10000ft^3$ sd=0.77m		$50000ft^3$ sd=1.71m		$100000ft^3$ sd=2.43m	
Exit Velocity = 0.51m/s							
95% loss	75% loss	95% loss	75% loss	95% loss	75% loss	95% loss	75% loss
0	0	50	40	200	160	280	230
Exit Velocity = 10.16 m/s							
95% loss	75% loss	95% loss	75% loss	95% loss	75% loss	95% loss	75% loss
0	0	20	0	45	40	105	90

[1]SD = Stack Diameter

These buffers were produced by modeling 4-hour periods where the flux all occurs in the first hour followed by 3 hours of zero flux. So, for the 95% loss scenario, the loss will be 3.8lb/$1000ft^3$ in 1 hour.

Scenario 4 – Aeration with Portable Stack not near building

This method uses a portable stack with the exit flow directed straight up, perpendicular to the ground. California does not specifically allow this method. The permit for such a method would be as a no stack release since the stack would not meet the criteria of either of the stack release categories. The method that EPA has used to model this scenario appears acceptable. However, it must be assumed that the ground level, vertically directed stack is not influenced by any nearby structures since that is the way this scenario was modeled. Guidelines to calculate the required separation between obstructions and stack releases should be included on the EPA Web site for assembling the Site Plan.

Addendum

Scenario 5 – Aeration with Mobile Ground Level Source Not Near Building (horizontal stack) (Note: this scenario was significantly changed in the addendum. The comments below pertain to the addendum results)

California does not allow this method of aeration. This method has the potential for significant acute exposure. It presents a difficult and complex modeling problem because the exit velocity is horizontal rather than vertical. There are several suggested methods to model this type of scenario. EPA has employed one of those methods. However, there may be more appropriate alternatives. The method that EPA has used, along with some alternative, are discussed below.

The EPA modeling used the EPA Guidelines suggested by CDPR in our previous review that specified setting the vertical exit velocity to 0.001m/s. This effectively removes the vertical mechanical plume rise. However, the question as to what to do with the stack diameter and height remains. The EPA Guidelines do not suggest for horizontal stacks a method to adjust the stack diameter or height. The main question is how, or whether, to constrain the volumetric exchange to remain at the actual rate. In this scenario EPA chose to maintain the volumetric exchange by calculating an effective diameter. An effective stack height must also be chosen. This is a method used by Canada and certainly is a valid option for some situations. However, because some of the volumetric exchange rates that EPA is interested in modeling are quite large the effective diameter becomes very large (effective stack diameters between 5.48m and 775.2m). The effective stack height used was one half the effective diameter so effective stack heights vary between 2.74m and 388m, depending upon the exit velocity scenario. This effective stack height alone will lead to non-representative results because for all but the smallest effective stack diameters the release height is much higher than the actual release height (ground level) and the plume may not even touch down at receptor level before the downwind distance is beyond the 1440m limit of PERFUM. If EPA elects to retain the effective diameter approach to model this scenario, one option would be to set the effective stack height at either one half the actual diameter or at the actual diameter of the conduit used to release the plume.

Below is a comparison for PPQ (EV) Horizontal Stack/50000 cubic feet/95%mass released shown in Table 7 page 5 of the Addendum to Phase 5. I used two different stack heights, but kept the same exit velocity = 0.001m/s and effective diameter = 173.34m. For my test I ran the PERFUM model using a stack height of one half the diameter of the minimum stack for 50000 cubic feet (1.7195/2 = 0.86m). This is closer to reality but may still be a higher release height than the actual release height. Results are shown below.

Stack Ht = 86.7m	Stack Ht = 0.86m
Full Exit Velocity	
195	230
240	305
315	540

As expected, the buffer zones are larger for the shorter stack height. However, these estimates are only presented to illustrate the significant effect of stack height. Without further analysis and more detailed information on the scenario the best approach cannot be specified.

Another modeling option specified in the Guidance for Air Dispersion Modeling issued by the Texas Commission on Environmental Quality (TCEQ) <www.tceq.state.tx.us/assets/public/permitting/air/Guidance/NewSourceReview/rg25.pdf>. Their specifications are: Stack exit velocity = 0.001m/s: stack exit diameter = 0.001m; actual release height.

If EPA elects to continue support for the horizontal ground level aeration method and wants to be sure that the exposure is accurately characterized by the modeling then considerable effort should be devoted to characterizing the actual risk associated with this method. Although it can be argued that the ISC model is not ideal for this scenario, there really is not a better modeling alternative. This may be one scenario where at least one monitoring study should be required in order assist in quantifying the risk. The monitoring data would be used to help define the appropriate modeling approach, not to characterize risk directly. This simply is not a typical exposure scenario, potential for exposure to hazardous concentrations seems high and the appropriate modeling treatment is debatable. It may be beneficial, before the modeling is finalized, to consult with modelers who regularly work in the industrial permitting area and who have experience modeling horizontal stacks.

Remainder of Addendum – with the exception of the PPQ horizontal stacks, the addendum generally addresses the CDPR comments. In addition, EPA has done a nice job of responding to the MBIP comments and modeling. The only additional comment I have is on Page 9 EPA should make it clear that the ISC model alone, not PERFUM, should be used for the site specific analysis where on-site measured air concentrations collected under a specific set of conditions

are compared to modeled concentrations. The on-site measured air concentrations must be collected in such a way that the results are an accurate reflection of the process. For example, the Addendum notes that at the flour mill there was a 2 hour gap between aeration and the sampling interval. Those sampling results would not be an accurate reflection of the aeration process. Also, as noted in the Addendum, on-site meteorological data must also be collected and used in the analysis.

0233 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide for Plant Protection an Quarantine (PPQ) Purpose in Support of the Reregistration Eligibility Decision (RED)

This assessment could be significantly affected by how the scenarios are modeled. All comments concerning modeling in the Risk Assessment and Addendum apply to this assessment of impacts to PPQ facilities.

Additional comments:

Page 10. Table 4. This table characterizes throughput at PPQ fumigation facilities. Of particular importance to the TRED/RED is the number of fumigations per day. The buffer zones were developed in such a way that each “application” in the simulation is an independent event. It has not been established whether the buffer zones are protective if multiple fumigations are conducted either sequentially or simultaneously (or both). Theoretically, so long as not more than six sequential fumigations per day are conducted the buffer zones should still be protective at the desired level (e.g., whole field 99% or other choice). This is because in the PERFUM simulations a new, independent fumigation is initiated sequentially, every 4 hrs. So long as the buffer zone is not exceeded in any one of the 4hr periods, multiple sequential fumigations will not cause an exceedence of the 1ppm 4hr average at the buffer zone distance, even if the wind was in exactly the same direction for 24 hr. However, there are two additional scenarios that should be considered. First if more than 6 sequential fumigations are conducted in 24 hours the threshold concentration (1ppm 4hr time weighted average) may be exceeded at the buffer zone distance because this implies that a new fumigation is initiated after an interval of less than 4 hours. The second scenario is that of multiple fumigations conducted simultaneously. The magnitude of this risk is dependent upon a number of factors, including the spatial separation between the simultaneous fumigations. Table 4 lists some facilities as conducted an average of 8 to 13 fumigations a day with the maximum number of fumigations conducted at between 14 and 141 per day. Those facilities may need site-specific modeling to establish that the proposed buffer zones are protective. CDPR has used the concept of independent sources to characterize the effect on receptors of multiple applications in proximity to each other.

Page 12. Footnote. For space fumigations and non-certified chambers, loss rate during treatment should be measured rather than assumed if is desired to use less than 2–3% per hour.

Pages 13 – 15. Treatment Buffers. As discussed in the review of the modeling, the assumption that all gas lost during the treatment holding period is lost in the first hour is not supported by data collected by CDPR. In addition, this method of simulating the treatment holding period loss leads to buffers larger than actually required. The loss during treatment holding is constant and gradual. On page 15 it is stated that a 4hour emission estimate was used to construct Table 6 buffer zones. The emission estimate used is for 1 hour, not 4 hours. The air concentration estimate is for 4hrs.

0234 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide on NonQuarantine Commodities in Support of the Reregistration Eligibility Decision (RED)

This assessment could be significantly affected by how the scenarios are modeled. All comments concerning modeling in the Risk Assessment apply to this assessment of impacts on NonQuarantine Commodities.

Additional Comments:

Page12. Table 4. The text states that "Table 4 examines a range of loss rates: 1, 5, 10 and 25% of the gas lost over 24 hours." This is not correct. As discussed in the review of the modeling in the Risk Assessment and in document 0234 above, and stated on Page 11 of this document, the loss is modeled as if it is lost over 1 hour. The air concentration estimate is a 4 hour average. These results do not reflect a 24hour process.

0235 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide on Dry Cured Pork Product Facilities in Support of the Reregistration Eligibility Decision (RED)

This assessment could be significantly affected by how the scenarios are modeled. All comments concerning modeling in the Risk Assessment apply to this assessment of impacts on Dry Cured Pork Product Facilities.

Additional Comments:

Page12. Table 4. The text states that "Table 4 examines a range of loss rates: 1, 5, 10 and 25% of the gas lost over 24 hours." This is not correct. As discussed in the review of the modeling in the Risk Assessment and in document 0234 above, and stated on Page 11 of this document, the loss is modeled as if it is lost over 1 hour. The air concentration estimate is a 4 hour average. These results do not reflect a 24hour process.

Page 14. Improving Gas Retention. It may be very difficult to obtain a significant reduction in buffer zone size with this option. Before any improvement in gas retention is approved as a

mitigation measure two exercises should be conducted. First, the initial loss rate should be measured with using a well-documented protocol. Then, modeling should be used to characterize the size of the loss reduction necessary to significantly reduce buffer zone size.

0236 – Qualitative Assessment of the Impact of Changes in the Use of Methyl Bromide in Structural and Food Processing Facilities in Support of the Reregistration Eligibility Decision (RED)

This assessment could be significantly affected by how the scenarios are modeled. All comments concerning modeling in the Risk Assessment apply to this assessment of impacts on Structural and Food Processing Facilities Commodities.

Additional Comments:

Page 14. The discussion in the last paragraph refers to low loss rates of 5 to 10% per 24-hour period for new, well-sealed steel or concrete facilities. CDPR monitoring indicates that the loss rate may be 1% to 3% per hour (24% to 72% for 24 hours) even for newer, well-sealed concrete facilities.

Page14 and Table 5. The text states that "Table 4 examines a range of loss rates: 5, 10 and 25% of the gas lost over 24 hours." This is not correct. As discussed in the review of the modeling in the Risk Assessment and in document 0234 above, and stated on Page 11 of this document, the loss is modeled as if it is lost over 1 hour. The air concentration estimate is a 4 hour average. These results do not reflect a 24hour process.

Page 16. Improving Gas Retention. It may be very difficult to obtain a significant reduction in buffer zone size with this option. Before any improvement in gas retention is approved as a mitigation measure two exercises should be conducted. First, the initial loss rate should be measured with using a well-documented protocol. Then, modeling should be used to characterize the size of the loss reduction necessary to significantly reduce buffer zone size.

0237 – Agency Responses to Phase 5 Public Comments Related to Methyl Bromide's Commodity Risk Assessments and Risk Mitigation Options Proposal

No Review required.

0238 – Federal Register/vol. 71, No. 153/Wednesday, August 9, 2006/ Notices/Page 45546. Methyl Bromide Tolerance Reassessment and Risk Management Decision (TRED) for Methyl Bromide, and Reregistration Eligibility Decision (RED) for Methyl Bromide's Commodity Uses; Notice of Availability.

No review is required. This document only provides the notice of posting, background discussion, and how to comment.

0240 – Impact Assessments for Postharvest Use of Methyl Bromide

No review required. This documents simply states that, if new information becomes available BEAD will reevaluate the impacts.

0241 – Federal Register Notice Vol 71 No. 189 P57505 Methyl Bromide: Tolerance Reassessment and Risk Management Decision for Methyl Bromide and Reregistration Eligibility Decision for Methyl Bromide's Commodity Uses: Extension of Comment Period

No review is required. This document only provides the notice of posting, background discussion, and how to comment.

0242 - Buffer Zone Look-up Tables for Methyl Bromide's Commodity Uses

For each table I attempted to verify the 500,000ft^3 scenario.

1.0 Treatment

1a. Treatment 24 hrs or greater

I could not find the PEFRUM input files for the 1lb/1000ft^3 through 4lb/1000ft^3 in this table so I could not verify those results.

I did verify 9lb/1000ft^3 and 500,000ft^3 volume. The simulation method is reasonable and similar to CDPR methods. However, the assumption of 25% or less of applied mass lost in 24 hours is not consistent with measured loss in the CDPR data set. We have observed 30% to 70% loss in 24 hours for noncertified spaces.

1b. Treatment up to 8hr & 4lbs/1000ft^3

I verified 4lbs/1000ft^3. The method of simulation described at the bottom of this table is discussed above. Assuming all mass lost in 24 hours is lost in the first hours is not a realistic scenario and, as shown above, leads to larger buffer zones than if a uniform loss over 24 hours is assumed.

1c. Treatment up to 8hrs & greater than 4lbs/1000ft^3

I was unable to verify the buffer zones for 9lbs/1000ft^3 and 500,000ft^3. According to the description below the table the input and output files should be located under the subdirectory labeled"4hrs 4 emissions" and use a flux of 38145g/s lost uniformly over 24hrs. Instead, the entries in the buffer zone table were found in the subdirectory "4hrs 1emission." This means that the same scenario used for Table 1b was used for Table 1c. However, the flux used appears to be incorrect since 38145g/s was used as the base flux. According to the calculations for the scenarios in Table 1b the base flux should be 915322g/sec lost over 1 hr followed by 3 hours of zero flux. The buffer zones using this flux would be much larger.

If the 500,000ft^3 output from the subdirectory labeled"4hrs 4 emissions" is used then the buffer zones for Table 1c should be:

25%	300
10%	150
5%	70
1%	0

All other columns in this table would need to be correct also. However, this correction would not address the assumed low 24hour loss rate discussed above.

2.0 Aeration, No Stack

2a. Aeration greater than 8 hrs & greater than 4lbs/1000ft^3

I verified both 9lbs and 15lbs/1000ft^3 for 500,000ft^3. The simulation method is consistent with CDPR methods.

2b. Aeration up to 8hrs & up to 4lbs/1000ft^3

I verified the 4lbs/1000ft^3 and 500,000ft^3 scenario. All mass released is assumed to occur over the first hour of aeration. The simulation method is consistent with CDPR methods.

2c. Aeration up to 8hrs & greater than 4lbs/1000ft^3

The notation at the bottom of the table indicates that emissions are assumed to occur over a 24-hour period. However, the heading of the table indicates aeration of up to 8 hrs so use of a 24-hour uniform emission would not be correct to match this stated scenario.

In fact, the intended scenario is not clear since the values in the buffer zone table for the uniform flux profile over 24 hours do not match those found in the "4hr 4 emissions" directory. I could not find the buffer zone values shown Table 2c in any of the PERFUM output files. So, I am not clear what scenario was used.

Buffer zone values from the "4hr 4emission" subdirectory for 9lb/1000 ft^3 and volume 500,000ft^3 are shown below:

99% 730
95% 710
90% 690
75% 620
50% 475

These buffer zones are in contrast to those shown in Table 2c for 9lb/1000ft^3 and volume 500,000ft^3:

99% 305
95% 300
90% 290
75% 265
50% 210

If the scenario is intended to reflect aeration of up to 8hrs then the 1 hour of emissions followed by 3 hours of zero flux is most representative. Aeration occurs relatively quickly even for no stack facilities if any type of forced air is used to aerate (e.g. portable fans).

Stack Aeration Tables (Table 3 through Table 22)

For all the buffer zone tables for stack aeration with building effects, the building dimensions and stack height used have a significant effect on the air concentrations and thus, the buffer zones. The building dimensions and stack characteristics used to generate these buffer zone tables are shown below:

Volume (ft^3)	Building Dimensions L x W x H			Stack Ht. above top of building (m)	Stack Ht. above ground (m)	Stack Diameter (m)	Exit Velocity (m/s)
	(m)	(m)	(m)				
25,000	9.6	9.6	7.6	3.1 &,15.2	10.7 & 22.8	1.22	10.16
50,000	13.6	13.6	7.6	3.1 & 15.2	10.7 & 22.8	1.72	10.16
100,000	11.1	11.1	22.9	3.0 & 15.2	25.9 & 38.1	2.43	10.16
250,000	17.6	17.6	22.9	3.0 & 15.2	25.9 & 38.1	2.43	25.4
500,000	24.9	24.9	22.9	3.0 & 15.2	25.9 & 38.1	3.44	25.4
750,000	30.5	30.5	22.9	3.0 & 15.2	25.9 & 38.1	4.21	25.4
1,000,000	35.2	35.2	22.9	3.0 & 15.2	25.9 & 38.1	4.86	25.4

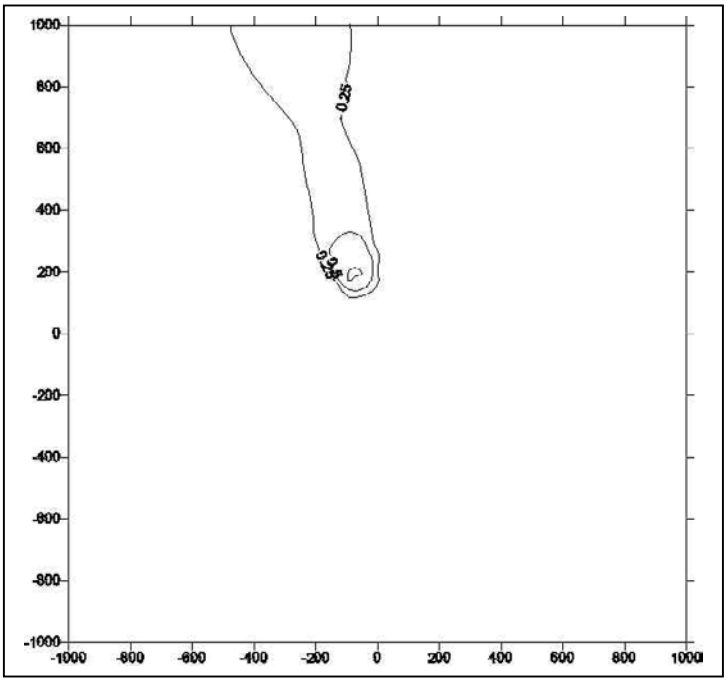
The buffer zone results are highly dependent upon these building inputs. The larger volume building dimensions are very tall buildings (about 9 stories), and thus may be representative of mills but not necessarily of other types of facilities. This should be clearly stated. The buildings allowed to operate using these tables should closely match the dimensions used to generate the tables.

I was unable to verify that the PERFUM2 inputs properly use the stack height and building effects information. The PERFUM2 input instructions state to specify the stack height as the height above the building height. The actual stack height above ground is the building height plus the stack height above the top of the building. However, the PERFUM2 input does not simply add those two heights and enter it as the total stack height with a base elevation of 0.0 meters. Instead, the ISC3 input files indicate that the stack base elevation (Zs, the source base elevation) is specified as the building height and the stack height is entered as 3.0m (10ft) or 15.2m (50ft). The assumption then is that the proper total stack height is used in the model runs. However, it is my understanding that the stack base elevation feature is used in the context of complex terrain applications, not in the way that the PERFUM2 model is using it. I suggest that whether the building effects are properly implemented should be verified.

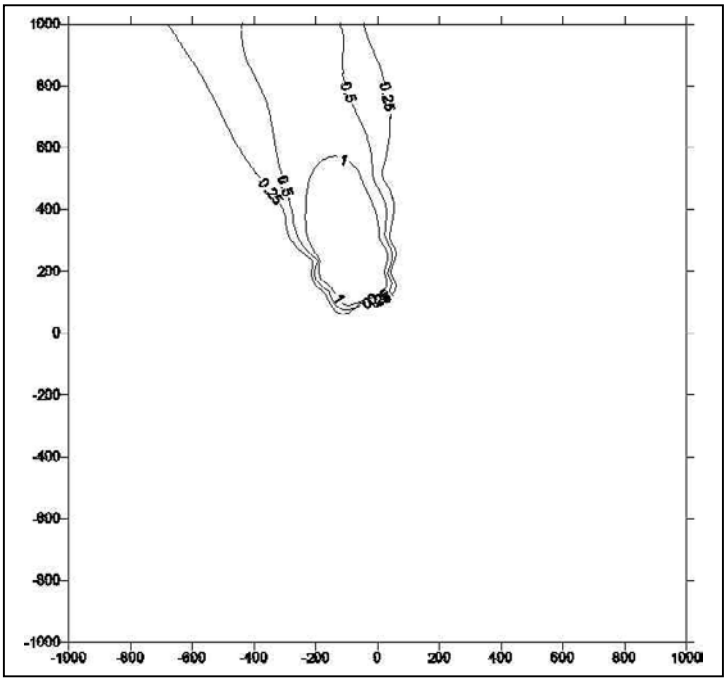
I did do two simple stack source runs to explore the possible difference between the inputs:

1) the stack base elevation = 0.0m and stack height = 35.0m with a building 34m tall
2) the stack base elevation = 34.0m and stack height = 1.0m with the same building 34m tall

The results, shown below with the same concentration contour levels, are quite different:



Base elevation = 0.0m
Stack Height = 35.0m
Concentration Contours (ug/m^3) : 0.25, 0.5, 1.0



Base elevation = 34.0m
Stack Height = 1.0m
Concentration Contours (ug/m^3): 0.25, 0.5, 1.0

The remainder of my review will assume for the time being that the building effects are properly modeled.

3.0 Aeration, 10ft Stack Height, 1 Air exchange every minute

3a. Aeration greater than 8 hours, greater than 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. However, at the air exchange rate of this scenario the flux profile would not be uniform for 24 hours. Even for the larger volumes the majority of the mass would be released quickly. The emissions pattern will be similar to the 4hours 1 emission flux profile. Therefore, in some cases the buffer zones may not be large enough.

3b. Aeration period up to 8 hours, up to 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. This modeling method is consistent with CDPR methods.

3c. Aeration up to 8 hours, greater than 4lb/1000ft^3

I was unable to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. From the description at the bottom of the table (and from the other tables I have already checked) I believe the output files in the "4hr 4 emissions" subdirectory results should be used. Instead of zero for all entries, I found for 15lb/1000ft^3 and volume 500,000ft^3 the results shown below:

99% 65m
95% 60m
90% 60m
75% 0m
50% 0m

Other cells may also be in error but I did not check any others. Even with these corrections, at the air exchange rate of this scenario the flux profile would not be uniform for 24 hours. It is difficult to justify the use of this flux profile for this scenario. Even for the larger volumes the majority of the mass would be released quickly. The emissions pattern will be similar to the 4hours 1 emission flux profile. Therefore, in some cases the buffer zones may not be large enough.

4.0 Aeration, 10ft Stack Height, 1 Air exchange every 2 minutes

This air exchange rate is equivalent to 0.5EV so these outputs are easily checked with the outputs provided.

4a. Aeration greater than 8 hours, greater than 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. However, at the air exchange rate of this scenario the flux profile would not be uniform for 24 hours. Even for the larger volumes the majority of the mass would be released quickly. The emissions pattern will be similar to the 4hours 1 emission flux profile. Therefore, in some cases the buffer zones may not be large enough.

4b. Aeration period up to 8 hours, up to 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. This modeling method is consistent with CDPR methods.

4c. Aeration up to 8 hours, greater than 4lb/1000ft^3

I was unable to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. From the description at the bottom of the table (and from the other tables I have already checked) I believe the output files in the “4hr 4 emissions” subdirectory results should be used. Instead of zero for all entries, I found for 15lb/1000ft^3 and volume 500,000ft^3 the results shown below:

99% 155m
95% 150m
90% 145m
75% 125m
50% 85m

Other cells may also be in error but I did not check any others. The other possibility, since the companion table in 3.0 had different entries is that I was unable to locate the correct result file to check the buffer zones. If this is the case then the description at the bottom of the table is not adequate for the reader to locate the correct output.

Even with these corrections, at the air exchange rate of this scenario the flux profile would not be uniform for 24 hours. It is difficult to justify the use of this flux profile for this scenario. Even for the larger volumes the majority of the mass would be released quickly. The emissions pattern will be similar to the 4hours 1 emission flux profile. Therefore, in some cases the buffer zones may not be large enough.

5.0 through 17.0

I did not check the remaining stack aeration tables. All comments previously made will apply to these tables.

18.0 Aeration, Portable 50ft stack, 1 Air exchange every minute

18a. Aeration up to 8 hours, greater than 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. However, at the air exchange rate of this scenario the flux profile would not be uniform for 24 hours. Even for the larger volumes the majority of the mass would be released quickly. The emissions pattern will be similar to the 4hours 1 emission flux profile. Therefore, in some cases the buffer zones may not be large enough.

18b. Aeration period up to 8 hours, up to 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. This modeling method is consistent with CDPR methods.

18c. Aeration up to 8 hours, greater than 4lb/1000ft^3

I was able to verify the 15lb/1000ft^3 and volume 500,000ft^3 scenario. At the air exchange rate of this scenario the flux profile would not be uniform for 24 hours. It is difficult to justify the use of this flux profile for this scenario. Even for the larger volumes the majority of the mass would be released quickly. The emissions pattern will be similar to the 4hours 1 emission flux profile. Therefore, in some cases the buffer zones may not be large enough.

19.0 through 22.0

Similar comment as for 18.0 and 19.0 will apply to these tables. I did not check these tables.

23.0 through 27.0

I did not check these tables because I made comments on the modeling of the PPQ scenario earlier in my review of "Addendum Scenario 5 – Aeration with Mobile Ground Level Source Not Near Building (horizontal stack)" that, if implemented, would significantly change the values in these tables.

0243 – Updated Rates and Exposure Times for Methyl Bromide's TRED/RED Label Table

No comment required. This is simply a list of application rates and exposure times.

Mary-Ann Warmerdam
Director

Department of Pesticide Regulation

Arnold Schwarzenegger
Governor

M E M O R A N D U M

TO: Randy Segawa, Senior Environmental Research Scientist
Environmental Monitoring Branch

FROM: Terrell Barry, Ph.D., Senior Environmental Research Scientist *Original signed by*
Bruce Johnson, Ph.D., Senior Environmental Research Scientist *Original signed by*
Environmental Monitoring Branch
(916) 324-4106

DATE: September 19, 2005

SUBJECT: VERIFICATION OF PROBABILISTIC EXPOSURE AND RISK MODEL FOR FUMIGANTS 24-HOUR PERIOD MAXIMUM CONCENTRATION CALCULATIONS

Summary

The probabilistic exposure and risk model for fumigants (PERFUM) (version compiled on 11/31/2004) was evaluated by comparing PERFUM results to those obtained in Johnson (2001). Comparative analysis was based upon results from a 40 acre field, Ventura meteorology and 24-hour time-weighted average concentration, maximum buffer percentiles only. At the highest flux of 292.2ug/m^{2}s, when calms processing was removed from PERFUM, there was good correspondence between PERFUM and Johnson (2001) for percentiles less than or equal to 90%. For the flux of 292.2 ug/m^{2}s the higher percentile buffers were not comparable due to the PERFUM restriction of a maximum buffer of 1440m. This restriction was not present in Johnson (2001). At lower flux there was good agreement over all percentiles with the exception of the 99.9 percentile. In that case, our buffer estimates were lower (shorter) than the PERFUM estimates. Flagpole height of 1.5 m, used in PERFUM, versus 1.2 m, used in Johnson (2001), had only a minor effect on output. Cubic spline interpolation cases were checked and found to be in good agreement. We checked percentile calculations and found some minor differences. In summary, for 24-hour time-weighted average concentrations, we believe PERFUM (version compiled on 11/31/2004) is acceptable.

Background

The "Probabilistic Exposure and Risk Model" (PERFUM, Sciences International 2004) (version compiled on 11/31/2004) is a modeling system which uses the U.S. Environmental Protection Agency (EPA) model known as the Industrial Source Complex Short Term (ISCST3) together with custom programming that estimates buffer zone distributions based on flux profiles, acreage, acute reference concentrations, and hourly meteorological data. The conceptual framework stemmed from Johnson (2001) who analyzed the effectiveness of methyl bromide buffer zones in California. The PERFUM modeling system, however, provides many convenient features for performing percentile analysis.

The PERFUM approach employs transects of receptors in a grid radiating away from a field. The software creates control files for ISCST3 that incorporate modeling constraints input by the user. The software also runs ISCST3 (which has been encoded as a subroutine to the main PERFUM module), which provides air concentration estimates at each node of the receptor transect system. PERFUM analyzes each concentration transect output by ISCST3 to determine buffer zone distance. For each exposure period, these calculations are performed anew and the final result is a distribution of buffer zones.

There are two kinds of buffer zone distributions: whole field and maximum direction. Whole field distributions sample from the required distribution length all the way around a field. A single exposure interval will yield many buffer zones, one from each transect radiating away from the field. The longest buffer zone distances will stem from downwind directions and the shortest distances will stem from the upwind directions. The maximum direction distributions are comprised of only one buffer zone estimate for each period. That buffer zone estimate is the absolute maximum over all transects during each interval.

To evaluate methyl bromide buffer zones in California Johnson (2001) developed programming modules to run ISCST3 and provide buffer zone distance percentile distributions. Minor modifications were made to these modules to obtain buffer zone estimates for Ventura meteorological data and thus, provide an independent basis for comparison to the output from PERFUM.

Objective

The objective of this work is to derive Ventura-only buffer zone estimates from analysis software developed to evaluate methyl bromide buffer zones (Johnson 2001) and compare these distributions to the Ventura-only output from PERFUM. This work was confined to testing the maximum distance buffer zone and 24-hour averages.

Methods

The Ventura meteorological data used by Johnson (2001) had been provided to Dr. Richard Reiss (the developer of PERFUM). The first step in this project was to verify that the Ventura meteorological data distributed with PERFUM was the same meteorological data employed in Johnson (2001). The meteorological data sets were identical.

The next step was to develop buffer zone percentiles exclusively for Ventura from the Johnson (2001) analysis. Files containing buffer zone distances, date of meteorology, and county code for each buffer zone distance had previously been stored. The simple approach required creating a computer program to read in the buffer zone file, and estimate percentiles

only for Ventura. There were 25 such files, reflecting the five acreages x five flux values used in Johnson (2001). The FORTRAN program PRCNTILE.FOR was created to run this analysis. It was tested by calculating percentiles for all of the data from four counties and comparing to the output in Table 5.2.1 (Johnson 2001). The results matched, therefore PRCNTILE.FOR was working properly. Then PRCNTILE.FOR was constrained to include only the Ventura based data. This provided the Ventura-only percentiles. In subsequent paragraphs, the citation "Johnson (2001–Ventura only)" will refer to analysis based only on the Ventura portion of the output used to develop Johnson (2001).

For PERFUM the highest flux used was 292.2 ug/m^{2}s in order to match the highest flux in Johnson (2001). PERFUM allows for using reduced fluxes via an application rate scheme. The highest application rate corresponds to the stated flux. Lower application rates can be input. PERFUM takes the ratio of the lower application rate to the higher application rate to adjust the flux. The actual program mechanics, however, don't require resimulation of the lower flux once the concentration estimates from the highest flux are obtained. Since concentration and flux are proportional, it is only necessary to use the ratio of the lower flux to the highest flux as a factor to adjust the concentration vector.

PERFUM was modified by inserting code that printed out all of the buffer zone transects. The PERFUM "test day" statements were duplicated and set up to print out all of the cases. PERFUM handles abbreviated data sets. For purposes of testing code modifications or checking individual transect calculations, it was not necessary to simulate five years of meteorological data.

In addition to comparing percentile distributions, specific examples of buffer zone estimation for specific transects were checked. PERFUM uses a cubic spline interpolation to estimate required buffer zones along a transect. Also, percentile calculations were checked. The methodology employed in PERFUM to estimate percentiles is probably not technically the most accurate. However, the sample sizes are large enough that technically accurate percentiles are practically the same. The methodology used in PERFUM for estimating the percentiles is similar to that employed in Johnson (2001).

Results

Estimation of buffer zones

PERFUM was run with conditions as follows: Start flux hour 1; 40 acres; flux 292.2 ug/m^{2}s constant each hour; test day 990201; flagpole 1.2 (all discrete receptors were set to 1.2m flagpole height); 24 hour interval; target concentration 815ug/m^3; square field; fine mesh. Except for the mesh (receptor locations) these conditions matched a subset of conditions in Johnson (2001). Taking the test output from this particular run (which gives in part the node by node concentrations within each transect at each application level for the test day), we imported

individual transects into TableCurve (v5.0) and used the TableCurve cubic spline feature to interpolate buffer zones at 815ug/m^3. Table 1 shows that PERFUM estimates and the TableCurve estimates are virtually identical.

Table 1. Comparison of cubic spline interpolation from Table Curve to PERFUM cubic spline interpolation to obtain buffer zone at 815 ug/m3.

Transect Number	PERFUM Buffer Estimate (m)	Table Curve Cubic Spline Estimate of Distance (m) at 815 ug/m3
177	424.4	424.45
178	424.2	424.2
158	187.8	187.75
164	306.5	306.5
134	68.5	68.48

Estimation of Percentiles

PERFUM was run with the same conditions as in the estimation of buffer zones section, except the flagpole height was set to 1.5m (all discrete receptors were set to 1.5m flagpole height). PERFUM was modified to print out all of the buffer zones for each day. A program, CHKDIST.FOR, was written to read in these buffer zones, extract the maximum buffer zone for each day, sort the maximum buffer zones, and assign a probability based on rank. There were 1796 buffer zones, one maximum for each day. The lowest buffer zone was assigned a probability of 1/1796, the next lowest was assigned 2/1796, and so on. The highest buffer zone was assigned 1=1796/1796. This output file, consisting of buffer zone lengths and assigned cumulative probabilities, was imported into Excel and buffer zone values at key percentiles were interpolated.

This was a test of PERFUM estimation of percentiles. There are some minor discrepancies between the two percentile derivations (Table 2). The buffer zone estimations at the highest percentiles reflect the PERFUM limitation to 1440m as the maximum buffer zone size. The largest difference in this comparison was 5 meters at the 99th percentile. This difference would be approximately 1 part in 285 or about 0.4%. The cause of the difference between the two estimations is unknown.

Table 2. Comparison of percentiles based on PERFUM output calculated by PERFUM and calculated by CHKDIST.FOR.

Percentile	PERFUM	CHKDIST
99.99	1440	1440
99.9	1440	1440
99	1435	1440
97	1305	1306
95	1190	1192
90	1010	1014
85	905	907
80	830	833
70	715	716
60	620	621
50	540	540

Comparison to Johnson (2001)

Johnson (2001) presents results for the combination of weather from four counties. As described above, results restricted to Ventura only were compared to PERFUM. Since the meteorological data used was identical, any differences between PERFUM and

Johnson (2001-Ventura only) would have to be due to differences in processing the ISCST3 output or running the ISCST3 model. One difference, as shown in Table 3, is the height of the receptors. The height set in the PERFUM distribution files is 1.5m. However, Johnson (2001) ran with a receptor height of 1.2m. When this is changed, only minor differences occur in the PERFUM output (Table 3). We determined that calms processing was the primary cause of differences between PERFUM and Johnson (2001-Ventura only). PERFUM uses calms processing as described in U.S. EPA (2003), reflecting a U.S. EPA policy on performing calculations for days with calm hours. Johnson (2001) did not use calms processing, so calm hours were assigned a concentration of 0 and the 24-hour concentration was calculated as the average of the noncalm hours. The number of noncalm hours was used in the denominator to find the average concentration. Under the calms processing policy for 24-hour periods, a denominator of 18 hours is required when the number of noncalm hours is less than 18. When the number of noncalms hours is 18 or greater, noncalms and calms processing will yield identical 24-hour averages.

Table 3. Comparison of PERFUM buffer zone estimates t
from Johnson (2001) restricted to

Percentile	PERFUM 40 acres, flagpole 1.5m, fine grid	PERFUM 40 acres, flagpole 1.2m, fine grid	PERFUM, 40 acres, flagpole 1.2m, all calms processing undone*	Estimate Johnson based Ventura (2001) only
99.99	1440	1440	1440	2946
99.9	1440	1440	1440	2605
99	1435	1435	1440	1687
97	1305	1305	1405	1407
95	1190	1195	1245	1254
90	1010	1015	1055	1059
85	905	905	945	946
80	830	835	870	870
70	715	715	745	746
60	620	620	660	663
50	540	540	580	583

*See text.

In PERFUM, calms processing has been taken out of the ISCST3 portion of the code, and inserted into the PERFUM portion of the code. For the purpose of comparison, we modified PERFUM code in order to "undo" the calms processing. With that change, the percentile estimate from about 90% and below matched very well with the percentiles from Johnson (2001-Ventura only) (Table 3). The upper percentiles, however, cannot match because PERFUM transects are bounded at 1440m. In order to assess the upper percentiles, a further comparison was made between PERFUM and Johnson (2001–Ventura only) using the two lowest flux rates specified in Johnson, 104ug/m^{2}s and 39 ug/m^{2}s (Table 4). For these lower fluxes, the upper percentiles were not obscured by the PERFUM 1440m limitation. The

agreement is good, with the exception of the 99.9 percentile. In both cases, the PERFUM buffer zone estimate was substantially larger than Johnson (2001–Ventura only). For the 104ug/m^{2}s case, PERFUM estimated 1005m, while Johnson (2001-Ventura only) estimated 885m. For the 39 ug/m^{2}s case, PERFUM estimated 280m compared to 243m. The other differences were unimportant.

Table 4. Comparison of PERFUM buffer zone estimates to estimates from Johnson (2001) restricted to Ventura for lower flux rates.

	Flux = 104 ug/m2s		Flux = 39 ug/m2s	
Percentile	PERFUM, 40 acres, flagpole 1.2m, all calms processing is undone*	Estimates based on Johnson (2001) for Ventura only	PERFUM, 40 acres, flagpole 1.2m, all calms processing is undone*	Estimates based on Johnson (2001) for Ventura only
99.99	1050	1045	305	301
99.9	1005	885	280	243
99	550	554	115	112
97	440	441	70	72
95	385	391	50	51
90	305	310	20	20
85	270	276	5	0
80	240	246	5	0
70	195	195	5	0
60	160	158	5	0
50	135	132	5	0

*See text.

Because of the matches between the percentiles from 90% and below, we are in substantial agreement with the performance of PERFUM for 24-hour maximum value calculations. In addition, in the cases we checked, PERFUM correctly interpolated the downwind distance corresponding to the health threshold. In checking the percentile calculations, we arrived at approximately the same numbers, but found small unexplained differences. Examination at lower fluxes indicated that the 99.9 percentile differences were large, with PERFUM estimating larger buffer zones than Johnson (2001–Ventura only). Other percentiles for the lower fluxes compared very well.

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Department of Pesticide Regulation

Mary-Ann Warmerdam
Director

Arnold Schwarzenegger
Governor

M E M O R A N D U M

TO: Randy Segawa, Environmental Program Manager (Supervisor) I
Environmental Monitoring Branch

FROM: Terrell Barry, Ph.D., Research Scientist III *Original signed by*
Bruce Johnson Ph.D., Research Scientist III *Original signed by*
Environmental Monitoring Branch
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DATE: October 23, 2007

SUBJECT: ANALYSIS OF THE RELATIONSHIP BETWEEN PERCENTILES OF THE WHOLE FIELD BUFFER ZONE DISTRIBUTION AND THE MAXIMUM DIRECTION BUFFER ZONE DISTRIBUTION

Background

In 1992 the Department of Pesticide Regulation (DPR) first implemented the use of air dispersion modeling in the development of mitigation measures for bystander exposure to methyl bromide. The initial buffer zone development employed screening level modeling techniques, including standard weather conditions, square field geometry, and 24 hour time weighted average (TWA) flux (Johnson 1999, Johnson and Barry 2005, Segawa et al. 2000). The buffer zones developed were approximately 95% protective on an individual application basis (Johnson, 2001). This means that for any given application, the probability that the TWA concentration at the buffer zone distance would exceed a specified exposure threshold anywhere around the field perimeter was approximately 5%.

In recent years, with the development of probabilistic modeling packages (PERFUM [Reiss and Griffin, 2006]; FEMS [Sullivan et al., 2004]; SOFEA [Cryer, 2005]), distributions of buffer zones for various application scenarios have been produced using five year sets of meteorological data. As explained later, a buffer zone length at a particular percentile of the distribution insures coverage at a level of protection (protection probability) equal to that percentile. This technique of selecting a buffer zone length that corresponds to a desired protection probability from a distribution of lengths is now one of the most important air dispersion modeling based mitigation tools. However, two very different methods have been used to construct distributions of buffer zone lengths for specific use scenarios. Even though the resulting buffer zone distributions represent fundamentally different philosophies of risk mitigation and are not equivalent, the terminology used to describe the protection probability is the same. Consequently, there is substantial confusion over the meaning of “protection probability” and related concepts with these different methods.

The two methods for constructing a distribution of buffer zone lengths are known as the “whole field” method and the “maximum direction” method. The general modeling procedure used to determine the buffer zone distributions for either the maximum direction or whole field method

starts with a given fumigant flux versus time function ("flux profile", e.g. Figure 1), which describes the course of emissions following an application. For a specific scenario the size of the field is fixed, as is the application rate. What varies from simulation to simulation is the meteorology used to calculate the downwind air concentrations. The downwind air concentrations are averaged over the appropriate exposure time (also called the threshold averaging period). The threshold averaging period and the threshold concentration (or reference concentration) is fumigant specific. For example, the DPR methyl bromide threshold averaging time is 24 hours and the DPR threshold concentration is 815 ug/m^3 as a 24-hr time TWA. In each period, the concentration isopleths generated by the model are compared to the concentration exposure threshold (for example, 815 ug/m^3 for methyl bromide). Buffer zones are determined by the distance from the field edge to where the threshold concentration occurs. Thus, the resulting buffer zone distributions reflect the variations in period-to-period meteorology.

For both methods discrete directions are represented as "spokes" emanating outward from the center of the field (e.g. Figure 2), and are defined by the discretization scheme used in the modeling procedure. However, for the maximum direction method, the comparison of concentrations on each spoke yields a single distance that is equal to the maximum distance at which the modeled TWA concentration is equal to the exposure threshold. This procedure is repeated over the length of the meteorology record and the distances are compiled to obtain a distribution. For example, for methyl bromide and using a 24 hour threshold averaging time, each day (24 hours) of simulation yields a single buffer zone estimate. In this case a 5 year simulation would provide approximately 365 x 5 = 1825 daily, maximum buffer zones which would be compiled to form a distribution. The number is approximate because meteorological data sets may be incomplete.

In contrast, the whole field method compiles distances in every direction around the field during each threshold averaging period for each simulation. The number of distances selected in each averaging period is equal to the number of spokes, and each selected distance is equal to the distance along the spoke where the modeled TWA concentration equaled the exposure threshold. Then, similar to the maximum direction method, the procedure is repeated over the length of the meteorology record to generate the whole field buffer zone distribution. For example, a single threshold averaging period simulation for methyl bromide (24-hour) would yield 200 buffer zone estimates (if the field had 200 spokes). The maximum of the 200 buffer zone estimates is the maximum direction buffer zone distance for that day. The remaining 199 estimates will generally be less than the maximum. In the whole field method, all 200 daily buffer zone estimates are compiled from each day to form the distribution. This results in approximately
365 x 5 x 200 = 365,000 estimates.

In developing fumigant buffer zones by both the screening approach and the probabilistic approach, DPR has controlled protection probabilities at the individual application level (Segawa et al. 2000, Johnson, 2001, Barry, 2006). To do this, for each threshold averaging period the single point farthest away from an application where the threshold concentration occurs determines the buffer zone for each realization of an application scenario. For example, over the long term, a buffer zone selected to be "95%" protective for a 24 hour TWA threshold will be long enough to capture the threshold air concentration everywhere around the perimeter of the field for 95% of all applications. Thus, on average over thousands of realizations, for every 100 applications, the buffer zone will be large enough for 95 of those applications–the buffer zone achieves the protection goal. However, 5 of those 100 applications will show air concentrations at the buffer zone that exceed the threshold air concentration. Thus, the buffer zone fails to achieve the protection goal at some locations around the perimeter of the field. This "maximum direction buffer zone" method (Reiss and Griffin, 2006) of constructing the protection probability controls individual application risk. Barry and Johnson (2005) previously verified the PERFUM maximum direction buffer zone protection probabilities.

While the whole field approach (Reiss and Griffin, 2006) employs the same general modeling procedure as the maximum direction method, the whole field buffer zone distributions are constructed using distances to the threshold air concentration in every direction around the field during each averaging period. Thus, the whole field approach includes in its distributions distances which are predominantly upwind and, therefore, small. The whole field buffer zone percentiles are equal to the probability that the TWA concentration is less than or equal to the threshold at any random location along the edge of the buffer zone of a random application. The whole field buffer zone percentiles do not correspond to a specified level of protection at the individual application level. Therefore it is important to determine the relationship between the maximum direction and whole field approaches in terms of the per application failure rate.

If risk managers are to make fully informed decisions, the method with which the protection probability is constructed must be completely transparent and well understood. The objective of this memorandum is four fold: (1) to describe procedures and assumptions used to derive the PERFUM whole field and maximum direction buffer zone distributions, (2) to provide a transparent comparison of the whole field method protection probabilities to the equivalent maximum direction protection probabilities using actual model fumigant datasets, (3) to verify in a specific scenario PERFUM2 calculations, and (4) to estimate in a specific scenario the distribution of perimeter fractions amongst days where the buffer zone was not protective. Our intent is to provide risk managers and stakeholders with a technical analysis that assists the process of risk mitigation.

Methods

Two types of data were used in this analysis to characterize the relationship between the maximum direction protection probability and the whole field protection probability: (1) Data collected from PERFUM outputs for modeling conducted by the U.S. Environmental Protection Agency (EPA) and (2) data calculated using PERFUM code modified to provide air concentration and buffer zone outputs not available from the distributed model.

Data collected from the USEPA PERFUM modeling outputs

PERFUM modeling results were obtained from U.S. EPA as part of the materials DPR staff reviewed related to U.S. EPA fumigant risk assessments. For the present analysis, PERFUM outputs for various soil applications of methyl bromide, chloropicrin and metam sodium under various meteorological data sets were used to assemble a database containing the 99th percentile (99%) whole field buffer zone length and its equivalent maximum direction percentile (rounded to the nearest 1%). The equivalent maximum direction percentile is the percentile of the maximum direction buffer zone distribution that corresponds to a buffer zone equal to the 99% whole field buffer zone length, and is numerically equal to the individual application level maximum direction protection probability. This procedure is illustrated graphically in Appendix F. The five meteorological data sets (locations) were: (1) Ventura, California, (2) Bakersfield, California, (3) Tallahassee, Florida, (4) Yakima, Washington, and (5) Flint, Michigan. Simulations were conducted at maximum application rates and differing application methods, specific to each fumigant. Comparisons between the 99% whole field buffer zones and the equivalent maximum direction percentiles are presented graphically and statistical summaries are included.

The objective was to characterize the relationship between the 99% whole field buffer zone length and its equivalent maximum direction buffer zone length distribution percentile over field sizes of 5, 20, and 40 acres. However, a significant limitation is the PERFUM 1440m upper limit on buffer zone length output. Because it is not possible to estimate percentiles for buffer zone lengths generated by PERFUM which are at or exceed 1440m, it was necessary to exclude from this analysis those fumigant application method, rate and size combinations that would produce large buffer zones which exceeded 1440m. Therefore, this analysis cannot fully characterize the relationship between the 99% whole field buffer zone distributions and the maximum direction buffer zone distributions.

PERFUM Code Modification

Modifications were made to the PERFUM2 source code in order to externally record internally generated values of interest (more on the modifications below). Using this modified code, 2 pesticide application situations were studied: 5 acre with fine grid and 20 acres with fine grid. The application scenario was shallow shank injection, tarped methyl bromide application using the maximum application rate of 430 lbs/acre. The flux profile is shown in Figure 1. While two 24-hour periods were included in the flux profile, the analysis focused on the first 24-hour period, which was the highest flux period. A listing of the PERFUM2 input file for 20 acres is shown in Appendix A. Ventura meteorology was used, though one day was removed due to a string of 24 hours of calms.

The PERFUM2.FOR source code was modified to print out daily concentrations ordered by both spoke/ring and spoke-specific buffer information. The modifications were exclusively in the subroutine "DAYCALC", which is contained in the PERFUM2.FOR file. The modifications are described more fully in Appendix B and a FORTRAN source code listing showing the modifications is presented in Appendix C. Briefly, code was inserted to open files and write out internal values. The code modifications did not change the logic or calculations of the program.

These modifications in the subroutine DAYCALC provided output which enabled (1) verification of the individual concentrations averages generated by PERFUM2, (2) analysis of the number of spokes each day where the reference concentration was exceeded along that spoke at the buffer zone distance, (3) verification of the 99% whole field buffer distance, and (4) further analysis of the fraction of the perimeter at the buffer zone distance where the health reference concentration would be exceeded. For (1) a single day was chosen, an independent ISCST3 control file was created and the discrete receptor concentrations from the single-day independent run were compared to the corresponding concentrations from PERFUM2 as found in CONCEN.OUT. For (2) the 99% whole-field buffer zone was compared to each spoke-specific buffer zone each day. The daily spoke exceedance information was used to estimate a daily fraction of the buffer perimeter where the reference concentration was exceeded. These daily lengths were compiled into a distribution. For (3) the individual spoke length "buffers" (distance to reach the reference concentration) were aggregated into a distribution and distributional points were compared to the PERFUM2 distribution points. For (4) an additional program was written to analyze output from the modified PERFUM2 to calculate a fraction of the perimeter where concentrations exceeded the reference concentration.

For days on which concentrations along the buffer zone exceeded the reference concentration, we calculated the fraction of the perimeter that exceeded the reference concentration with two methods: by a simple count of exceedance spokes divided by total spokes and by an edge/corner spoke perimeter calculation that adjusted for the different arc-length represented by the edge versus corner spokes. There was no substantive difference in these results, so the perimeter calculations based on the more accurate arc-length are presented. In this discussion, the edge/corner spoke method is the same as the arc-length method. Appendix D lists a FORTRAN

utility which estimated the fraction of perimeter at the buffer zone distance where the threshold concentration was exceeded and Appendix E presents results comparing the two methods for computing the perimeter distances where the threshold concentration was exceeded.

Results

Data collected from the USEPA PERFUM modeling outputs

Figures 3 through 5 show the change in the equivalent maximum direction buffer zone distribution percentile with the 99% whole field buffer zone length. The three figures are on the same scale to facilitate cross comparison. For methyl bromide (Figure 3) the equivalent maximum direction percentiles are clustered between about 85% and 90%. For metam sodium (Figure 4) and chloropicrin (Figure 5), the equivalent maximum direction percentiles show a greater range, from about 95% to 63%. There are several factors potentially contributing to differences observed between fumigants. The most significant factor may be the averaging time of the health threshold. The methyl bromide averaging time is 24 hours, the metam sodium averaging time is 8 hours, and the chloropicrin averaging time is 4 hours. It should be noted that the health threshold air concentration for metam sodium applications is actually for methyl isothiocyanate, which is a breakdown product of metam sodium and the contaminant of concern. An additional factor is that the 4-hr and 8-hr TWA whole field buffer zones with the lowest maximum direction buffer equivalent percentile occurred at night. Thus, shorter threshold averaging time coupled with a flux profile that caused the whole field buffer zone size to be driven by nighttime averaging periods was associated with the lowest maximum buffer zone equivalent percentiles.

Figure 6 summarizes the relationship between the 99% whole field buffer zone length and the equivalent percentile in the maximum direction buffer zone distributions for application methods used to apply the three fumigants. Figure 6 shows the distribution of maximum direction buffer zone percentiles with the median value labeled for each application scenario. The width of the box plots illustrates the variability for each application method in the equivalent maximum direction distribution percentiles. The methyl bromide 99% whole field buffer zones are the least variable with consistent median maximum direction buffer zone percentiles of 86 to 88. Thus, under the use scenarios characterized in this analysis on average about 12% to 14% of methyl bromide applications with a 99% whole field buffer zone will have a buffer zone failure somewhere along the whole field buffer zone perimeter. Figure 6 clearly shows variable performance of the 99% whole field buffer zones for metam sodium and chloropicrin. The median equivalent maximum direction percentiles vary between a high of the 92.5 and a low of 71. In addition to the large spread in the median equivalent maximum direction percentile for metam sodium and chloropicrin application methods, the variability within any particular application method is also quite different. For example, the metam sodium intermittent sprinkler

and intermittent shank methods show very little variation and median equivalent maximum direction buffer zone percentiles of 91% and 92.5% respectively. In contrast, chloropicrin untarped broadcast and untarped bed methods show highly variable equivalent maximum direction buffer zone percentiles with median percentiles of 71% and 74.5%, respectively.

PERFUM Code Modification

Verifications. The single day verification showed complete agreement between the PERFUM2-generated concentrations and those from an independent ISCST3 run. The independently assembled distributions of whole-field buffer zone lengths yielded a 99% whole field buffer zone which agreed with the PERFUM2 99% whole field buffer zone for the 5 acre and 20 acre find grid scenarios. There was a minor difference in that PERFUM2 appears to round the estimated buffer zones to the nearest 5m. These verifications provide additional confidence in the PERFUM2 calculations.

Distributions of exceedance perimeter lengths. From the total 1794 days simulated, the 99% whole field buffer was not protective at some point along the perimeter of the buffer zone distance from the field on 271 days and 230 days for the 5 acre and 20 acre fields, respectively. Thus the 99% whole field buffer corresponded to an 85%-tile (=100*(1794-271)/1794) and 87%-tile (=100*(1794-230)/1794) maximum direction buffer for the 5 and 20 acre scenarios, respectively. These independently derived calculations were consistent with the results in Figure 6 for methyl bromide method 1.

Amongst the days where exceedances occurred, Figures 7 and 8 provide distributions for the fraction of the buffer zone perimeter based on the arc-length method which exceeded the reference concentration. The two methods for calculating the fraction yielded somewhat different histograms, but the general limits and shapes were similar (details in Appendix E). In both cases perimeter fractions ranged from 0.01 to about 0.15. In part, the differences between the 2 methods resulted from the different number of edge versus corner spokes between 5 acre and 20 acres fields and the relatively different arc lengths represented by the 5 acre and 20 acre cases.

The histograms in Figures 7 and 8 provide some indication of the distribution of fractions of perimeters which are exceeded, when there is an exceedance somewhere along the buffer zone perimeter. Figures 9 and 10 provide the same data expressed as cumulative distributions of perimeter exceedance fractions and can be utilized more quantitatively to calculate probabilities.

Thus, for example, for the 20 acre field, amongst days when there is an exceedance, the probability is about 50% that the length along the buffer zone distance perimeter will be greater than about 7% of the perimeter, using the arc-length perimeter calculation method (Figure 10).

Given that the 20 acre buffer perimeter for a 99% whole field buffer of 200m is 2,395m, there will be a 50% probability that the distance of exceedance along the buffer perimeter is greater than 168m.

Discussion

The 99% whole field buffer zones show median equivalent maximum direction buffer zone percentile levels of between 71% and 92.5% (Figure 6). Thus, the individual application 99% whole field buffer zone median failure rate is between 7.5% and 29% of applications. The highest failure rate of 37% was for chloropicrin broadcast untarp application method at Tallahassee, Florida.

The failure rate appears to be related to the averaging time of the health threshold. Shorter averaging times show higher individual application failure rates. Thus, the per application buffer zone failure rate determined using the 99% whole field method (ostensibly a 1% failure rate) results in maximum direction median failure rates of between 7.5% and 29% of applications. These results are for application scenarios where both the whole field and the maximum direction buffer zones are less than or equal to 1440m. Performance of large (>1440m) 99% whole field buffer zones is unknown.

For the 20 acre methyl bromide application example that we analyzed, when there is a failure, the data extracted from PERFUM indicates that the perimeter distances along which the health reference level is exceeded can be larger than the length of a football field. We would expect that varying field size, flux profile, or exposure period would influence the shape of the distributions in Figures 7-10 and hence, influence the size of the expected perimeter lengths which would be expected to experience concentrations higher than the reference level.

While the “whole field” method (Reiss and Griffin, 2006) has the stated objective of characterizing “whole population” risk, that method does not incorporate a numeric or spatial distribution of potentially exposed bystander populations. Consequently the whole field method does not explicitly incorporate the probability that bystanders are located on or near the buffer zone perimeter. The implicit assumption is that the probability is low and uniformly distributed around the field (Freeman, 2004). However, analysis of DPR soil application methyl bromide worksite plans (Barry, 2005) shows approximately 20% of applications have at least one sensitive site (e.g., residences, high schools) within 50ft of the buffer zone. The majority of applications showed between 1 and 10 sensitive sites and fewer showed between 10 and 50 or more (e.g. larger residential developments).

Summary

- The relationship between maximum direction and whole field buffer zone procedures was studied.

- The 99% whole field buffer zones corresponded to median equivalent maximum direction percentiles of 71% to 92.5%. This corresponds to a median individual application buffer zone failure rate of between 7.5% and 29%. The highest individual application buffer zone failure rate was 37% for the chloropicrin broadcast untarp application method at Tallahassee, Florida.

- Metam sodium and chloropicrin exhibited a wider range of equivalent percentiles than methyl bromide due to the shorter exposure threshold periods.

- Additional verification of PERFUM2 calculations was satisfactory.

- For a 20 acre methyl bromide shallow tarped scenario, amongst days where a 99% whole field buffer was exceeded, there was a 50% probability that the length of the perimeter that was exceeded would be greater than 168m.

- The whole field method does not take into account specific population locations and in California, residential development can be found next to approximately 20% of treated fields at the buffer zone distance.

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Segawa, R. T. Barry and B. Johnson. 2000. Recommendations for methyl bromide buffer zones for field fumigations. Memorandum to Dr. John S. Sanders, Chief, Environmental Monitoring Branch, dated January 21, 2000.

Sullivan, D.A., M.T. Holdsworth, and D.J. Hlinka. 2004. Monte Carlo-based dispersion modeling of off-gassing releases from the fumigant metam-sodium for determining distances to exposure endpoints. Atmospheric Environment vol 38(16):2471-2481.

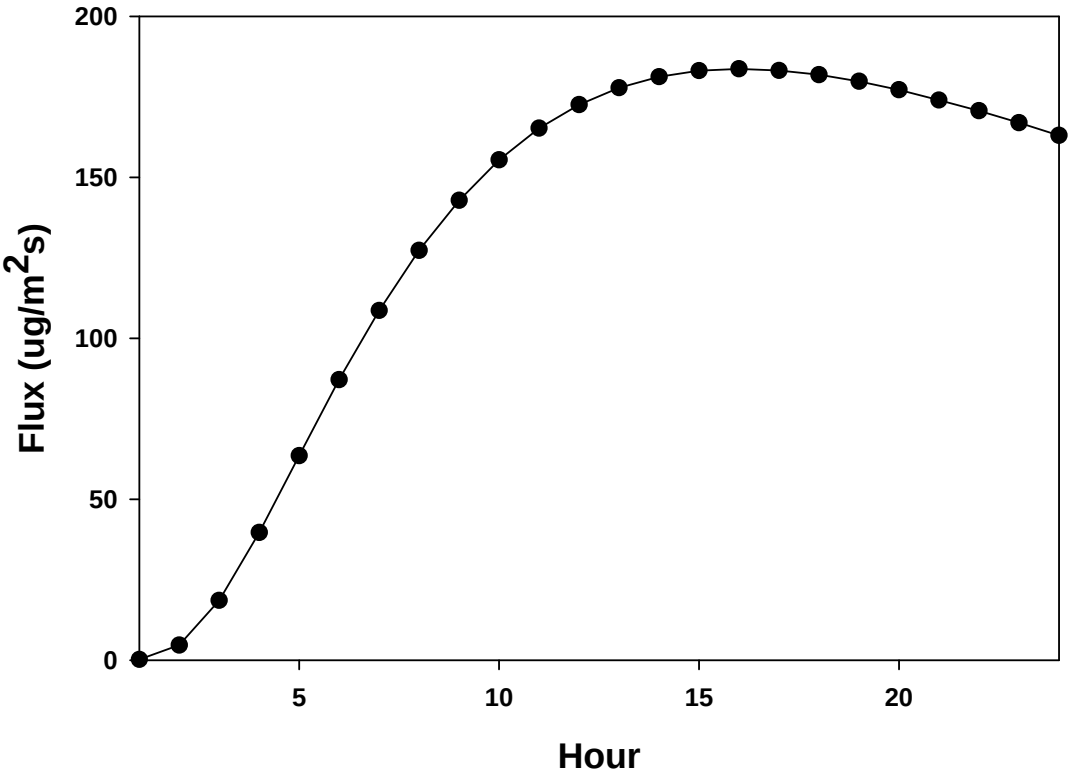


Figure 1. Flux profile for methyl bromide for first 24 hours.

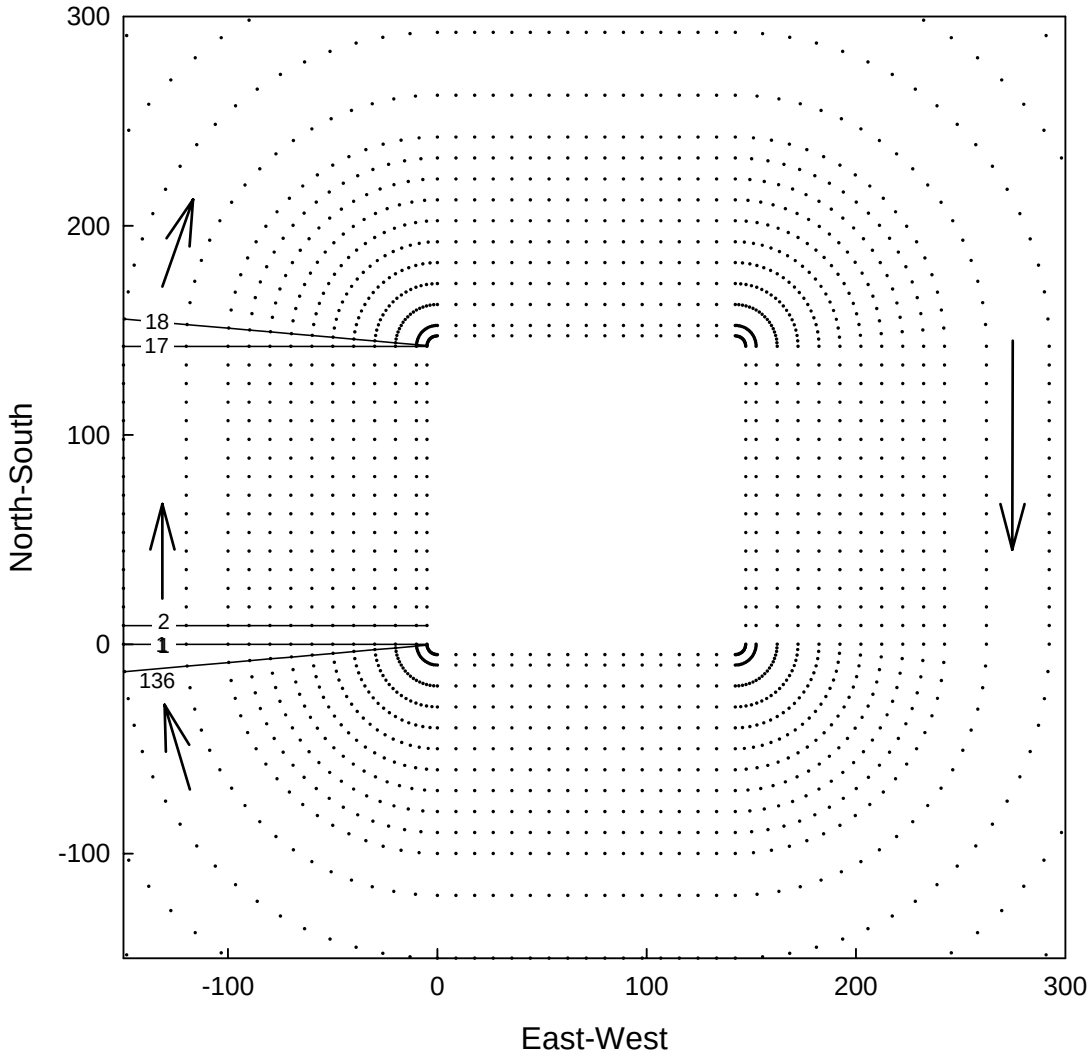


Figure 2. Spoke numbering scheme for 5 acre, square plot, fine grid. First spoke begins at southwest corner of field, extending due west. Subsequent spokes originate from the edge moving clockwise. There are 17 spokes along each straight edge and 17 spokes radiating from each corner, for a total of 136 spokes. Lines are drawn for illustration purposes for spokes 1,2,17,18 and 136.

Figure 3. Relationship between the methyl bromide 99% whole field buffer zone length (m) and the equivalent maximum direction buffer zone percentile. Equivalent maximum direction percentile = individual application level protection probability = (1 – individual application buffer zone failure rate).

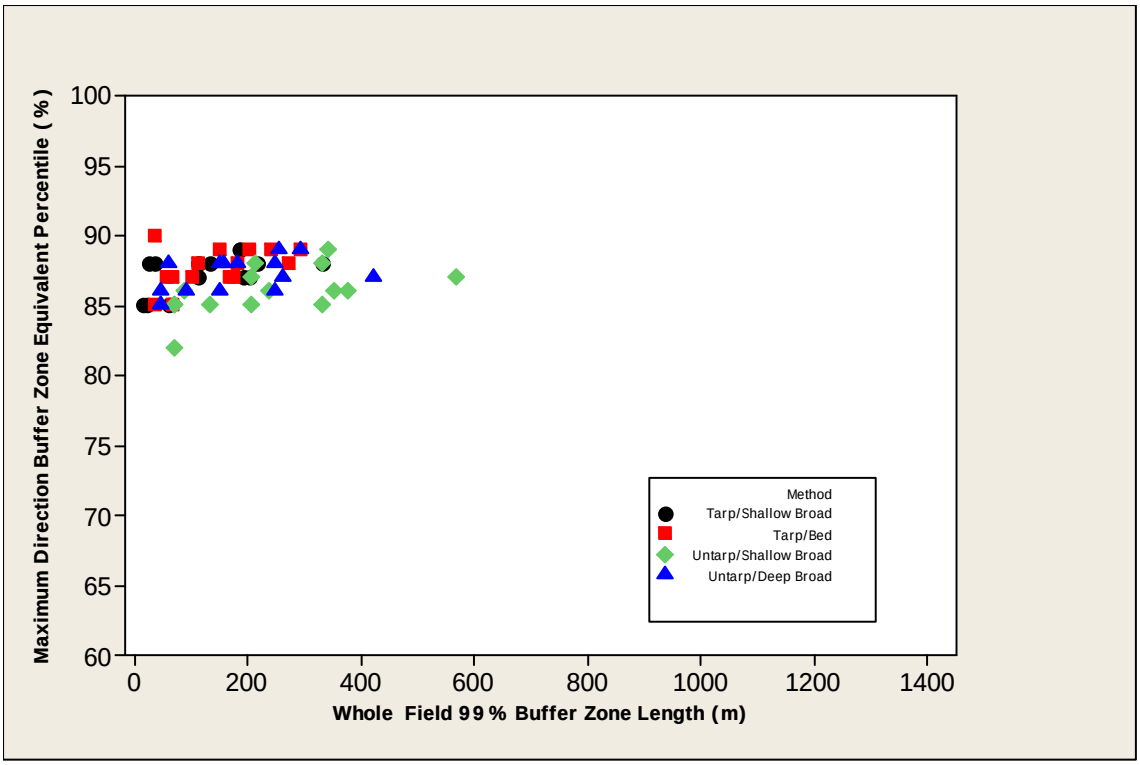


Figure 4. Relationship between the metam sodium 99% whole field buffer zone length (m) and the equivalent maximum direction buffer zone percentile. Equivalent maximum direction percentile = individual application level protection probability = (1 – individual application buffer zone failure rate).

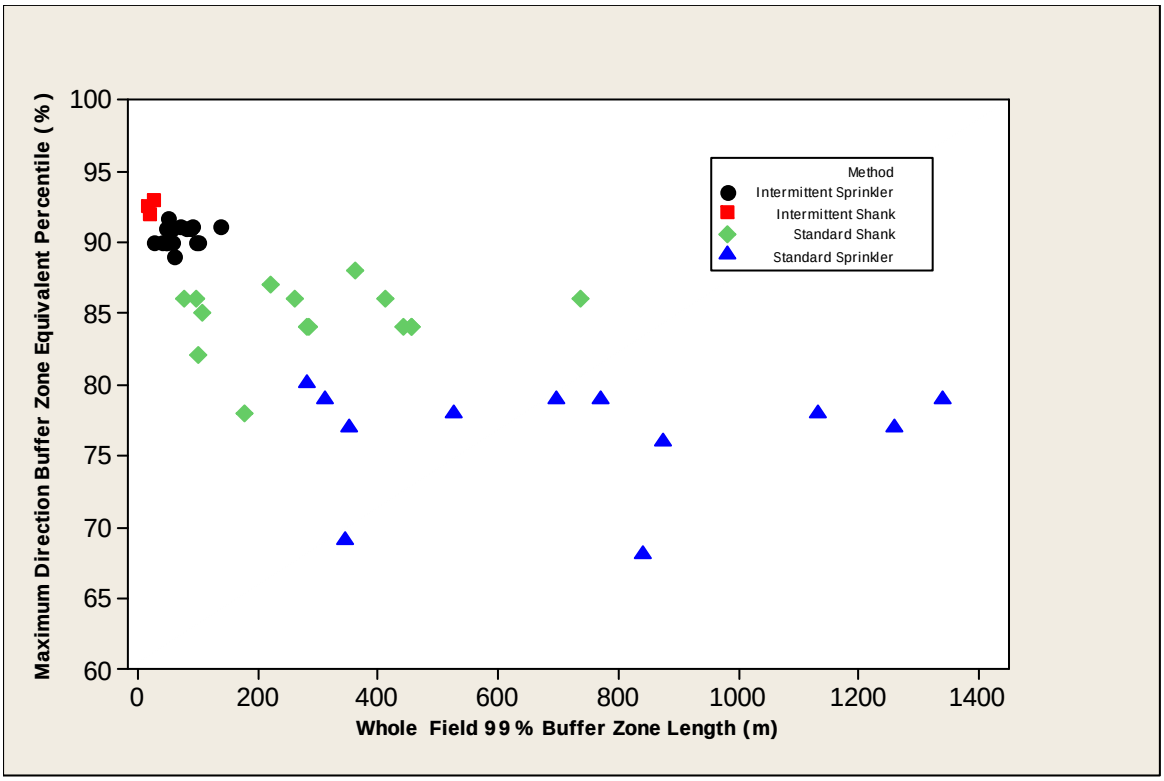


Figure 5. Relationship between the chloropicrin 99% whole field buffer zone length (m) and the equivalent maximum direction buffer zone percentile. Equivalent maximum direction percentile = individual application level protection probability = (1 – individual application buffer zone failure rate).

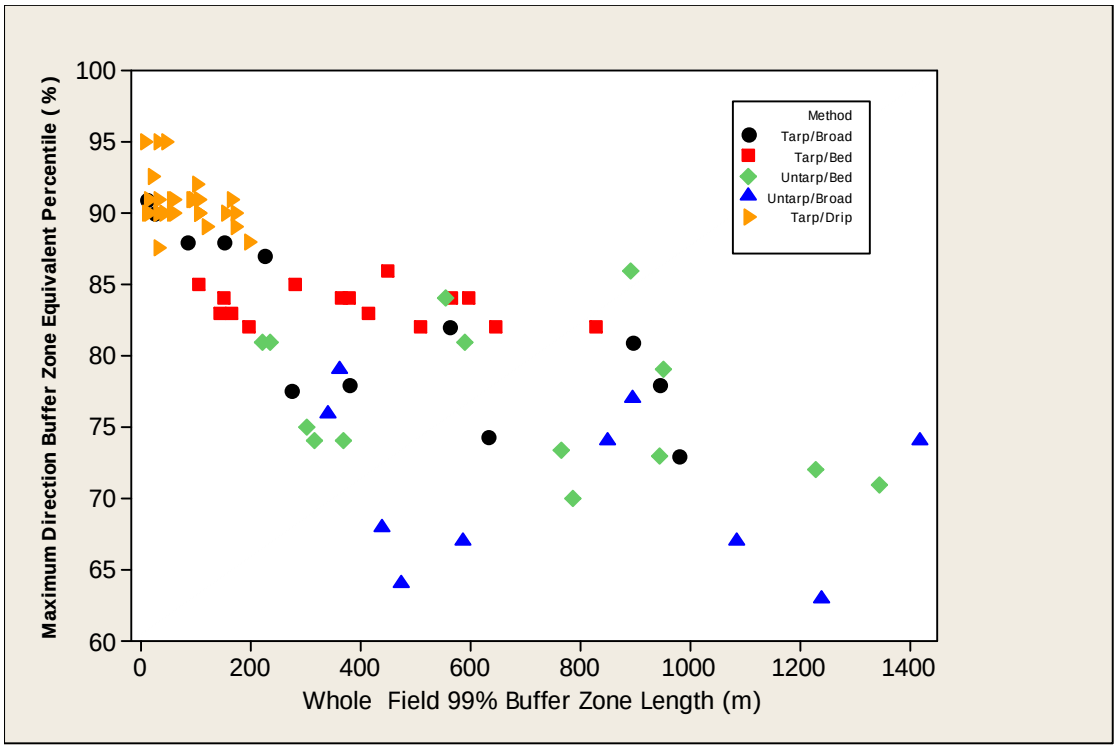
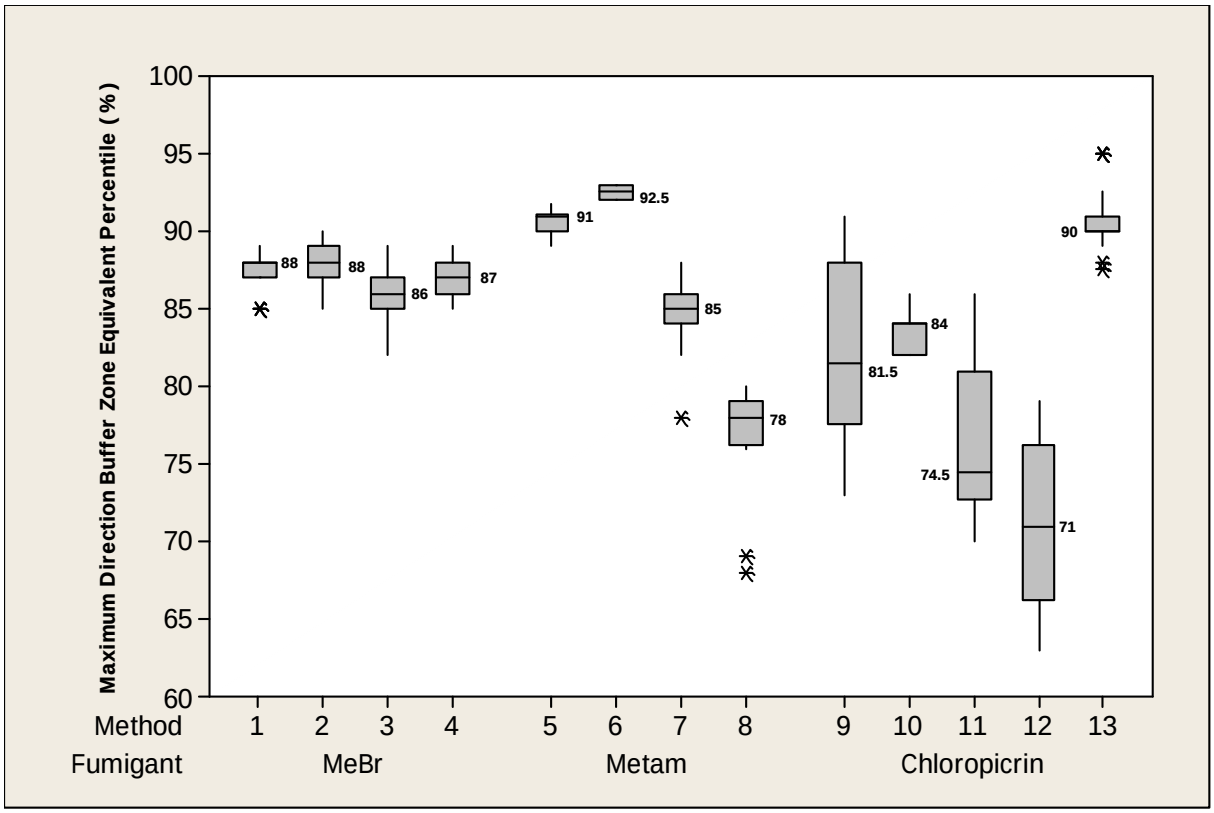


Figure 6. Summary of the maximum direction buffer zone equivalent percentiles for the 99% whole field buffer zone of application methods for methyl bromide, metam sodium and chloropicrin. The application methods within each fumigant are as follows: methyl bromide (MeBr) 1 = tarp/broadcast, 2 = tarp/bed, 3 = untarp/shallow, 4 = tarp/deep. Metam sodium (Metam) 5 = intermittent watering-in sprinkler, 6 = intermittent watering-in shank, 7 = standard shank, 8 = standard sprinkler. Chloropicrin (Chloropicrin) 9 = tarp/broadcast, 10 = tarp/bed, 11 = untarp/bed, 12 = untarp/broadcast, 13 = tarp/drip. Key to the boxplot: the median value is the line shown inside each box. The value of the median for each box is labeled next to the line. The top and both of the box indicate the lower and upper quartiles. The line (whisker) extends to the lower and upper values that are within 1.5 times the inter-quartile range. The stars indicate outlier values. Equivalent maximum direction percentile = individual application level protection probability = (1 – individual application buffer zone failure rate).



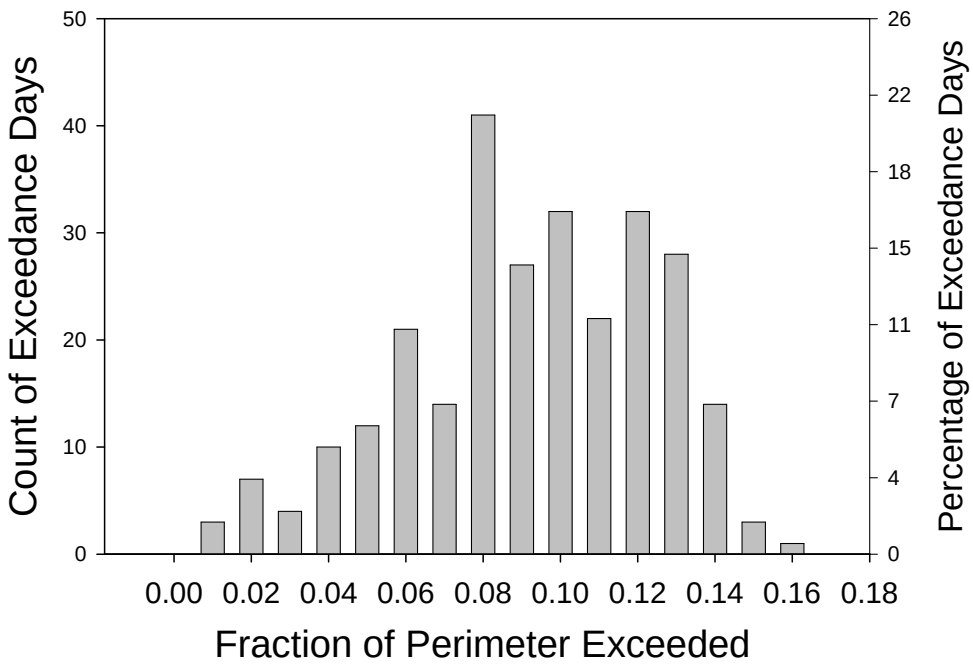


Figure 7. Fine grid, 5 acre scenario with histograms of the daily fractions of the perimeter where the concentration exceeded the reference level. The total days were 1794, of which 1523 days showed no exceedance. This figure plots the exceedances for the 271 days where 1 or more spokes showed an exceedance.

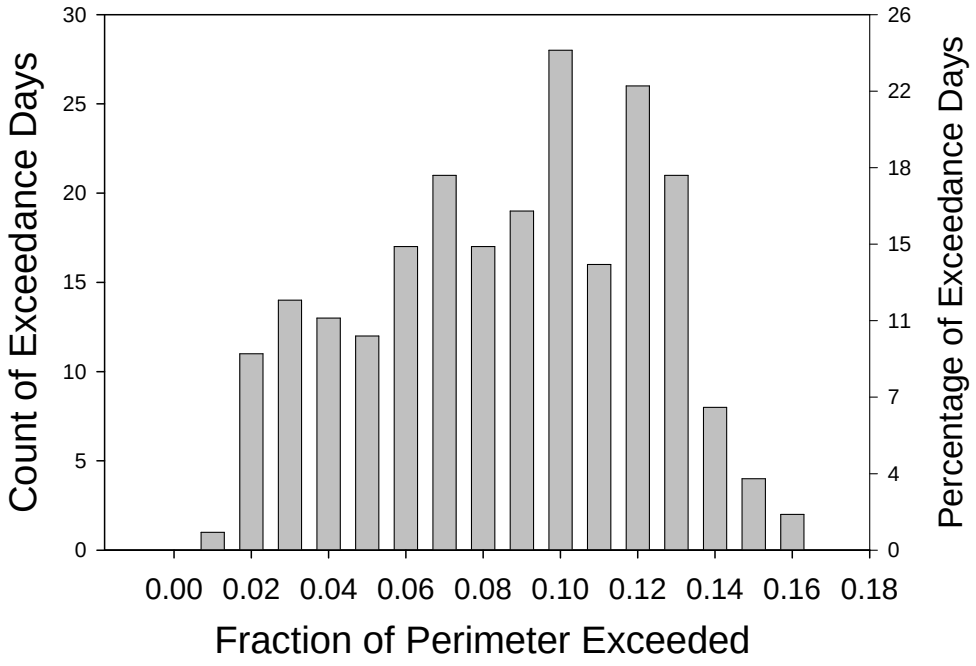


Figure 8. Fine grid, 20 acre scenario with histograms of the daily fractions of the perimeter where the concentration exceeded the reference level. The total days were 1794, of which 1564 days showed no exceedance. This figure plots the exceedances for the 230 days where 1 or more spokes showed an exceedance.

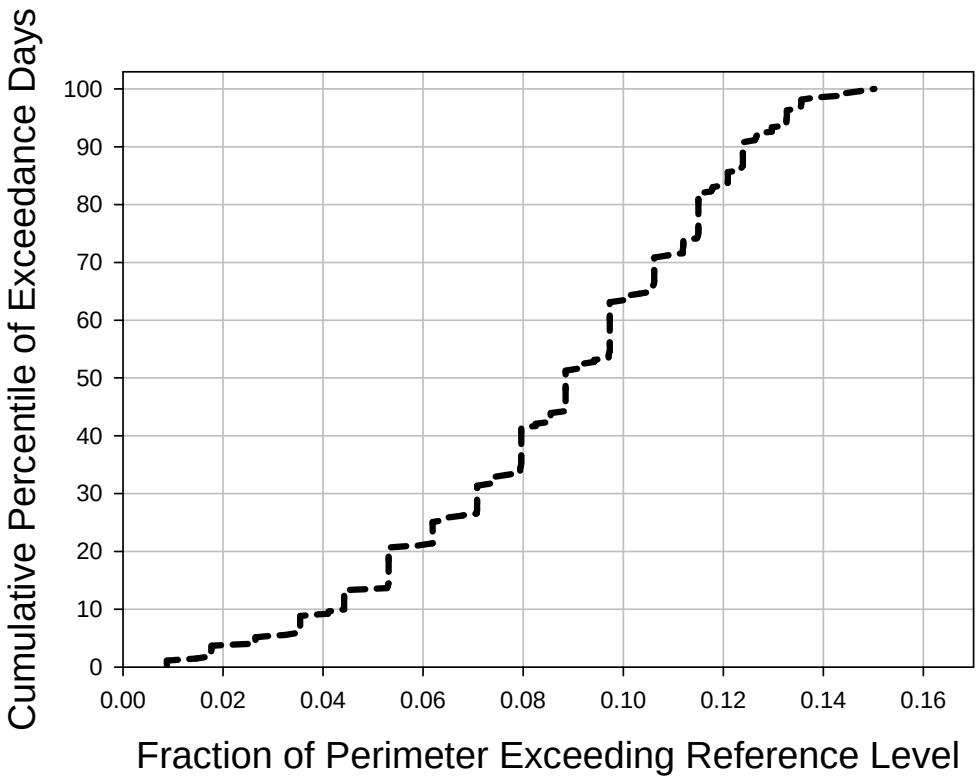


Figure 9. Cumulative distribution of perimeter length exceedances for 5 acre, fine grid scenario based on 271 days where at least one spoke exceeded the reference concentration at the buffer zone distance.

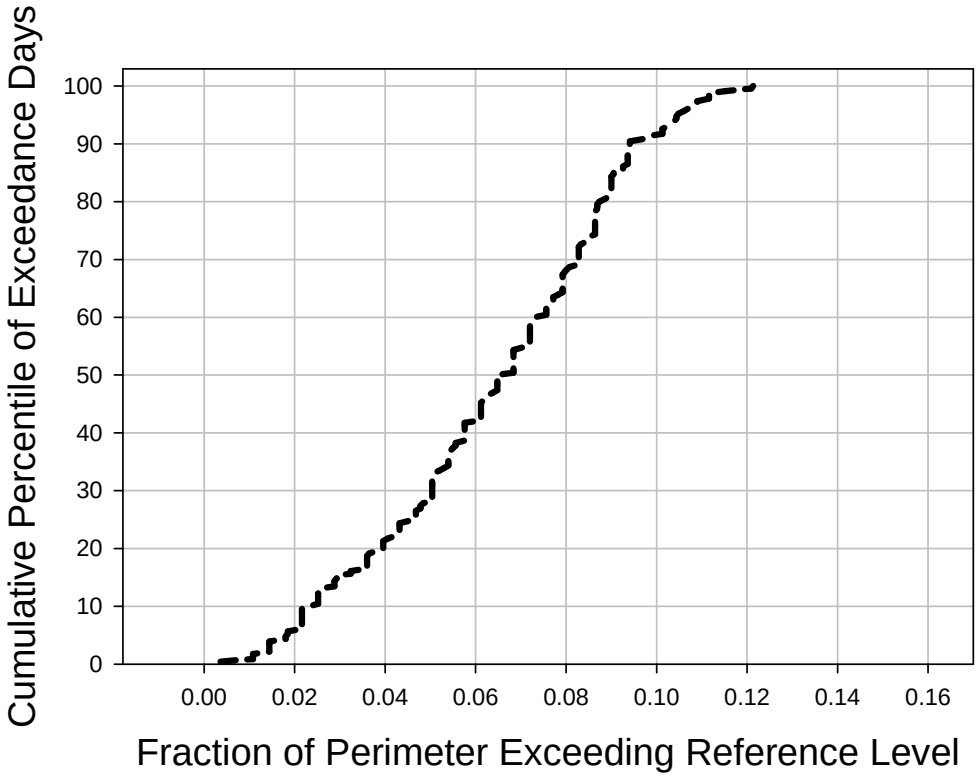


Figure 10. Cumulative distribution of perimeter length exceedances for 20 acre, fine grid scenario based on 230 days where at least one spoke exceeded the reference concentration at the buffer zone distance.

Appendix A. Control file used for 20 acre, fine grid, shallow, tarped methyl bromide application.

```
001  * PERFUM2 Input File
002  *** Specify scenario type ****
003  ** SF = single field
004  ** MF1 = multiple field no. 1 (4 fields surrounding main field
005  ** MF2 = multiple field no. 2 (large field broken into quadrants)
006  ** MOE = margin of exposure (for single fields only)
007  ** GRN = greenhouse scenario
008  Scenario Type:                SF
009  * ISCST3 Portion of Control File - Used for all scenarios
010  ISCST3 input file:            SF.inp
011  ISCST3 output file:           SF.out
012  Met station ID:               99999
013  Upper air station ID:         99999
014  Field length x-direction (m): 284.5
015  Field length y-direction (m): 284.5
016  Grid density (C/F):           F
017  ** Additional information for MF1 Scenario
018  Distance between sources (m): 450.0
019  Fluxes (enter or proportion): P
020  Flux proportion:              1.0
021  ** Additional information for MF2 Scenario
022  Main source:                  3
023  Flux choice (P/E):            P
024  Flux proportion for NE:       0.30
025  Flux proportion for NW:       0.15
026  Flux proportion for SW:       1.0
027  Flux proportion for SE:       0.05
028  ** Additional information for the Greenhouse scenario
029  Source type (P/A):            P
030  Building Height (meters):     15.0
031  Adjusted Height (meters):     15.0
032  Flux choice (C/E):            C
033  App rate (lbs/1000ft3):       3.0
034  Time spent applying (hours):  0.1
035  Time spent treating (hours):  4.0
036  AER (hr-1) treatment:         0.5
037  AER (hr-1) aeration:          2.0
038  Stack height, m (above bldg): 1.0
039  Stack diameter (m):           1.0
39A  Exit velocity (m/sec):        0.05
040  * Buffer zone model portion - general inputs for all scenarios
041  Flux data source:             CDPR Commodity Permit Conditions
042  Meterological source          Ventura, California
043  Number of simulation days:    2
044  Averaging Period:             24
045  Distribution Avg. Period:     24
046  Begin Year:                   1995
```

```
End Year:                       1999
Starting Hour:                  10
Meteorological file:            vtx.MET
Output file:                    PERFUM.OUT
Plot file:                      PERFUM.PLT
Contour file:                   PERFUM.CTR
Contour Percentile:             95
NOEL or HEC (ug/m3):            38830.0
UF:                             30.0
Buffer length (m):              165.0
** Include application rates for calculation
Number of Application rates:  1
Application rate no. 1:         430.0
Application rate no. 2:
Application rate no. 3:
Application rate no. 4:
Application rate no. 5:
Application rate no. 6:
Application rate no. 7:
Application rate no. 8:
Application rate no. 9:
Application rate no. 10:
** Flux data for Main Source
Hour1:                          183.68 100.28
Hour2:                          183.2 97.04
Hour3:                          181.85 93.9
Hour4:                          179.79 90.86
Hour5:                          177.16 87.92
Hour6:                          174.0 85.08
Hour7:                          170.63 82.34
Hour8:                          166.92 79.68
Hour9:                          163.01 77.12
Hour10:                         0.2 158.95
Hour11:                         4.63 154.81
Hour12:                         18.54 150.6
Hour13:                         39.63 146.38
Hour14:                         63.52 142.16
Hour15:                         87.1 137.98
Hour16:                         108.61 133.83
Hour17:                         127.26 129.75
Hour18:                         142.83 125.75
Hour19:                         155.4 121.82
Hour20:                         165.21 117.99
Hour21:                         172.57 114.25
Hour22:                         177.8 110.6
Hour23:                         181.21 107.06
Hour24:                         183.09 103.62
** Flux data for Multiple Source No. 1
Hour1:
Hour2:
```

```
Hour3:
Hour4:
Hour5:
Hour6:
Hour7:
Hour8:
Hour9:
Hour10:
Hour11:
Hour12:
Hour13:
Hour14:
Hour15:
Hour16:
Hour17:
Hour18:
Hour19:
Hour20:
Hour21:
Hour22:
Hour23:
Hour24:
** Flux data for Multiple Source No. 2
Hour1:
Hour2:
Hour3:
Hour4:
Hour5:
Hour6:
Hour7:
Hour8:
Hour9:
Hour10:
Hour11:
Hour12:
Hour13:
Hour14:
Hour15:
Hour16:
Hour17:
Hour18:
Hour19:
Hour20:
Hour21:
Hour22:
Hour23:
Hour24:
** Flux data for Multiple Source No. 3
Hour1:
Hour2:
```

```
Hour3:
Hour4:
Hour5:
Hour6:
Hour7:
Hour8:
Hour9:
Hour10:
Hour11:
Hour12:
Hour13:
Hour14:
Hour15:
Hour16:
Hour17:
Hour18:
Hour19:
Hour20:
Hour21:
Hour22:
Hour23:
Hour24:
** Flux data for Multiple Source No. 4
Hour1:
Hour2:
Hour3:
Hour4:
Hour5:
Hour6:
Hour7:
Hour8:
Hour9:
Hour10:
Hour11:
Hour12:
Hour13:
Hour14:
Hour15:
Hour16:
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Hour18:
Hour19:
Hour20:
Hour21:
Hour22:
Hour23:
Hour24:
```

Appendix B. Discussion of modification of PERFUM2 to obtain daily spoke-specific buffer information.

Two situations were studied: 5 acre with fine grid and 20 acres with fine grid. The application scenario was shallow, tarped methyl bromide application using the maximum application rate of 430 lbs/acre. The flux is shown in Figure 1. While two 24-hour periods were included in the flux profile, the analysis focused on the first 24-hour period, which was the highest flux period. A listing of the PERFUM2 input file for 20 acres is shown in Appendix A. Ventura meteorology was used, though one day was removed due to a string of 24 hours of calms.

The PERFUM2.FOR source code was modified to print out both daily concentrations ordered by spoke/ring and spoke-specific buffer information. PERFUM2 calls ISCST3 (which has been adapted to become a subroutine for PERFUM2) and collects the concentration estimates at each spoke/ring coordinate for a day. Then PERFUM2 proceeds spoke by spoke and estimates the distance along each spoke to reach the reference concentration. The modifications were exclusively in the subroutine “DAYCALC”, which is contained in the PERFUM2.FOR file. The modifications are shown in full in Appendix B. Briefly, code was inserted to open files and write out internal values. The code modifications did not change the logic or calculations of the program.

Thus these modifications in the subroutine DAYCALC provided output which enabled (1) verification of the individual concentrations averages generated by PERFUM2, (2) analysis of the number of spokes each day where the reference concentration was exceeded along that spoke at the buffer zone distance, and (3) verification of the 99% whole field buffer distance. For (1) a single day was chosen, an independent ISCST3 control file was created and the discrete receptor concentrations from the single-day independent run were compared to the corresponding concentrations from PERFUM2 as found in CONCEN.OUT. For (2) the 99% whole field buffer zone was compared to each spoke-specific buffer zone each day. The daily spoke exceedance information was used to estimate a daily fraction of the buffer perimeter where the reference concentration was exceeded. These daily lengths were compiled into a distribution. For (3) the individual spoke length ‘buffers’ (distance to reach the reference concentration) were aggregated into a distribution and distributional points were compared to the PERFUM2 distribution points.

A small FORTRAN utility was written to analyze the results in SPOKEBUF.OUT. A listing of this program, COUNTXC.FOR, is provided in Appendix C. This program takes as user input, the whole-field buffer zone at a given percentile, and uses it to determine on a daily basis, the number of spokes where the actual concentration at the buffer zone distance exceeded the reference concentration. This was determined by comparing the ‘spoke bufferzone’ (in the last column of Table B1) to the whole field buffer zone and counting up the number of spokes for each day where the spoke bufferzone was larger than the whole-field buffer zone. This resulted

in a per day number ranging from 0 to a maximum possible NSPOKE, counting the number of spokes where the whole-field buffer zone would be smaller than the spoke-bufferzone, or

Table B1. Small excerpt from SPOKEBUF.OUT for fine grid, 5 acre simulation. Columns are Julian day, year, IAPP, IDAYS, IAVG, number of spokes per field (twice), spoke number, and spoke-buffer. The spoke-buffer is the distance determined along each spoke to reach the reference concentration.

2	95	1	1	1	136	136	1	5.00
2	95	1	1	1	136	136	2	5.00
2	95	1	1	1	136	136	3	5.00
2	95	1	1	1	136	136	4	5.00
2	95	1	1	1	136	136	5	5.00
2	95	1	1	1	136	136	6	5.00
2	95	1	1	1	136	136	7	5.00

equivalently, where the concentration at the whole-field buffer distance was greater than the reference concentration.

The use of .GT. ("greater than") versus .GE. ("greater than or equal to") was compared and found no differences in the 5 acre fine grid, but 1 extra exceedance spoke in the 20 acre fine grid. Thus the differences were negligible and results are reported using the "greater than" version.

At the beginning of COUNTXC the user enters a value for 'TRUBUF', which in this study was the whole-field buffer zone at the 99th percentile. This is the value used to compare to each of the spoke-buffers. For 5 acres the 99th percentile whole field buffer was 60m and for 20 acres it was 200m. COUNTXC outputs a file consisting of 1794 records, which is the number of valid days of meteorological data for the Ventura meteorological data set. The columns consist of several fields. The fields are the Julian day, two digit year, number of spokes in flux period 1 where the buffer-spoke distance exceeded the whole-field buffer distance and a similar number for period 2. The next field (P1EDG) gives a count of the number of "edge spokes" that exceeded TRUBUFF on that day during flux period 1. Following that is the number of corner spokes (P1COR) that exceeded the TRUBUFF on that day during flux period 1.

We calculated the fraction of the perimeter that exceeded the reference concentration with two methods: by a simple count of exceedance spokes divided by total spokes and by an edge/corner spoke perimeter calculation that adjusted for the different arc-length represented by the edge versus corner spokes.

The columns "FRAC BY COUNT" gives the spoke exceedance count divided by the total spoke number. In this case, Table B2, the 20 acre field fine grid utilized 200 spokes. So, for example, the second line is labeled as Julian day 3 for 1995. What this actually corresponds to is Ventura meteorology from 10:00 on January 2 through 9:00 on January 3 inclusive, since the application start hour was 10:00. This is labeled as Julian day 3. For this 24-hour meteorology period, 25 spokes saw an exceedance of the threshold at the buffer zone distance of 200m. All 25 spokes were from edge spokes. No corner spokes showed exceedances on this day. The fraction by simple counting was 0.125 (=25/200).

The second fraction, "FRAC BY LEN", shows the edge/corner perimeter calculation, which uses the arc-adjusted fraction of the perimeter. The total perimeter at the buffer zone distance, D, consists of the four sides, S, plus a circle with radius B (TRUBUFF, i.e. the 99% whole field buffer zone), which has a perimeter of $2\pi B$ and thus the entire perimeter is $D=4S+2\pi B$

In order to calculate the contribution from each edge spoke, it is necessary to determine the number of edge spokes. The general pattern of spokes is shown in Figure 2. For fine grids there are 17 spokes at each corner. This gives 18 divisions at the corner, which provides 5 degree separations between corner spokes. The file SPOKEBUF.OUT contains the total number of spokes for each field. By subtraction, the number of edge spokes can be determined. For the 20 acre fine grid, the total number of spokes was 200. The number of corner spokes was 68 (=4*17) and the number of edge spokes was 132. In order to get the perimeter contribution from each edge or each corner spoke, the corresponding perimeter is divided by the number of that kind of spoke. For edge spokes, CE=4S/#edge spokes and for corner spokes, $CC=2\pi B$/#corner spokes. For 20 acre fine grid, for example, CE=284.5*4/132=8.62m/spoke and for the corners, CC=2*3.14*200/68=18.47m/spoke.

Table B2. Small excerpt from COUNTXC.OUT, for the 20 acre, fine grid run, showing Julian day, year, number of spoke-buffers exceeding whole-field buffer zone distance for period 1 and period 2, count of edge spokes exceeding the buffer (i.e. when the reference concentration along a spoke occurred at a distance greater than the tested buffer zone), count of corner spokes exceeding the buffer, fraction of spokes exceeding the buffer and fraction of the perimeter exceeding the perimeter at the buffer distance from the field. The tested buffer was the 99th percentile whole-field buffer zone calculated by PERFUM.

```
THE TESTED BUFFER ZONE USED WAS     200.00
 THE STRAIGHT EDGES PERIMETER TOTAL         1138.00
 THE CIRCULAR PERIMETERS TOTAL              1256.64
 THE TOTAL PERIMETER AT THE BZ DIST         2394.64
 THE LENGTH PER EDGE SPOKE IS                8.6212
 THE LENGTH PER CORNER SPOKE IS             18.4799
 THE NUMBER OF CORNER SPOKES IS        68
 THE NUMBER OF EDGE SPOKES IS         132
 JULIAN DAY,YEAR,PERIOD 1 EXCEED COUNT, PERIOD 2 EXCEED COUNT
 PER 1 EDGE SPOKE CNT, PER 1 CORNER SPOKE CNT, PER 1 FRACTION BY CRUDE COUNT,
 PER 1 FRACTION BY PERIMETER LENGTH ADJST FOR CORN
```

JULDAY	YEAR	CNT1	CNT2	P1EDG	P1COR	FRAC BY COUNT	FRAC BY LEN
2	95	0	0	0	0	0.0000	0.0000
3	95	25	0	25	0	0.1250	0.0900
4	95	20	0	18	2	0.1000	0.0802
5	95	0	0	0	0	0.0000	0.0000
6	95	20	0	20	0	0.1000	0.0720
7	95	0	0	0	0	0.0000	0.0000
15	95	0	10	0	0	0.0000	0.0000
16	95	8	0	8	0	0.0400	0.0288
17	95	14	0	11	3	0.0700	0.0628
18	95	0	0	0	0	0.0000	0.0000
19	95	0	0	0	0	0.0000	0.0000
20	95	0	0	0	0	0.0000	0.0000

In line 3 of Table B2, there were 18 edge spokes and 2 corner spokes where the reference concentration was exceeded at the buffer zone distance. The simple count fraction was (=20/200). The corner/edge perimeter calculation fraction was 0.1 0.08 (=(17*8.62+2*18.47)/2394).

Finally, SORTSPOKE.FOR was written to process the output in the file, SPOKEBUF.OUT, by extracting the spoke-by-spoke distances to the reference concentration, sorting these distances and creating an output file called SORTSPOKE.OUT. The distance percentiles in SORTSPOKE.OUT corresponds to the whole-field cumulative distributions estimated by PERFUM2. Thus at for these two cases, the PERFUM2 whole-field buffer zone percentile calculation could be checked.

Appendix C. Modifications to the subroutine DAYCALC.

The DAYCALC code is shown below. The modifications made to this subroutine for our analysis are bolded and begin at line 1528 (line numbers not shown) of the PERFUM2 routine, DAYCALC, with a comment “BRJ070726 ADDED CODE HERE TO…”.

```
C*****************************************************************************************

      SUBROUTINE DAYCALC

C*****************************************************************************************
C                 DAYCALC
C
C        PURPOSE: Calculate daily average concentrations at each receptor
C                 point.  Then an interpolation is performed for each
C                 spoke in the receptor grid, and a buffer length is
C                 calculated for each spoke.  Also, the daily maximum
C                 buffer length is calculated.  All of these calculations
C                 are additionally performed on a monthly basis for
C                 seasonal analysis.
C
C        INPUTS:  Daily totals of concentrations by receptor points
C
C        OUTPUTS: Daily average buffer lengths
C
C        CALLED FROM:  ISCST3 subroutine
C
C*********************************************************************


       USE MAIN1
       USE BUFFER1

       IMPLICIT NONE

       INTEGER I,J,K,M


       NDAYS_PER = NDAYS_PER + 1

C      Start application rate loop
       DO 500 IAPP=1,NAPPRATES
C      Start flux day loop
       DO 500 IDAYS=1,NFLUXDAYS
C      Start avering time loop
       DO 500 IAVG=1,IAVG_PER

       IDIST_AVG = DIST_AVG(IAVG)

C      Calculate daily average concentration.  Use EPA's calms policy.  For a
C      24-hour period, divide daily concentration total by the maximum of the
C      non-calm hours, or 75% of the the number of hours (24)- +0.4 added per
C      ISCST3 code

      PER_HOURS = MAX(NON_CALM_HOURS(IAVG),NINT(AVG_TIME*0.75+0.4))
      IF(NON_CALM_HOURS(IAVG) .EQ. 0) THEN
        GOTO 500
      ENDIF
```

```
C      Divide by the number of non-calm hours to get the average concentration.
C      Adjust for the application rate.

C BRJ 070726 ADDED CODE HERE TO OUTPUT THE CONCENTRATIONS AND RING/SPOKE IDS
       OPEN(UNIT=27182,STATUS='UNKNOWN',POSITION='APPEND',
     1      FILE='CONCEN.OUT')  !CLOSE FILE AFTER 10 DO LOOP

       DO 10 I=1,NUMREC

         IRING = RINGID(I)
         ISPOKE = SPOKEID(I)

C        Averaging period calculation
         CONC_DISP_TMP(IRING,ISPOKE) =
     >     CONC_DISP(I,IDAYS,IAVG)/PER_HOURS


C        Adjustment for application rate
         CONC_DISP_TMP(IRING,ISPOKE) =
➢       CONC_DISP_TMP(IRING,ISPOKE)*(AppRate(IAPP)/AppRate(1))

C BRJ 070726 WRITE OUT THE DAY,YEAR, RING ID AND SPOKE ID AND CONCENTRATION
         WRITE(27182,37182)LJDAY,LYEAR,IDAYS,I,IRING,ISPOKE,
     1         CONC_DISP_TMP(IRING,ISPOKE)
37182    FORMAT(1X,6I6,F15.2)

10     CONTINUE
       CLOSE(27182)

        BUFFER_MAX = 0.                 ! initialize maximum buffer zone variable to zero

C BRJ 070724 OPEN FILE FOR APPENDING, INTERPOLATE SUBROUTINE PRODUCES 'BUFFER', WHICH IS
C BUFFER ALONG THAT SPOKE, FOR EACH SPOKE, SO WILL PRINTOUT NUMBER OF SPOKES PER FIELD, SPOKE
C NUMBER AND BUFFER, ARE ASSUMING 24 HOUR EXPOSURES
        OPEN(UNIT=31415,STATUS='UNKNOWN',POSITION='APPEND',
     1       FILE='SPOKEBUF.OUT')  !CLOSE THE FILE AFTER 110 DO LOOP BELOW
C
C       Begin to loop over each spoke
        DO 110 ISPOKE=1,NSPOKE_PER_FIELD

C         Call the interpolation subroutine to estimate the buffer distance for this spoke

          CALL INTERPOLATE(ISPOKE)

C BRJ 070724 INSERT THE PRINT STATEMENT TO GET THE TIME AND OTHER RELEVENAT INFO FOR THIS BUFFER

          WRITE(31415,61415)LJDAY,LYEAR,IAPP,IDAYS,IAVG,
     1                              NSPOKE_PER_FIELD
     2                                ,NSPOKE_PER_FIELD,ISPOKE,BUFFER
61415     FORMAT(1X,8I5,F10.2)


C         Update the buffer zone frequency arrays.  These arrays store the
C         frequency by which each buffer distance was found.
C         For the whole field calculation, the BUFFER_FREQ array is used
C         For the whole field monthly calculation, the BUFFER_FREQ_MON
C         array is used.  The first array indices refer to specific buffer
C         distances between 0 and 300, at *5 meters for each indice


          IASSIGN = 0                   ! Variable to check if a frequency was assigned
```

```
(……section of code omitted…….)

110     CONTINUE
C BRJ 070724 CLOSE THE SPECIAL OUTPUT FILE
        CLOSE(UNIT=31415)
```

The first modification opens a new file “CONCEN.OUT”, which receives the daily average concentrations by spoke. This file was used to directly compare independently run ISCST3 calculations for a selected day to verify the PERFUM2 calculations.

A few lines later a file called “SPOKEBUF.OUT” is opened for output. A few lines down, within the 110 Do Loop, the original code calls a subroutine, INTERPOLATE(ISPOKE). This subroutine computes the distance out along the particular spoke identified by the index, ISPOKE, until the reference concentration is reached. The value is returned in variable called BUFFER, which is not shown in this portion of the code. The second modification consists of a couple of lines which write out to the file, SPOKEBUF.OUT, the current values for several variables. The important variables are LJDAY, LYEAR, IDAYS, ISPOKE and BUFFER. LJDAY is the Julian day of the year. LYEAR is the last 2 digits of the calendar year (95, for example). IDAYS is the period number. In this case, there were two 24-hour flux periods and so IDAYS took on a value of either 1 or 2. ISPOKE is the spoke number, which in this case ranged from 1 to 40 for the 5 acre field. The control file was set up to only use one application rate, so that IAPP was always 1. Similarly, IAVG was equal to 1, as the number of averaging periods per 24 hour day. The final modification occurred just after the end of the 110 DO LOOP and closed the output unit.

Thus, these modifications to the PERFUM2 source code created two new files, CONCEN.OUT and SPOKEBUF.OUT, which respectively record the concentration calculations and list day by day, the distances along each spoke to reach the reference concentration. A single day of output consisted of 2*NSPOKE records (for five acres coarse grid, NSPOKE=40, 5 acres fine grid NSPOKE=136 and for 20 acres fine grid, NSPOKE=200) because there were two 24-hour flux periods in this example. Table 1 shows a small excerpt from SPOKEBUF.OUT for a 5 acre, coarse grid. The last column in Table B1, spoke buffer, gives the estimated distance along that particular spoke on that particular day to reach the reference concentration.

Appendix D. Listing of program COUNTXC.FOR.

```
C     Last change:  BRJ  30 Jul 2007    4:15 pm
        PROGRAM COUNTXC
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C 070730 MODIFIED COUNTXB (WHICH WAS FOR 5 ACRES) TO COUNTXC, WHICH WILL BE
C FOR 20 ACRES. 20 ACRES, ACCORDING TO THE CONCEN.OUT (WHICH IS NOW ZIPPED
SINCE
C IT'S OVER 1GB) THERE ARE 200 SPOKES FOR THE 20 ACRE FIELD.  AND WITH THE
NORMAL CONFIGURATION OF 17 SPOKES
C AT EACH CORNER (TO GIVE THE 5 DEGREES OF SEPARATION, HAH, CLOSE THAN 6)
C SO, 200-4*17=132 AND 132/4 = 33 SPOKES PER EDGE.  AND THE EDGE LENGTH IS
284.5M
C SO THAT 284.5/32=8.89M, WHICH MATCHES THE DISCRETE RECEPTOR FILE, WHERE
C THE PROGRESSIVE INCREMENT BETWEEN SPOKES ALONG THE EDGE IS 8.89
(BUFSPOKE.OUT)
C
C
C 070727 COUNTXB USES COUNTXA, AND ADDS SEVERAL MORE COLUMNS.  TWO COLLUMNS
C WILL BE FOR COMPUTING THE FRACTION OF THE PERIMETER THAT IS EXCEEDED,
C USING EQUAL WEIGHTS FOR EACH SPOKE (136 SPOKES FOR FINE GRID FOR 5 ACRES)
C THE NEXT FOUR COLUMNS (2 FOR EACH PERIOD) WILL USE THE ACTUAL PERIMETER
C CALCULATIONS, THSU FOR THE STRAIGHT SIDES (WEST, NORTH, EAST, SOUTH) EACH
C SPOKE IS WORTH (4*142.3)/68=8.37M AND FOR THE CORNERS, EACH SPOKE IS WORTH
C (2*PI*B)/68, WHICH FOR 60M IS 5.54M, AND THE TOTAL PERIMETER IS 519.29 FOR
TRUBUF=60
C
C 070726 COUNTXA MODIFIED TO USE PARAMETER NSPOKE IN PLACE OF 40 TO GET
FLEXIBILITY
C ON THE NUMBER OF SPOKES, SINCE IT APPEARS WE USED COARSE GRID FOR FIRST GO
ROUND
C INSTEAD OF FINE GRID, WHICH HAS INSTEAD OF 40 SPOKES, (15+17)*4=128 SPOKES,
VOILA!
c ACTUALLY, BASED ON THE OUTPUT FROM PERFUM2BJ (WHICH PRINTS OUT NSPOKE), THE
NUMBER
C OF SPOKES FOR THE FINE GRID 5 ACRE PLOT IS 136, I THINK THAT THE 15+17
FIGURE COMES
C FROM THE FIXED ISCST3 TEMPLATE CONTROL FILES THAT REISS HAD AVAILABLE FROM A
PREVIOUS
C VERSION, NOW THE CONTROL FILES ARE BUILT ON THE FLY
C
C 070725 I TRIED USING GE AND GT, GAVE SAME RESULTS IN FIRST EXAMPLE
C
C
C PROGRAM COUNTX, USES AS INPUT A SPECIAL OUTPUT FILE FROM
C PERFUM2 WHICH CONTAINS DAY, YEAR, SPOKE BUFFER
C AND ALSO USER INPUT FOR THE 'BUFFER' HOWEVER DETERMINED
C THEN COUNTX RUNS THROUGH THE FILE AND CALCULATES FOR EACH 24 HOUR PERIOD
```

```
C WHAT FRACTION OF THE PERIMETER EXCEEDED THE THRESHOLD, AND
C OUTPUTS THAT NUMBER FOR SUMMARY INTO A FREQUENCY DISTRIBUTION
C-------FOLLOWING IS OUTPUT LINE IN PERFUM2BJ---------------
C
C          WRITE(31415,61415)LJDAY,LYEAR,IAPP,IDAYS,IAVG,
C     1                            NSPOKE_PER_FIELD
C     2                                 ,NSPOKE_PER_FIELD,ISPOKE,BUFFER
C61415     FORMAT(1X,8I5,F10.2)
C-----------------------------------------------------------
C LJDAY IS JULIAN DAY OF YEAR
C LYEAR IS 2 DIGITS OF YEAR
C IAPP IS COUNTER FOR THE APPLICATION RATE (SHOULD ALWAYS BE 1 IN THIS
EXAMPLE)
C IDAYS IS THE NUMBER OF FLUX DAYS (IS 1 OR 2 IN THIS EXAMPLE, SINCE 2 X 24
HOUR FLUX PERIODS)
C       I WILL ONLY BE USING THE FIRST 24 HOUR FLUX PERIOD
C IAVG IS A COUNTER FROM 1 TO IAVG_PER, THE LATTER IS THE NUMBER OF AVERGING
PERIODS PER DAY
C NSPOKE_PER_FIELD IS THE NUMBER OF SPOKES PER FIELD (40 FOR COARS GRID 5
ACRES, 136FOR FINE)
C ISPOKE IS THE SPOKE NUMBER
C BUFER IS A REAL NUMBER, THE DISTANCE AT WHCIH THE THRESHOLD CONCENTRATION IS
REACHED
C  LJDAY LYEAR IAPP IDAYS IAVG NS_P_F ISPOKE BUFFER
C12345678901234567890123456789012345678901234567890 1
C     2   95    1    1    1   40   40    1      5.00
C     2   95    1    1    1   40   40    2      5.00
C     2   95    1    1    1   40   40    3      5.00
C     2   95    1    1    1   40   40    4      5.00
C     2   95    1    1    1   40   40    5      0.00
C     2   95    1    1    1   40   40    6      0.00
C     2   95    1    1    1   40   40    7      0.00
C     2   95    1    1    1   40   40    1      5.00
C     2   95    1    1    1   40   40    2      5.00
C     2   95    1    1    1   40   40    3      5.00
C     2   95    1    1    1   40   40    4      5.00
C     2   95    1    1    1   40   40    5      0.00
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        IMPLICIT NONE
        INTEGER NSPOKE
        REAL SIDE !SIDE OF SQUARE FIELD
        REAL PI  !THE CONSTANT
C        PARAMETER (NSPOKE=136)  5 ACRES
C        PARAMETER (SIDE=142.3) !FOR 5 ACRES SIDE IS 142.3M
        PARAMETER (NSPOKE=200) !200 SPOKES FOR 20 ACRES, STILL 17 PER CORNER
        PARAMETER (SIDE=284.5) !FOR 20 ACRES SIDE IS 284.5M
        PARAMETER (PI=3.14159) !AHHHH, PI WONT CHANGE WITH ACREAGE
        INTEGER LJDAY(NSPOKE,2),LYEAR(NSPOKE,2),SPOKE(NSPOKE,2)
        REAL BUFF(NSPOKE,2),TRUBUF
```

```
        INTEGER COUNTDAYS, I,J,K, COUNT1,COUNT2,COUNTREC
        INTEGER IAPP(NSPOKE,2),IDAYS(NSPOKE,2),IAVG(NSPOKE,2)
        INTEGER NS_P_F(NSPOKE,2)
        INTEGER ISPOKE(NSPOKE,2)
        REAL PERIMETER, EDGELEN, EDGEPERSPOKE,ARCPERSPOKE, ARCLEN
        INTEGER EDGECNT,CORNCNT,KI
        REAL FRACPERI,FRACCNT
        INTEGER CORNSPOKE,EDGESPOKE !CALCULATED NUMBER OF CORNER SPOKES VS
EDGE SPOKES
        INTEGER EC20 !FUNCTION DETERMINES IF EDGE (=1) OR CORNER (=0) FOR 20
ACRES
        !PERIMETER IS TOTAL PERIMETER LENGTH AT A BUFFER ZONE DISTANCE
        ! EDGELEN IS LENGTH OF FIELD PERIMETER (SUM OF 4 SIDES)
        !EDGEPERSPOKE IS LINEAR DISTANCE EACH EDGE SPOKE REPRESENTS
        !ARCPERSPOKE IS ARC DISTANCE EACH CORNER SPOKE REPRESENTS
        !ARCLEN IS PERIMETER OF CIRCLE WITH BUFFER ZONE AS RADIUS
        OPEN(UNIT=1,STATUS='OLD',FILE='SPOKEBUF.OUT')
        OPEN(UNIT=2,STATUS='UNKNOWN',FILE='COUNTXC.OUT')
        WRITE(6,100)
100     FORMAT(1X,'ENTER THE REAL NUMBER FOR THE BUFFER ZONE ')
        READ (5,*)TRUBUF
        WRITE(6,110)TRUBUF
110     FORMAT(1X,'THE BUFFER DIST YOU ENTERED WAS ',F12.3,
     1         /1X,' ')
        WRITE(2,95)TRUBUF
95      FORMAT(1X,'THE TESTED BUFFER ZONE USED WAS ',F10.2)
        EDGELEN=4.*SIDE  !FIELD PERIMETER
        ARCLEN=TRUBUF*2.*PI
        PERIMETER=EDGELEN+ARCLEN  !PI TIMES D IS CIRCUMFERENCE, REMEMBER?
        CORNSPOKE=4*17  !REISS ALWYAS USES 17 SPOKES ON CORNERS (18 DIVISIONS
GIVES 5 DEGREE SEPARATION)
        EDGESPOKE=NSPOKE-CORNSPOKE !TOTAL NUMBER OF EDGE SPOKES ARE WHAT IS
LEFT OVER
        EDGEPERSPOKE=EDGELEN/FLOAT(EDGESPOKE)    !AMT OF STRAIGHT EDGE PER N E
S W SPOKE
        ARCPERSPOKE=ARCLEN/FLOAT(CORNSPOKE) !AMT OF ARC DIST PER NW, NE, SE,
SW SPOKE FROM CORNER

        WRITE (2,97) EDGELEN,ARCLEN,PERIMETER,EDGEPERSPOKE,ARCPERSPOKE,
     1               CORNSPOKE, EDGESPOKE
97      FORMAT(1X,'THE STRAIGHT EDGES PERIMETER TOTAL ',F15.2,
     1        /1X,'THE CIRCULAR PERIMETERS TOTAL      ',F15.2,
     2        /1X,'THE TOTAL PERIMETER AT THE BZ DIST ',F15.2,
     3        /1X,'THE LENGTH PER EDGE SPOKE IS       ',F15.4
     4        /1X,'THE LENGTH PER CORNER SPOKE IS     ',F15.4,
     5        /1x,'THE NUMBER OF CORNER SPOKES IS     ',I5,
     6        /1X,'THE NUMBER OF EDGE SPOKES IS       ',I5)
        WRITE(2,107)
107     FORMAT(1X,'JULIAN DAY,YEAR,PERIOD 1 EXCEED COUNT, ',
     1            'PERIOD 2 EXCEED COUNT',
```

```
     2        /1X,'PER 1 EDGE SPOKE CNT, PER 1 CORNER SPOKE CNT, '
     3           , 'PER 1 FRACTION BY CRUDE COUNT, '
     4        /1X,'PER 1 FRACTION BY PERIMETER LENGTH ADJST FOR CORN')

C             WRITE(2,350)LJDAY(1,1),LYEAR(1,1),COUNT1,COUNT2,EDGCNT,CORNCNT,
C     1              FRACCNT,FRACPERI
C350     FORMAT(1X,6I8,2F12.4)
        WRITE(2,101)
101     FORMAT(7X,'JULDAY',' YEAR ','  CNT1 ','   CNT2 ', '   P1EDG ',
     1            '  P1COR '
     1            'FRAC BY COUNT ','FRAC BY LEN ')
        COUNTDAYS=0
        COUNT1=0
        COUNT2=0
        COUNTREC=0
C THERE ARE NSPOKE SPOKES PER FIELD, SO USE THAT TO STRUCTURE CALCULATIONS

1       CONTINUE  !BIG READ LOOP STARTS HERE

         DO I=1,NSPOKE      !THIS SHOULD BE WITH IDAYS=1
          READ(1,170,END=1000)LJDAY(I,1),LYEAR(I,1),IAPP(I,1),IDAYS(I,1)
     1                       ,IAVG(I,1),NS_P_F(I,1),SPOKE(I,1),
     2                        BUFF(I,1)
         END DO

         DO I=1,NSPOKE      !THIS SHOLD BE WITH IDAYS=2
          READ(1,170,END=1000)LJDAY(I,2),LYEAR(I,2),IAPP(I,2),IDAYS(I,2)
     1                      ,IAVG(I,2),NS_P_F(I,2),SPOKE(I,2),BUFF(I,2)
170       FORMAT(1X,6I5,5X,I5,F10.2)
         END DO
         COUNTDAYS=COUNTDAYS+1
C DO SOME CHECKING
         DO I=1,NSPOKE
          IF((I.NE.SPOKE(I,1)).OR.(I.NE.SPOKE(I,2)).OR.(IDAYS(I,1).NE.1)
     1                      .OR.(IDAYS(I,2).NE.2).OR.(IAPP(I,1).NE.1).
     2                      OR.(IAPP(I,2).NE.1).OR.
     3                       (NS_P_F(I,1).NE.NSPOKE).
     4                      OR.(NS_P_F(I,2).NE.NSPOKE).OR.
     5                      (LJDAY(1,1).NE.LJDAY(MIN(NSPOKE,I+1),2))
     6                           .OR.
     7                      (LYEAR(1,1).NE.LYEAR(MIN(NSPOKE,I+1),2)))
     8                         THEN
C NOTE LAST PART OF PRECEEDING DOESN'T CHECK EVERYTHING BUT IF FIRST VALUE OF
C DAY AND YEAR EQUAL CORRESPONDING VALUES FOR THE NSPOKE RECORDS IN THE SECOND
HALF
C THEN I ASSUME THAT LYEAR, LJDAY VALUES FOR FIRST HALF ARE ALSO CONSTANT
             WRITE(6,203)
203          FORMAT(1X,'INDEXING ERROR..CHECK FOLLOWING DAY (1ST HALF ',
     1                 'SHOWN ')
             DO J=1,NSPOKE
```

```
              WRITE(6,205)LJDAY(J,1),LYEAR(J,1),IAPP(J,1),IDAYS(J,1),
     1                    IAVG(J,1),NS_P_F(J,1),SPOKE(J,1),BUFF(J,1)
205           FORMAT(1X,7I5,F10.2)
             END DO
             STOP
           ENDIF
         END DO

C DO SOME PROCESSING - SIMPLE CRUDE APPROACH, COUNT UP THOSE BUFFERS GREATER
THAN TRUBUF
C AND SOME ADDED PROCESSING FOR COUNTXB, USE THE ACTUAL PERIMETER CALCULATIONS
C ALSO COUNT THE INSTANCES OF EDGE VS CORNER SPOKE EXCEEDANCES, BASICALLY
FIRST
C 17 SPOKES ARE WEST, 2ND 17 ARE NW, 3 RD ARE NORTH, AND SO ON
C WILL DO THE EXTENDED CALCULATIONS ONLY FOR THE FIRST PERIOD
        COUNT1=0
        COUNT2=0
        EDGECNT=0
        CORNCNT=0
        DO I=1,NSPOKE
         IF(BUFF(I,1).GT.TRUBUF)THEN
C           KI=INT((I-1)/17)+1  !THIS FANCY-PANTS BIT WONT WORK FOR 20 ACRES,
USE FUNCTION EC20
            KI=EC20(I)  !GIVES VALUE OF 1 IF EDGE, VALUE OF 0 IF CORNER
           IF(MOD(KI,2).EQ.1)THEN
            EDGECNT=EDGECNT+1
           ELSEIF(MOD(KI,2).EQ.0)THEN
            CORNCNT=CORNCNT+1
           ENDIF
           COUNT1=COUNT1+1
         ENDIF
         IF(BUFF(I,2).GT.TRUBUF)COUNT2=COUNT2+1
        END DO
C HAVE TABULATED EXCEEDANCES FOR THIS DAY, NOW CALCULATE PERIMETERS AND
FRACTIONS
 !PERIMETER IS TOTAL PERIMETER LENGTH AT A BUFFER ZONE DISTANCE
        ! EDGELEN IS LENGTH OF FIELD PERIMETER (SUM OF 4 SIDES)
        !EDGEPERSPOKE IS LINEAR DISTANCE EACH EDGE SPOKE REPRESENTS
        !ARCPERSPOKE IS ARC DISTANCE EACH CORNER SPOKE REPRESENTS
        !ARCLEN IS PERIMETER OF CIRCLE WITH BUFFER ZONE AS RADIUS
        FRACPERI=FLOAT(EDGECNT)*EDGEPERSPOKE+FLOAT(CORNCNT)*ARCPERSPOKE !THE
WHOLE EXCEEDANCE LENGTH
        FRACPERI=FRACPERI/PERIMETER
        FRACCNT=FLOAT(COUNT1)/FLOAT(NSPOKE)
C RECORD THIS DAY OF RESULTS
        WRITE(2,350)LJDAY(1,1),LYEAR(1,1),COUNT1,COUNT2,EDGECNT,CORNCNT,
     1              FRACCNT,FRACPERI
350     FORMAT(1X,6I8,2F12.4)
        COUNTREC=COUNTREC+1
        GOTO1
```

```
1000    CONTINUE  !REACHED END OF FILE
        WRITE(6,1100)COUNTDAYS,COUNTREC
1100    FORMAT(1X,I10,' DAYS PROCESSED ',I10,' RECORDS WRITTEN')
        END PROGRAM

        INTEGER FUNCTION EC20(I)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C THIS FUNCTION RETURNS 1 IF I IS AN EDGE SPOKE AND 0 IF I IS A CORNER SPOKE
FOR 20 ACRES
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        IMPLICIT NONE
        INTEGER I,K
C 1-33 WEST EDGE                          1
C 34-50 NW CORNER                         0
C 51-83 NORTH EDGE                        1
C 84-100 NE CORNER                        0
C 101-133 EAST EDGE                       1
C 134-150 SE CORNER (MY LEAST FAVORITE)   0
C 151-183 S EDGE                          1
C 184-200 SW CORNER (MY MOST FAVORITE)    0
        IF(I.LT.1.OR.I.GT.200)GOTO10
        K=MOD(I-1,50) !MAPS 1-200 INTO 0-49
        IF(0.LE.K.AND.K.LE.32)THEN
          EC20=1                    !WE GOT A SIDE
          RETURN
        ELSEIF(33.LE.K.AND.K.LE.49)THEN
          EC20=0                    !WE GOT A CORNER
          RETURN
        ENDIF
10        WRITE(6,100)I
100     FORMAT(1X,'ERROR IN EC20 WITH I= ',I10)
        STOP
        END
```

Appendix E. Comparison of two methods for estimating the fraction of the perimeter where the threshold concentration was exceeded.

Amongst the days where exceedances occurred, Figures E1 and E2 provide distributions for the fraction of the buffer zone perimeter based on the arc-length method which exceeded the reference concentration. The two methods for calculating the fraction yielded somewhat different histograms, but the general limits and shapes were similar. In both cases the fractions ranged from 0.01 to about 0.15. In part, the differences between the 2 methods resulted from the different number of edge versus corner spokes between 5 acre and 20 acres fields and the relatively different arc lengths represented by the 5 acre and 20 acre cases.

For the 5 acre field, there were a total of 2447 edge spokes and 335 corner spokes where exceedances occurred. For the 20 acre field, edge spokes were also dominated where exceedances occurred with 3337 and 217 edge and corner spoke exceedances, respectively. A quick check against the 99th percentile whole field buffer, which was used to calculate these exceedances, provides satisfactory agreement. That is, for five acres, (2447+335)/(1794*136) is about 1%, as is, for twenty acres, (3337+217)/(1794*200). There were 136 and 200 spokes for the 5 and 20 acre field fine grid simulations.

The histograms in Figures E1 and E2 provide some indication of the distribution of fractions of perimeters which are exceeded, when there is an exceedance somewhere along the buffer zone perimeter. Figures E3 and E4 provide the same data expressed as cumulative distributions of perimeter exceedance fractions and can be utilized more quantitatively to calculate probabilities. Figures E3 and E4 depict the contrast between the 5 acre and 20 acre fields where the 2 methods provide comparatively reversed results. That is, for 5 acres, the corner/edge perimeter method gives higher perimeter fractions for 5 acres, but lower perimeter fractions for 20 acres. This reversal is caused by the difference in effect of the 99% whole field buffer, which for the 5 acre case results in an average arc length per corner spoke which was less than the arc length for the edge spoke (5.5m versus 8.4m), but in the 20 acre case, was larger than the edge spoke (18.5m versus 8.6m). This, in combination with the general prevalence of exceedances along the edge spokes instead of the corner spokes, accounts for the differences between the two methods for calculating the daily perimeter exceedance fraction.

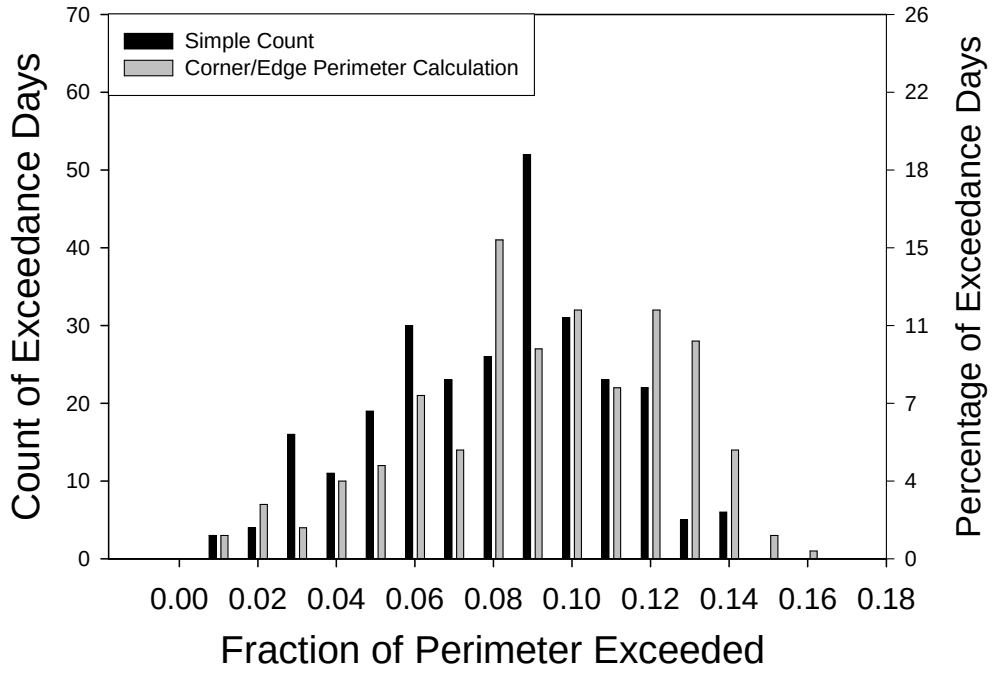


Figure E1. Fine grid, 5 acre scenario with histograms of the daily fractions of the perimeter where the concentration exceeds the reference level. The total days were 1794, of which 1523 days showed no exceedance. This figure plots the exceedances for the 271 days where 1 or more spokes showed an exceedance.

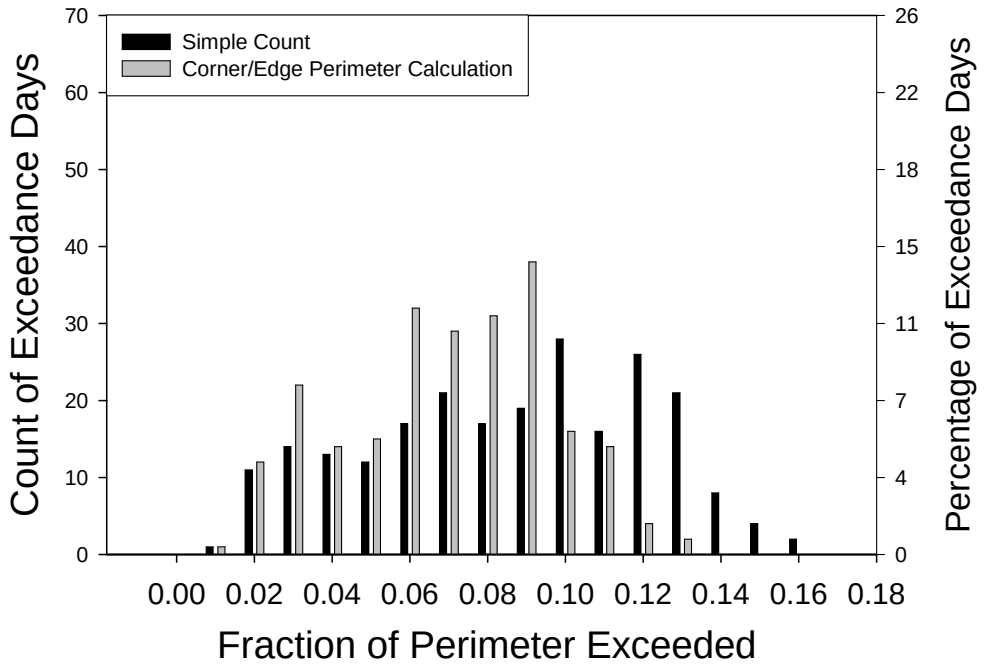


Figure E2. Fine grid, 20 acre scenario with histograms of the daily fractions of the perimeter where the concentration exceeds the reference level. The total days were 1794, of which 1564 days showed no exceedance. This figure plots the exceedances for the 230 days where 1 or more spokes showed an exceedance.

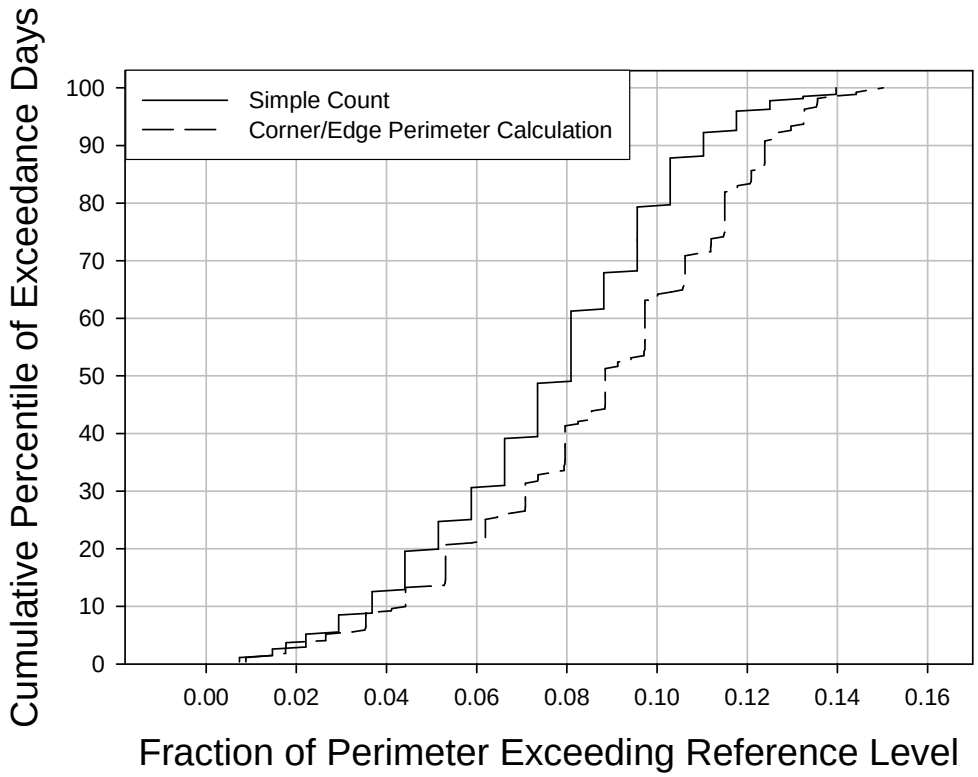


Figure E3. Cumulative distribution of perimeter length exceedances for 5 acre, fine grid scenario where 271 days showed at least one spoke exceeded the reference concentration at the buffer zone distance.

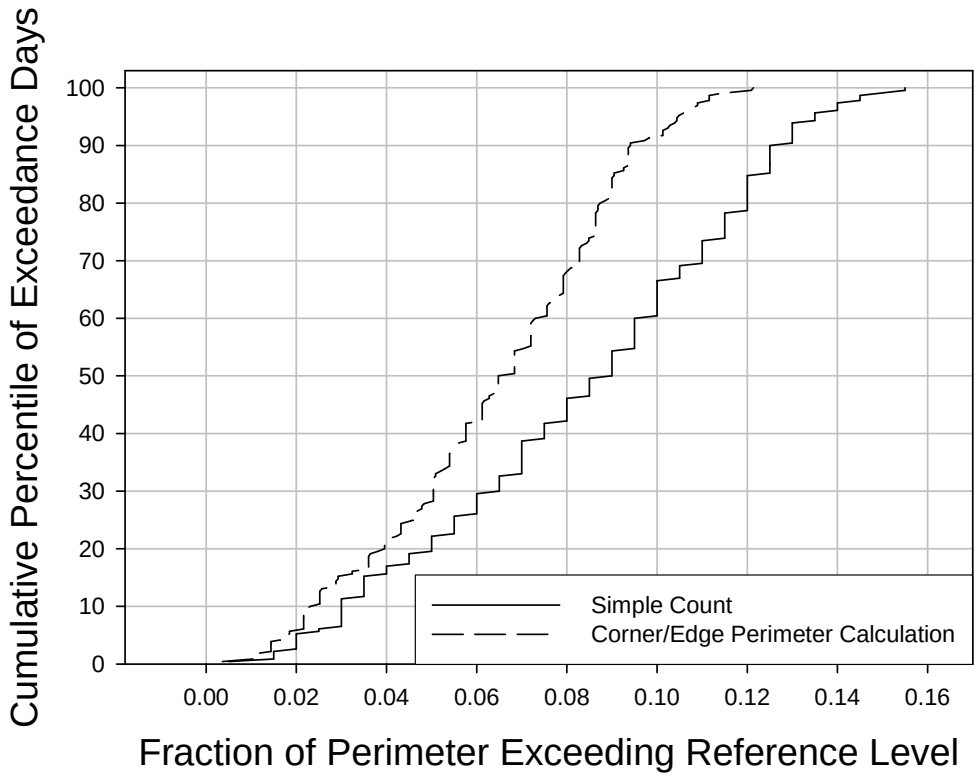


Figure E4. Cumulative distribution of perimeter length exceedances for 20 acre, fine grid scenario based on 230 days where at least one spoke exceeded the reference concentration at the buffer zone distance.

Appendix F. Procedure to compare the whole field buffer zone distributions with the maximum direction buffer zone distributions.

The whole field buffer zone distribution for each fumigant/application method/maximum application rate/meteorological data (scenario) combination was examined to find the 99% whole field buffer zone. Then for that same scenario the equivalent percentile at that buffer zone length in the maximum direction buffer zone distribution was found.

Results are presented by fumigant in the text of this memorandum. The tables below show an example of the PERFUM output used to locate the 99% whole field buffer zone length and the equivalent maximum direction buffer zone distribution percentile. Figure F1 illustrates the procedure graphically.

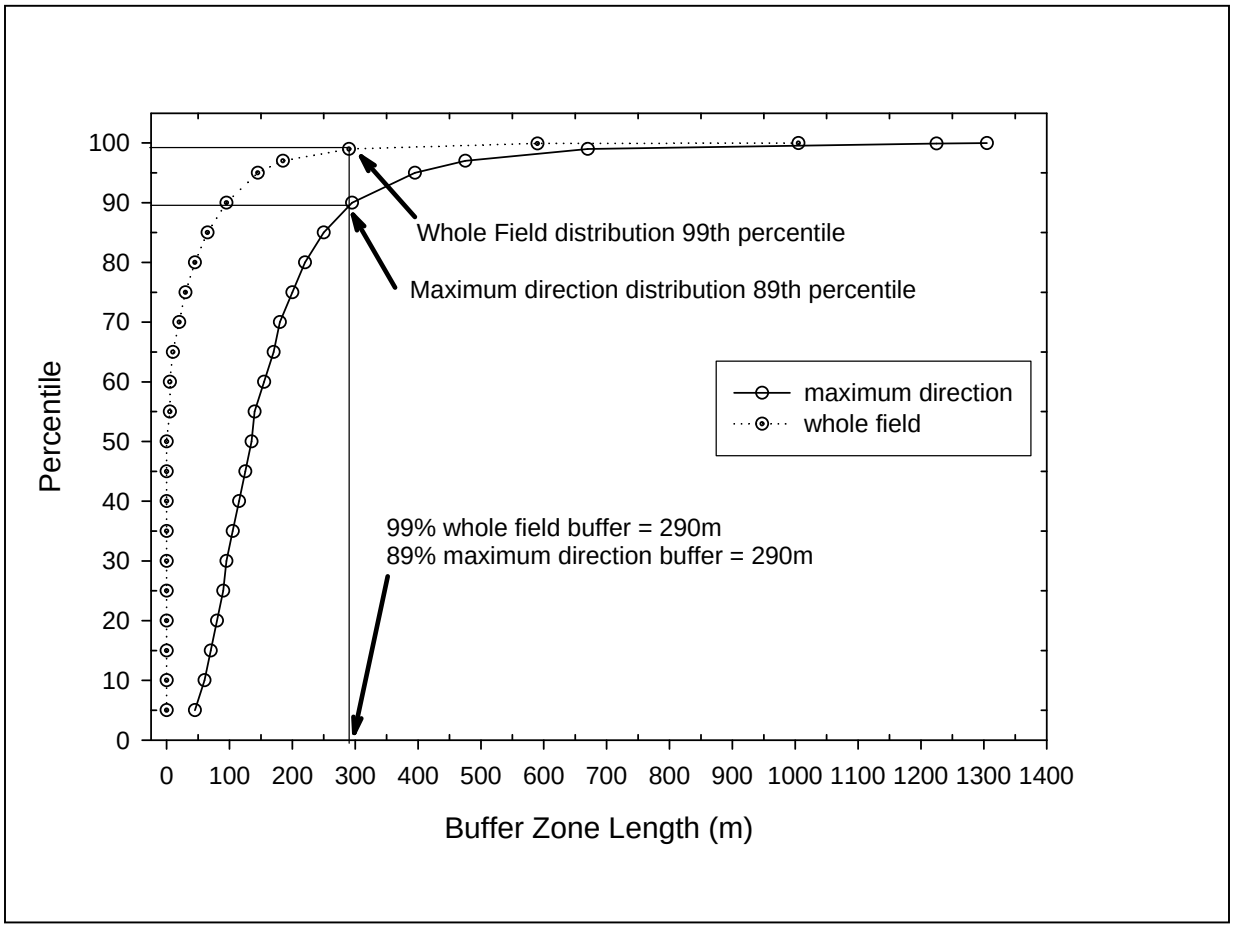
Table F1. Whole field buffer percentiles for an application rate of 250.0 for Flux Profile Day No. 1

Percentile	Buffer Zone(m)
5	0
10	0
15	0
20	0
25	0
30	0
35	0
40	0
45	0
50	0
55	5
60	5
65	10
70	20
75	30
80	45
85	65
90	95
95	145
97	185
99	290
99.9	590
99.99	1005

Table F2. Maximum concentration buffer percentiles for an application rate of 250.0 for Flux Profile Day No. 1

Percentile	Buffer Zone (m)
5	45
10	60
15	70
20	80
25	90
30	95
35	105
40	115
45	125
50	135
55	140
60	155
65	170
70	180
75	200
80	220
85	250
90	295
95	395
97	475
99	670
99.9	1225
99.99	1305

Figure F1. Illustration of the relationship between the 99% whole field buffer zone length and the equivalent maximum direction distribution percentile for the same buffer zone length.



Department of Pesticide Regulation

Mary-Ann Warmerdam
Director

Arnold Schwarzenegger
Governor

October 30, 2008

U.S. Environmental Protection Agency
Office of Pesticide Program
Regulatory Public Docket 7502P
1200 Pennsylvania Avenue, NW
Washington, District of Columbia 20460-0001

SUBJECT: Comments for Dockets EPA-HQ-OPP-2007-0350, EPA-HQ-OPP-2005-0128, EPA-HQ-OPP-2005-0125, and EPA-HQ-OPP-2005-0123

Below please find comments on Dawson and Smith (2008), which describes factors that may impact soil fumigant emissions from agricultural fields. The review by Dawson and Smith (2008) is part of each of the four dockets listed above.

Review of Dawson, Jeffry L. and Charles Smith. 2008. Factors which impact soil fumigant emissions. U.S. Environmental Protection Agency, Office of Pesticide Programs, Health Effects Division (7509P). June 9, 2008.

This document describes factors which may impact soil fumigant emissions from agricultural fields.

1. The literature cited in this document is highly varied in terms of quality. Yet all literature is cited equally. Dawson and Smith (2008) state on page 153: "Consequently, all emissions studies of appropriate quality were used." The word "appropriate" does not appear to be defined. In a short paragraph, the authors wrestle with data quality objectives on page 153. They describe possible performance goals for research at different scales, from laboratory to field. But they demur by stating: "It is not apparent that such performance goals were established in much of the research which has been reviewed."

   We found that the cited literature was variable in terms of quality. For example, the reference section (page 162) lists the following reference:

   Gao, S., 2006. Using Surface Water Application to Reduce 1,3-Dichloropropene Emission from Soil Fumigation. J. Environ. Qual. 2006 35: 1040-1048.

   [This citation incorrectly omits a second author: TJ Trout].

This particular study is a laboratory column study in which flux was measured frequently during daylight hours, but with a single measurement during the night time hours (see Figure 37 in Dawson and Smith 2008). It is unclear how this heavily unequal measurement weighting would impact the results. The internal chamber pressure was maintained "…such that pressure inside the chamber should be no more than 0.6% below atmospheric pressure." [Gao and Trout 2007, page 2]. Any pressure differential, either positive or negative, could have significant impact on the flux. Moreover, some methodological questions arise because the head-space air in the column was disturbed in order to apply supplemental water to simulate irrigation.

Other studies are PowerPoint presentations from the MBAO conference: for example, [19]Ajwa (2007). A draft report of this particular study was found to be deficient in chemistry QA/QC (review 071217.doc, B Johnson). PowerPoint presentations do not contain the detail needed to properly assess the quality of a study.

Alongside citations which are Power Point presentations, are EPA MRID studies (for example, [85], Cryer and Wesenbeeck 2007), which may receive internal regulatory review, but otherwise are not reviewed or even available for public review.

To the credit of Dawson and Smith (2008), it appears than when possible, a web reference is provided and the citations can be obtained. Also, when figures or data are presented from laboratory column studies, in many cases the fact that the study was a laboratory column type of study is mentioned. This is important because of the potential difficulties involved in generalizing from column studies to the field.

2. We agree that an important problem regarding the use and regulation of the use of tarps is the lack of standardization of nomenclature and performance criteria for tarps. This document provides a good discussion of this area, highlighting the difficulties.

3. We agree with the difficulties mentioned (page 31) regarding extrapolating laboratory measured tarp permeabilities to field performance: "…Wang indicated that there is a discrepancy between predicted film performance-based on the types of studies conducted. In all examples cited, laboratory data over-predicted the ability of a film to reduce emissions when compared with field results."

4. We agree that there is a need for further research before specific factors can be assigned for tarp credit (page 32).

5. We agree that it is uncertain at this point to assign reductions due to the use of soil amendments (Dawson and Smith page 60).

6. A difficulty and added complication with the entire discussion in Dawson and Smith (2008) is a lack of focus on endpoints. Giving credit for reduction in volatilization must address the issue of time frame. Toxicologists determine relevant reference levels for various exposures. These reference levels embody a time period (eg. 4 hours, 24 hours, 7 days, etc). Buffer zone mitigations are generally short term restrictions, less than a week, maybe for 1-2days. They are calculated based on the peak flux or peak concentrations which may occur over 8 to 24 hour periods, for example. It may well be possible to mitigate peak concentrations by flattening a flux profile, where the entire cumulative flux remains the same. For example, utilizing a tarp may slow down emissions, but not reduce the total cumulative emissions. Hence, the tarp may flatten the profile and reduce peaks of either flux or concentration. Mitigations for total cumulative volatilization are essentially for time periods of 2-4 weeks. It is conceivable that a mitigated flux profile could show reduced cumulative volatilization, while the peak flux and hence, peak concentrations, remain the same. Thus, whether a particular activity represents a mitigation, in the sense of reducing air concentrations, will depend on the relevant exposure time frame.

7. Table 25 lists field volatility studies "used to calibrate Chain-2D." Staff requested the control files used to simulate Knuteson and Dolder (2000), a drip irrigation study in Salinas, California. We were informed that no simulation had been performed on this study (Smith, personal communication).

8. The Department of Pesticide Regulation has serious doubts regarding the CHAIN2D model offered by the Chloropicrin Manufacturers Task Force (Cryer and Wesenbeeck 2007, Wesenbeeck 2007ab, listed as [83], [84], and [85] in Dawson and Smith 2008). Detailed staff reviews are appended to this document (Johnson 2008abc). In brief, the modeling system is not validated. Major features of the model such as drip irrigation or the dynamic boundary layer were not tested. The testing that was done utilized a wholly unsupported 'shank trace' feature to arbitrarily make model results fit more closely to measured results. The basis for the model, CHAIN2D, is ten year old software which is no longer supported by the original authors. The CHAIN2D software, as modified by the CMTF, is itself fragile and evidently only runs under restricted conditions. A hydraulic parameter estimation scheme gives wildly incorrect estimates. The general approach, which uses average texture class hydraulic parameters, may give incorrect results. This modeling tool is not well supported. The documentation is poor. The Office of Air, for example, has the SCRAM Web site, which is devoted to supporting their models, keeping track of model changes, providing a user forum, documentation and other activities which are necessary in order to maintain a robust modeling system. None of this is available for the CMTF CHAIN2D modeling system.

9. Model runs provided in Dawson and Smith (2008) corroborate some of the uncertainty we found in the CHAIN2D modeling system. Figures 103 and 104 (page 117), for example, indicate severe flux underestimates by the CHAIN2D modeling system. For chloropicrin,

peak measured flux was about 225 ug/m2s, while during the same period, the model estimated about 25 ug/m2s and only peaked at 100 ug/m2s (Figure 103). For metam sodium (Figure 104), maximum measured flux occurred during two different periods at about 80 ug/m2s compared to maximum modeled flux of 60 ug/m2s. However, the shape of the profiles during the first 12 hours were complementary with the highest measured flux corresponding to the lowest modeled flux and vice versa.

10. Dawson and Smith state that one of the reasons for choosing CHAIN2D was that it was publicly available. However, a key feature of the CHAIN2D software, as modified by Cryer and Wesenbeeck (2007) is a dynamic boundary layer modification which was based on a fluid flow model, FLUENT, which is wholly proprietary and costs approximately $20,000 per year to lease.

11. Dawson and Smith (page 105) characterize the Chloropicrin Manufacturers Task Force CHAIN2D submission as "…a slightly modified version of CHAIN-2D…." This characterization is inaccurate since the visual basic code supporting the modeling tool amounts to about 2000 additional lines of code. Moreover, the qualitative impact of changing computer code cannot be gauged by simply counting the number changed lines and dividing by the total number of lines of code. A single line of code could cause profound changes to model output.

If you have any questions, please contact Bruce Johnson, Ph.D., of my staff, at (916) 324-4106.

Sincerely,

Original sighed by Randy Segawa
for

John S. Sanders, Ph.D.
Environmental Program Manager
Environmental Monitoring Branch
(916) 324-4155

Enclosures

cc: Bruce Johnson, Ph.D.

References

(numbers in brackets refer to the numbered reference in Dawson and Smith 2008)

[19] Ajwa, H.,. 2007. Fumigant Emission Reductions by Using Low Permeability Film and Thiosulfate Water Seal. 2007 Methyl Bromide Alternatives Outreach Conference. Available at: <http://mbao.org/2007/PDF/Preplant/PP1/Ajwa(6).pdf>.

[85] Cryer, S.A. van Wesenbeek, I (2007) Simplifying The Implementation of CHAIN-2D With Modifications Specific For Soil Fumigation (12/21/07) (EPA MRID 473105-02, CMTF 2007-4).

Dawson, Jeffry L. and Charles Smith. 2008. Factors which impact soil fumigant emissions. U.S. Environmental Protection Agency, Office of Pesticide Programs, Health Effects Division (7509P). June 9, 2008.

[34] Gao, S. and TJ Trouit. 2006. Using Surface Water Application to Reduce 1,3-Dichloropropene Emission from Soil Fumigation. J. Environ. Qual. 2006 35: 1040-1048.

Johnson, Bruce. 2008a. Memorandum to Randy Segawa on Review of Wesenbeeck (2007b) dated October 29, 2008.

Johnson, Bruce. 2008b. Memorandum to Randy Segawa on Review of Cryer and Wesenbeeck (2007) dated October 29, 2008.

Johnson, Bruce. 2008c. Memorandum to Randy Segawa on Review of Wesenbeeck (2007a) dated October 29, 2008.

[83] van Wesenbeek, I (2007) Validation of CHAIN-2D Modeling Against Chloropicrin and 1,3-D Field Volatility Studies (12/28/07) (EPA MRID 473122-00, CMTF 2007-3).

[84] van Wesenbeek, I (2007) Impact of Mitigation Practices on Emissions of Chloropicrin During Soil Fumigation As Predicted By CHAIN-2D (12/21/07) (EPA MRID 473105-01, CMTF 2007-5).

Mary-Ann Warmerdam
Director

Department of Pesticide Regulation

Arnold Schwarzenegger
Governor

M E M O R A N D U M

TO: Randy Segawa
Environmental Program Manager I
Environmental Monitoring Branch

FROM: Jing Tao, Ph.D. *Original signed by*
Environmental Scientist
Environmental Monitoring Branch
916-324-4201

DATE: June 29, 2009

SUBJECT: RESPONSES TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY COMMENTS ON VOLUME III, ENVIRONMENTAL FATE OF THE METHYL IODIDE RISK CHARACTERIZATION DOCUMENT FOR INHALATION EXPOSURE

This memorandum contains the Environmental Monitoring branch responses to the U.S. Environmental Protection Agency (EPA) comments on the environmental fate document, volume III of three volumes comprising the Department of Pesticide Regulation (DPR) Risk Characterization Document for Inhalation Exposure. Each U.S. EPA comment is in bold italics, followed by the Environmental Monitoring response.

1. Page 1 (Table 1); page 8. (second paragragh) - CALDPR's cited ODP value of 0.0015 is an order of magnitude lower the reported in EPA's risk assessment, 0.029. … In addition, Zhang et al. (1998) reported that the methyl iodide ODP can approach 0.1 in the tropics assuming dense methyl iodide emissions at low latitudes. The research from Wuebbles, (2001) and Zhang et al., (1998) considered the ODP of the parent, not just the halogenated radical as in Solomon, (2004). Class I ozone depleting compounds possess an ODP of greater than 0.1. There fore, the EPA and CALDPR's report ODP values both fall below the 0.1 threshold.

Response: The value 0.0015 was the estimate of ODP due to methyl iodide photo-dissociation in the stratosphere (Atmospheric and Environmental Research, Inc., 2000). The ODP of 0.029 in Wuebbles (2001) was the ODP estimate for n-Propyl bromide. Zhang et al. (2001) cited Ohr et al. (1996) that the ODP of iodomethane is less than 0.016, which was obtained by personal communication with S. Solomon in Ohr et al. (1996). DPR believes the value of 0.0015 is more appropriately used because it was obtained from an actual study.

2. Page 1 (Table 1) and page 13(first paragraph) – In table 1, CALDPR states that the atmospheric lifetime is 5.2 days which is inconsistent on page 7 which refers to the atmospheric half-life of 2-8 days. CALDPR used atmospheric photolytic half-life and atmospheric lifetime interchangeably, which is incorrect. …

Response: 5.2 days was the average estimate of atmospheric lifetime by Atmospheric and Environmental Research, Inc. (2000). The author mentioned that for short-lived chemicals, the distribution of the chemical in the troposphere is not uniform and the lifetime depends on where the material is emitted. 5.2 days is an average assuming a globally uniform surface (Page 11, the 2nd paragraph). Atmospheric and Environmental Research, Inc. (2000) cited several studies that photolysis as the main removal pathway of CH_3I in the troposphere and thus considered that the atmospheric lifetime is close to photolysis removal lifetime (Page 11, the 2nd paragraph).

3*. *Page 3 (second paragraph) and page. 5 (3rd paragraph) – CALDPR states that methyl iodide is quickly biodegraded under aerobic conditions with an aerobic soil metabolism half-life under 2 hours. This is consistent with EPA's risk assessment with the exception of the caveat that volatilization also may have contributed to the short half-life as well.

Response: DPR stated that aerobic soil metabolism includes every process in the soil and mentioned that volatilization contributed more than 90 percent methyl iodide lost in the soil within 24 hour after application (Page 8, the last paragraph).

4*. *Page 3 (second paragraph); page.8 (3rd paragraph) – CALDPR states that the maximum air concentration based on field volatility studies was 0.65 ppm. However, air concentrations up to 0.99 ppm were measured 30 cm above level in the Manteca, CA field volatility study.

Response: The result of Manteca study has been added to the document (Page11, the last paragraph). Maximum residue in air was 0.31 ppm on the day of application around the perimeters and 1.51 ppm in the center of the plot.

5*. *Page 6 (first paragraph) – The term, "inch", needs to be inserted in the sentence…

Response: The term "inch" has been added.