Methyl Iodide (Iodomethane)

RISK CHARACTERIZATION DOCUMENT FOR INHALATION EXPOSURE

Volume II

Exposure Assessment

CH_3I

External Panel Review Draft

Worker Health and Safety Branch
Department of Pesticide Regulation
California Environmental Protection Agency

August 2009

EXPOSURE ASSESSMENT DOCUMENT FOR PESTICIDE PRODUCTS CONTAINING METHYL IODIDE

By

Roger Cochran, Staff Toxicologist (Specialist)

California Environmental Protection Agency
Department of Pesticide Regulation
Worker Health and Safety Branch
Human Health Assessment Program
1001 I Street, Box 4015
Sacramento, California 95812

HS-1866
July, 2009

FINAL DRAFT

ABSTRACT

Methyl iodide is a new active ingredient that is being proposed as a pre-plant fumigant to control pests in soil. With the phase-out of methyl bromide use (USEPA, 1993), methyl iodide is actively being developed as an alternative in pre-plant soil fumigation. USEPA has approved the use of methyl iodide, but the chemical is not currently registered for use in California.

The expected primary route of exposure to methyl iodide for humans is through inhalation due to the chemical's high vapor pressure. Acute (8-hour) and long-term exposures of workers and bystanders to methyl iodide were estimated using air concentrations detected in chemical-specific studies performed at super- and sub-maximal application rates. Measured air concentrations of methyl iodide were adjusted to reflect the maximal label-approved application rates. Label-required buffer zones and respiratory personal protective equipment or engineering controls for applicators were also factored in before worker and bystander exposures were calculated.

Acute exposures from tasks performed by fumigation workers, expressed as absorbed daily dosage, ranged from 1.1 µg/kg-day for drip-irrigation applicators to 141.7 µg/kg-day for tarp monitors engaged in shank injections. Seasonal absorbed daily dosages ranged from 0.6 µg/kg-day for planters to 26.2 µg/kg-day for shank-injection applicators. Theoretical long-term or annual absorbed daily dosages ranged from 0.1 µg/kg-day for planters to 6.6 µg/kg-day for shank-injection applicators. Theoretical lifetime absorbed daily dosages ranged from 0.05 µg/kg-day for planters to 3.5 µg/kg-day for shank injection applicators.

Each bystander exposure scenario is for a 40-acre field and an individual that is 152 m (500 ft) from the edge of the field. Acute (8-hour) exposures arising from tasks performed by non-fumigation workers or other adult bystanders in fields at the 152 m (500 ft) label-required buffer zone near previously fumigated tarped fields, ranged from 325 µg/kg-day to 882 µg/kg-day. Potential acute (24-hr) exposures of resident bystanders to application site concentrations of methyl iodide at the 152 m (500 ft) buffer zone near 40-acre fields fumigated by different methods ranged from 278 µg/kg-day (adults) to 969 µg/kg-day (infants). Seasonal exposures of resident bystanders immediately outside the buffer zone ranged from 19 µg/kg-day (adults) to 40 µg/kg-day (infants). Theoretical, amortized annual exposure of bystanders to the potential ambient air concentrations of methyl iodide near fumigated fields ranged from 5 to 10 µg/kg-day for adults and infants, respectively.

Table of Contents

Contributors

Statistical Analysis: Sally Powell
Human Health Assessment Program
Worker Health and Safety Branch
Department of Pesticide Regulation
California Environmental Protection Agency

Analysis of Flux: Terrell Barry
Environmental Monitoring Branch
Department of Pesticide Regulation
California Environmental Protection Agency

List of Tables

List of Figures

I. INTRODUCTION

Methyl iodide (MI), also known as iodomethane, is a colorless liquid that turns yellow, brown, or red when exposed to sunlight and moisture. MI has an acrid odor that is a poor warning indicator of human exposure. There are a number of industrial uses for MI. Because of its high refractive index, MI is used in microscopy. Methyl iodide is also used as an embedding material for examining diatoms, in testing for pyridine, and as a methylating agent in organic synthesis (ACGIH, 1986). MI is naturally emitted in small amounts by rice plantations.

Methyl iodide is also being proposed as a new active ingredient for pre-plant, field fumigation to control pests in soil (including weed seeds, nematodes, insects, and diseases), as an alternative to methyl bromide (MB). MB is scheduled to be phased out of use (USEPA, 1993; UNEP, 1995; UNEP, 1998). The Department of Pesticide Regulation (DPR) is charged with protecting individuals and the environment from potential adverse effects that may result from the use of pesticides in the State (California Food and Agriculture Code (CFAC), Sections 11501, 12824, 12825, 12826, 13121-13135, 14102, and 14103).

MI may be acutely toxic for humans. DPR does not have data to assess all of the theoretical worker exposure scenarios, or potential exposures to the public from all methyl iodide applications identified in Table 1. The scenarios identified for MI were not based entirely on the labels for MI, but also on the work tasks associated with the known uses of methyl bromide as a pre-plant soil fumigant. Since the exposures associated with every scenario will not be assessed, it is important to assess representative scenarios in which the expected exposures will be equal to, or greater than, those of all other scenarios.

Pre-plant soil fumigations using methyl bromide have been applied by either (1) shank injection, or (2) drip irrigation (Thongsinthusak and Haskell, 2002). Both of these techniques have been done with, or without, plastic tarps covering the treated soil. However, the Federal labels specifically require the use of tarps during pre-plant soil fumigation with MI. Consequently, theoretical scenarios involving un-tarped fields do not need to be assessed. The labels allow the use of both standard and highly retentive (VIF™ and approved Metallic™) tarpaulins. The use of highly retentive tarpaulins requires a reduced application rate of MI. However, to be health protective, DPR assumes that the highest label-approved application rate of MI will be used in conjunction with the standard tarpaulin.

Pre-plant shank injections of methyl bromide can be made with either deep shanks (>12") or shallow shanks (8-12") (Thongsinthusak and Haskell, 2002). However, applicator exposures to MB done with deep shank techniques were assumed to be equal to or less than shallow shank applications. As the chemical/physical properties of MI are similar to those of MB (Thongsinthusak and Haskell, 2002), it is expected that occupational exposures to MI will follow the same pattern as MB. Thus, the occupational exposures from shallow-shank injection of MI will likely be at least as great, if not greater than, those for deep shank injection. Consequently, shallow shank injection activities will be used as representative of all shank injection activities. Likewise, bystander exposures to MI emanating from deep shank injected plots are expected to be less than that from the representative shallow shank injected areas.

Table 1. Potential exposure scenarios associated with all formulations of methyl iodide to be used in California for pre-plant field fumigation.

Fumigation Activity	Application Method	Route of Exposure
Handlers: Tractor driver Driver's assistant Shoveler Supervisor **Early Entry Handlers:** Tarp cutter Tarp remover Tarp remover driver **Fieldworker (post REI[a]):** Planter	Shallow and deep shank, tarped soil, broadcast injection	Inhalation, dermal absorption
Handlers: Tractor driver Shoveler Tarp monitor Supervisor **Early Entry Handlers:** Hole puncher Tarp remover Tarp remover driver **Fieldworker (post REI):** Planter	Shallow and deep shank, tarped raised bed injection	Inhalation, dermal absorption
Handlers: Applicators Supervisor **Early Entry Handlers:** Hole puncher Tarpaulin remover Tarpaulin remover driver **Fieldworker (post REI):** Planter	Drip irrigation system, tarped field, liquid fumigant	Inhalation, dermal absorption
Applicators and bystanders working adjacent fields; Residents living immediately adjacent to application sites; Residents in farming communities.	All forms of application	Inhalation, dermal absorption

[a] REI = Restricted entry interval

In the past, pre-plant soil fumigations with methyl bromide have used drip irrigation techniques with raised beds and flat fields, though not in the manner of MI's planned use (Thongsinthusak and Haskell, 2002). After consultation with several County Agricultural Commissioners, it appears that pre-plant soil fumigations with drip irrigation in flat fields are no longer used. Therefore, this exposure assessment currently only addresses raised bed applications for the drip irrigation scenario. The exposures of tarp removers and tarp remover drivers associated with broadcast injections are expected to be equal to, or greater than that of workers potentially engaged in the same tasks associated with tarped, raised bed applications. Table 2 presents the representative exposure scenarios for applicators and bystanders. The individuals in these representative scenarios are expected to experience MI exposures that would be equal to, or greater than those of individuals in the respective possible scenarios listed in Table 1.

Table 2. Representative[a] exposure scenarios, label-approved treatments, and potentially exposed individuals.

Representative Exposure Scenarios	Other Label-Approved Treatments	Potential Individuals Exposed
Shallow shank, tarped soil, broadcast injection		Tractor driver, Driver's assistant, Shoveler, Supervisor, Tarp cutter Tarp remover, Tarp remover driver Fieldworker: (post REI[b]) Planter
	Deep shank, tarped soil, broadcast injection	Same as above
Shallow shank, tarped raised bed injection		Tractor driver, Shoveler, Tarp monitor, Supervisor, Hole puncher, Fieldworker: (post REI) Planter
Drip irrigation system, tarped field, liquid fumigant		Applicators, Supervisor, Hole puncher Fieldworker: (post REI), Planter
Bystanders		Bystanders working adjacent fields; Residents living immediately adjacent to application sites, Residents in farming communities.

[a] Representative scenarios are those activities in which the expected exposures of individuals will be equal to, or greater than, those individuals in all other similar scenarios.
[b] REI = Restricted entry interval

This exposure assessment document contains sections dealing with physical and chemical properties, formulations, proposed usage, label precautions, human illnesses, dermal toxicity/sensitization, animal/human metabolism, inhalation uptake and dermal absorption. Information from these sections will likely contribute to a better understanding of the nature, potential usage, and potential for human exposure. Acute exposure estimates are usually presented as an 8- or 24-hour time-weighted-average (TWA) air concentration of methyl iodide. These 8- or 24-hr TWA estimates are grouped as acute exposure (daily exposure). The repetitive exposures considered in this document are seasonal (more than a week, but less than a year) and annual exposures.

A. Physical and Chemical Properties

Physical and chemical properties of methyl iodide as mentioned below were obtained from the Farm Chemicals Handbook (Meister, 2004), the Merck Index (Budavari *et al.*, 1996), and the registrant (Aryesta, 2000; Aryesta, 2002; Brookman and Curry, 2002a; Brookman and Curry, 2002b).

Chemical name: Iodomethane, monoiodomethane
CAS registry number: 74-88-4
California chemical code: 5783
USEPA PC Code: 000011
Common name: methyl iodide
Trade names: Midas.
Molecular formula: CH_3I
Molecular weight: 141.95 g/mole
Chemical structure: CH_3-I
Physical appearance and stability: Colorless to pale yellow liquid with an acrid odor. It is non-corrosive to metals, incompatible with strong oxidizing and reducing agents, and stable at room temperature in sealed containers. On exposure to light, discoloration occurs due to decomposition and subsequent liberation of free iodine.
Solubility: Methyl iodide is soluble in water (1.42×10^4 ppm = 14.2 g/L @ 25°C), and is miscible with alcohol and ether.
Boiling point: 42 ^{o}C
Melting point: -66.1 ^{o}C
Vapor pressure: 398 mm Hg (25^{o}C)
Specific gravity: 2.279g/mL (liquid)
Henry's Law Constant (K_h): 0.0054 atm-m^3/mol (25°C)
Conversion factor: 1 ppm = 5.81 mg/m^3 at 25 ^{o}C

B. Federal Regulatory History

Methyl iodide (iodomethane) has been proposed as an alternative to methyl bromide for pre-plant soil fumigation. Methyl bromide is scheduled by U.S. EPA to be removed from the market based on its depletion of ozone in the stratosphere (USEPA, 1993; Sims *et al.*, 1995; UNEP, 1995; Ohr *et al.*, 1996). A draft risk assessment for methyl iodide dated January 5, 2006 was posted on U.S. EPA's website for public comment on January 6, 2006 (USEPA, 2006). The final risk assessment for MI was posted on the U.S. EPA website on August 3, 2007 (USEPA, 2007). In 2008, USEPA granted conditional registration of MI with no time limitation.

U.S. EPA reported: "Risks to occupational handlers, (including tractor drivers, co-pilots, shovelers, soil sealers, and tarp removers), involved in pre-plant field fumigation were evaluated using iodomethane-specific handler monitoring data (USEPA, 2006). The data indicate that exposures exceed U.S. EPA Health Effects Division's (HED's) level of concern for some workers involved in the application of iodomethane when no respiratory protection is used (e.g., tractor drivers, co-pilots, and shovelers). Air purifying organic vapor removing respirators (APRs) which reduce exposure levels by a factor of 10 were also considered and exposures were reduced below HED's level of concern for all workers involved in application with these devices, although for some application tasks, APRs are not required to achieve acceptable exposure levels. Respirators would be the most practical protective equipment choice for reducing exposures for most workers in this case. This was because the field monitoring data used for this analysis already reflected the use of some engineering controls such as tarps, tractor cabs, deep injection, or other devices including fans in proximity to drivers. The duration of exposure had no impact on the results of this assessment.

For workers who entered fields days after application to prepare for planting (e.g., tarp cutters or hole punchers), exposures were not of concern 5 days after application (which reflects the available data) without any sort of respiratory protection. This was also the case for planters where exposures were not of concern 7 days after application without any sort of respiratory protection (which also reflects the available data)."

With regards to bystander exposures, the U.S. EPA Interim Registration Eligibility Document (IRED) stated: "For known area sources (i.e., treated agricultural fields), HED first used monitoring data to assess bystander exposures to iodomethane. Risks exceeded HED's level of concern based on these data. In addition, the Industrial Source Complex - Short Term model (ISCST3) was used to further characterize exposures by extrapolating to conditions under which empirical data are not available. In the ISCST3 analysis, varied meteorological conditions, field sizes, and emission rates were considered. Results demonstrate that for the cases considered, many risks exceed HED's level of concern (MOEs <30) for distances less than 100 meters downwind of the treated fields larger than 1 acre especially when the atmosphere is relatively stable and where wind speeds < 5 mph. MOEs decrease as field sizes increase while MOEs increase as the atmosphere becomes less stable leading to conditions where more off-target drift can occur. There is not a significant impact in the results due to the two different human equivalent concentrations (HECs) that were considered."

C. California Regulatory History

Methyl iodide is an active pesticide ingredient that is not currently registered for use in the State of California. DPR is conducting a risk assessment to determine the necessary safe practices before registering this pesticide for pre-plant field fumigation activities. Six, federally approved labels of different formulations of the active ingredient have been submitted for consideration in the registration process.

D. Formulations

At the present time, there are six methyl iodide-containing products that have been approved by U.S. EPA and are being considered for registration in California. Table 3 shows the percentage of the active ingredient (a.i.) and trade (product) names of these proposed products as of January, 2008. All products contain chloropicrin, but only one uses it solely as a warning agent. A warning agent is a chemical with good warning properties, including persistent odor or irritation, that can be mixed with other chemicals to allow an average person with normal sensory perception to detect the presence of the warning agent at concentrations below which both chemicals are toxic (NIOSH, 1987). Chloropicrin is used as a warning agent because it causes severe eye and mucous membrane irritation at relatively low concentrations, which allows its presence to be detected at much lower concentrations than other chemicals with weaker warning properties. Although there are no DPR regulations or policies setting a limit on the percentage of chloropicrin in a product when it is designated as a warning agent, typically it is used at a concentration of 2% or less. U.S. EPA designates products containing more than 2% chloropicrin as restricted use pesticides (40 CFR 152.175). Chloropicrin is also used as a pre-plant soil fumigant, but this document does not address exposure to chloropicrin. The Department of Pesticide Regulation is assessing the potential risk from exposure to chloropicrin, when used as an active ingredient, in a separate risk assessment effort.

Table 3. General information for submitted products containing methyl iodide as an active ingredient[a].

Product Name	U.S. EPA Registration #	Company	Formulation	Frequency of Application	Methyl Iodide Application Rate[b]
Iodomethane Technical	66330-44	Arysta	99.8% MI[c]	Formulation use only	Not applicable
Midas® 98:2	66330-43	Arysta	98% MI, 2% chloropicrin	Outdoor pre-plant soil fumigant	175
Midas® 50:50	6630-57	Arysta	50% MI, 50% chloropicrin	Outdoor pre-plant soil fumigant	350
Midas® EC Bronze	6630-58	Arysta	49.9% MI, 44.78% chloropicrin	Outdoor pre-plant soil fumigant	350
Midas® 33:67	6630-59	Arysta	33% MI, 67% chloropicrin	Outdoor pre-plant soil fumigant	530
Midas® EC Gold	66330-60	Arysta	33% MI, 61.7% chloropicrin	Outdoor pre-plant soil fumigant	530
Midas® 25:75	66330-42	Arysta	25% MI, 75% chloropicrin	Outdoor pre-plant soil fumigant	700

[a] Information derived from the U.S. EPA product labels.
[b] Pounds of formulation per broadcast acre.
[c] Methyl iodide

E. Labeled Uses

As methyl iodide is not yet registered in California, there are no reported current usages. The proposed usages (based on U.S. EPA approved labels) are shown in Table 4.

Table 4. Proposed uses of methyl iodide[a].

Product Name	Proposed Use	Application Method and Equipment
Midas®98:2	Methyl iodide pre-plant soil fumigant to control weed seeds, including broadleaf weeds such as nutsedge, pigweed, broomrape and lambsquarters, and grasses such as bermudagrass, and annual bluegrass. Effectiveness against hard seed weeds, such as mallow, dodder, morning glory, and certain leguminous weeds may be variable. Plant-parasitic nematodes, such as root-knot, root lesion (meadow), cyst, citrus, burrowing, false root-knot, lance, spiral, ring, sting, stubby root, dagger, awl, sheath and stung (stylet) nematodes. Soil-borne Insects, such as wireworms, cutworms, grubs, rootworms, ants and garden symphylans. Soil-borne diseases, such as *Verticillium*, *Pythium*, *Rhizoctonia*, *Phytophthora*, and *Fusarium.*	Fumigations with MIDAS 98:2 shall only be performed in accordance with the following three application techniques: 1) Raised Bed Application, 2) Broadcast/Flat Fume Application, or 3) Deep Injection Auger Probe Application (stone fruit, nut trees, vines, and field-grown ornamentals only). More specific information can be found on the label cached in Appendix I.
Midas®50:50	Methyl iodide pre-plant soil fumigant. Only for pre-plant fumigations of fields intended for commercial production of listed crops and field-grown ornamentals, for the control of soil-borne pests including weed seeds, nematodes, insects, and diseases	Broadcast/flat fume applications. More specific information can be found on the label cached in Appendix I.

1 **Table 4. Proposed uses of methyl iodide [a] (continued)**

Product Name	Proposed Use	Application Method and Equipment
Midas® EC Bronze	Methyl iodide pre-plant soil fumigant. Only for pre-plant fumigations of fields intended for commercial production of listed crops and field-grown ornamentals for the control of soil-borne pests including weed seeds, nematodes, insects, and diseases	Drip irrigation (Chemigation) and raised bed drip fumigation. More specific information can be found on the label cached in Appendix I.
Midas® 33:67	Methyl iodide pre-plant soil fumigant only for pre-plant fumigations of fields intended for commercial production of listed crops and field-grown ornamentals, for the control of soil-borne pests including weed seeds, nematodes, insects, and diseases	1) Raised Bed Application, 2) Broadcast/Flat Fume Application, or 3) Deep Injection Auger Probe Application (stone fruit, nut trees, vines, and field-grown ornamental trees and shrubs only). More specific information can be found on the label cached in Appendix I.
Midas® EC Gold	Methyl iodide pre-plant soil fumigant only for pre-plant fumigations of fields intended for commercial production of listed crops and field-grown ornamentals, for the control of soil-borne pests including weed seeds, nematodes, insects, and diseases	Drip irrigation (Chemigation) and raised bed drip fumigation. More specific information can be found on the label cached in Appendix I. .
Midas® 25:75	Methyl iodide pre-plant soil fumigant Only for pre-plant fumigations of fields intended for commercial production of listed crops and field-grown ornamentals, for the control of soil-borne pests including weed seeds, nematodes, insects, and diseases	Broadcast/flat fume application and raised bed soil fumigation. More specific information can be found on the label cached in Appendix I.

2 [a] Information derived from the U.S. EPA approved product labels

F. Label Precautions/Personal Protective Equipment

All MI products are classified as Restricted Use Pesticides. Due to their acute toxicity these products are in toxicity category I, and bear the signal words "Danger/Corrosive." The general precautionary statements for MI read: *"Causes irreversible eye damage. Corrosive to skin. Causes skin burns. May be fatal if inhaled or swallowed. Harmful if absorbed through skin. Do not get in eyes, on skin, or on clothing. Do not breathe vapor. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals."*

The complete label precautions and prescribed personal protective equipment for the U.S. EPA-registered products containing methyl iodide and chloropicrin are given in Appendix I. *"**Applicators and other handlers** (to include tractor drivers, co-pilots, shovelers, and tarp monitors) **must wear**:*

- *Loose fitting or well ventilated long-sleeved shirt and long pants.*
- *Shoes plus socks.*
- *Full face shield or safety glasses with brow, temple and side protection is required. DO NOT wear goggles.*
- *An air-purifying respirator with a 3M Brand No. 60928 cartridge filter, or equivalent (MSHA/NIOSH approved number prefix TC-23C). For tractor drivers and co-pilots the following can be used in lieu of an air-purifying respirator.*
- *A tractor equipped with a working-area air-fan dilution system consisting of a ducted fan/blower which provides air flow to the breathing zone of the tractor driver and co-pilot. The fan/blower must be mounted so that the fan/blower intake is 126 inches from the ground and the fan/blower must be capable of operating at a minimum of 1,600 revolutions per minute and producing a minimum flow rate of 3,000 cubic feet of air per minute.*

Other handlers (to include planters, hole punchers, tarp cutters, tarp removers, and tarp remover drivers) must wear:

- *Loose fitting or well ventilated long-sleeved shirt and long pants.*
- *Shoes plus socks.*

Full face shield or safety glasses with brow, temple and side protection is required. DO NOT wear goggles."

On two of the labels (Midas 98:2 and Midas 50:50) additional respiratory protection may be required. "A full face respirator of one of the following types **if the air concentration of chloropicrin exceeds 4 PPM**: (a) a supplied-air respirator (MSHA/NIOSH approved number prefix TC-19C) or (b) a self-contained breathing apparatus (SCBA) (MSHA/NIOSH approval number prefix TC-13F)."

The labels provide tables for estimating 24-hour time-weighted-average buffer zones for unprotected workers and bystanders. *"…unprotected workers and bystanders do not enter the buffer zone during the 48 hours following the end of the application. <u>Exception</u>: Unprotected workers and bystanders may travel through (but not engage in any activity in) the buffer zone during the 48-hour period, provided their total exposure time in any 24-hour period is 15 minutes or less. However travel by unprotected workers or bystanders through the fumigated area itself is prohibited during the entire 5-day Entry-Restricted period. Handlers protected with Personal Protective Equipment (PPE) required for early entry into a treated area may work in buffer zones.*

The buffer zone of the field to be treated cannot overlap the buffer zone of another field treated within the last 48 hours."

G. Illness Reports

As methyl iodide is not yet registered in California, there are no reported illnesses from its use in the proposed manner.

H. Dermal Toxicity/Sensitization

Methyl iodide is a toxicity category I eye irritant, and can cause permanent damage to corneas (Bonnette, 2001b). It is a toxicity category II skin irritant (Bonnette, 2001c), and a mild dermal sensitizer (Bonnette, 2001a).

I. Pharmacokinetics

Methyl iodide, technical (99.7% purity), marked with radiolabeled MI (^{14}[C]-CH_3I) was used as test substance in deionized water (oral) or air (inhalation) for pharmacokinetic studies (Sved, 2002). Male Sprague-Dawley rats, dosed orally, received a single gavage dose at 1.5 or 24 mg/kg in the main test, and 1 or 35 mg/kg in the supplemental test. Inhalation groups received single 5½-hour whole-body exposures at 25 ppm (141 mg/m^3) or 233 ppm (1317 mg/m^3) in the main test; and 21 ppm (119 mg/m^3) or 209 ppm (1181 mg/m^3) in the supplemental test. Main test treatment groups were sub-divided into 3 groups of 4 animals each for scheduled necropsy. The first group was necropsied at 0 hr (inhalation) or 1 hr post-dosing. The second group was necropsied at 6 hours; and the third sub-group was necropsied at 168 hours. In the supplemental test, inhalation exposure groups were further divided into sub-groups of 3 animals. Half the inhalation sub-groups were necropsied immediately after exposure. The oral groups and the remaining inhalation sub-groups were necropsied 48 hours post-exposure. Expired air and urine were collected 0-6, 6-12, and 12-24 hrs post-dosing/exposure, then daily through 168 hrs. Group mean recoveries (% of dose) following oral dosing in the main test were 82.6% and 65.4% at 1.5 mg/kg and 24 mg/kg respectively. Recovery values for the supplemental test were 104.9% and 123.5% at 1 and 35 mg/kg respectively. Inhalation exposure recoveries were 56.3% and 54.4% in the main test, and 104.8% and 91.4% in the supplemental study, at the low and high dose levels, respectively. Carbon dioxide was the major route of elimination of radiolabeled ^{14}C. Approximately 50-60% of the oral dose and 40-47% of the inhaled dose was eliminated as CO_2 in 48 hours post-treatment. Urinary elimination accounted for 30-35% of administered dose through 168 hours post-treatment. Fecal elimination accounted for 2%. After oral dosing, concentrations of MI equivalents in blood peaked at 4 hours and then began to decrease. Blood levels remained relatively constant through 2 hours post inhalation exposure, and then began to decrease. Blood concentrations were greater following inhalation exposure versus oral dosing with liver metabolism the likely mediating factor. Tissue concentrations of MI equivalents were similar to or lower than the concentration in blood following oral dosing (except liver and GI tract) and higher than blood levels after inhalation exposure. Major urinary metabolites (via methylation) include S-methyl glutathione and N-(methylthioacetyl) glycine. Minor urinary metabolites were identified as methylthioacetic acid; S-methyl cysteine; and methylmercapturic acid. Six to twelve hours post-treatment was the peak time of elimination.

J. Inhalation Uptake/Dermal Absorption

The severity of systemic toxicity caused by a pesticide is directly related to the amount of the chemical that is absorbed. In order to estimate the dose absorbed through the various routes of exposure, it is necessary to have a measure of the percent absorption for each of those routes. In the case of the fumigant, methyl iodide, the principal routes of exposure are likely to be via inhalation and dermal absorption.

Inhalation uptake: A published study reported on the inhalation retention/absorption of methyl iodide in human subjects (Morgan and Morgan, 1967). Eighteen human volunteers were exposed to ^{132}[I]-methyl iodide in air under laboratory conditions. Exposure durations for the subjects lasted 5 minutes. Retention/absorption for the 18 subjects ranged from 53% to 92%, with a mean value of 72%. However, the table reporting the individuals' percent absorption/retention indicated that the values were derived from subjects breathing at different rates. In another part of the paper, the effect of breathing rate on retention/absorption was reported for two individuals. In one individual, a 20-fold increase in the breathing rate resulted in tidal volume falling ten-fold and the percent retention/absorption dropping from 86% to 38%. In the other individual, a 15-fold increase in the breathing rate produced a ten-fold fall in tidal volume and the percent retention absorption dropped from 92% to 45%. Thus, the percent retention/absorption of methyl iodide for individuals at rest or at work can vary widely. As a consequence, a default factor of 100% retention/absorption will be used (Frank, 2008). This will probably result in overestimates of the absorbed dose of methyl iodide through the inhalation route, but there does not appear to be a means for accurately gauging the degree of overestimation.

Dermal absorption: No studies on the dermal absorption of methyl iodide vapor were submitted to DPR. Nor were any published studies of dermal absorption found in the published literature. However, dermal exposure to MI vapors may be an important source of absorbed dose in some exposure scenarios. For example, illness reports in the literature for a similar fumigant, methyl bromide (Thongsinthusak and Haskell, 2002), indicated that there may be potential for significant dermal exposure of workers who wear self-contained-breathing apparatus (SCBA) in a high methyl iodide concentration environment for extended periods. However, none of the currently proposed uses of methyl iodide are considered likely to result in human exposure to high atmospheric concentrations of MI for extended periods of time. Examination of published articles indicates that if the dermal contribution to an absorbed dose of methyl iodide were similar to those indicated for volatile organic compounds (Riihimaki and Paffli, 1978; McDougal *et al.*, 1985; Wieczorek, 1985; McDougal *et al.*, 1990; Loizou *et al.*, 1998), then dermal absorption could add as much as 1% to the total absorbed dose. Consequently, potential exposure from dermal absorption of methyl iodide vapor will be considered in this document.

K. Environmental Fate

The estimated lifetime of MI in the atmosphere at northern mid-latitudes was 6.9 days, and an average of 5.2 days at all latitudes (AER, 2000). The lifetimes were used along with a chemical transport model to calculate an ozone depletion potential (ODP) value for MI of 0.0015. Chlorofluorocarbon (CFC11), by way of comparison, has an ODP of 1.0.

An aerobic soil metabolism study was conducted using [^{14}C]-methyl iodide at a concentration of 31 µg/g in soil from Watsonville, CA at 20°C in the dark (Wujcik, 2001a). The concentration was equivalent to that expected in a single field use of 263 kg active ingredient/hectare. The experimental degradation/dissipation times, DT50 and DT90, were calculated to be 2.0 and 6.8 hours, respectively (r^2=0.98).

An anaerobic aquatic metabolism study was conducted using [^{14}C]-methyl iodide at a concentration of 13 mg/L in the water from sediment-water systems from Watsonville, CA (Wujcik, 2001b). The concentration approximated the estimated concentration of MI in water at a depth of 200 cm following an application of 263 kg of active ingredient/hectare. The experimental degradation/dissipation times, DT50 and DT90, were calculated to be 41.8 and 139 hours, respectively (r^2=0.897).

Adsorption and desorption experiments were performed using a batch equilibrium method on five different soils with four concentrations of MI in 0.01M calcium chloride (McFadden and Landphair, 2001). The common adsorption and desorption equilibration time for all five soils was 24 hours. The sorption coefficients (K_d and K_{oc}) from the adsorption experiment ranged from 0.4 to 1.2 mL/g and from 14 to 61 mL/g, respectively. The sorption coefficients (K_d and K_{oc}) from the desorption experiment ranged from 2.0 to 3.2 mL/g and from 67 to 317 mL/g, respectively. The results of the study indicate that methyl iodide has minimal adsorption to soil.

II. EXPOSURE ASSESSMENT

Methyl iodide exposure estimates include those determined for applicators during preplant fumigation of soil; applicators working in a field adjacent to a previously treated field; worker bystanders (workers not directly involved in fumigation activities, but work in the nearby fields); other bystanders can include persons who live or spend time adjacent to fumigated fields, and persons who live in nearby communities with the potential to be exposed to ambient air levels of methyl iodide. The potential exposure scenarios associated with the use of the various registered formulations were summarized earlier in Table 2.

A series of studies were submitted by the registrant that detailed air concentrations of methyl iodide that workers might be exposed to during the application process. These data can be used to estimate occupational exposures. Other studies examined air concentrations of MI at various distances from the fields where it was applied using different application techniques. These data can be used to estimate bystander exposures.

A. Occupational Exposure Studies

Tarped/raised-bed/shank injection. A worker/applicator exposure study was conducted near Guadalupe on the central California coast (Baker *et al.*, 2004a). Monitored meteorological conditions indicated no rainfall during the period of the study, with an average air temperature ranging from 14.8°C to 17.1°C. Each day, from 11:00 AM until 8:00 PM an onshore breeze increased hourly wind velocity from less than 1 meter (m)/second (s) (approximately 2.24 mph) to up to a maximum of 20 m/s. The methyl iodide application was via tarpaulin (standard polyethylene tarp, 1.5 mil) covered/raised-bed/shallow shank injection (10-inch depth). Metal shanks were used to inject the pre-plant fumigant into prepared, raised-bed soil. A plastic tarp, extruded via machine, was used to immediately cover the soil to retard the fumigant escaping the soil. Methyl iodide (99.7% purity) was applied to a 2.5 acre plot at an measured rate of 178.5 lbs of active ingredient (a.i.)/treated acre; although the label for the product used in the study allowed a maximum of 235 lbs a.i./treated acre. The effective broadcast rate (including area between raised beds) was 143.2 lbs a.i./acre. The test was on bare ground, and the test subjects were workers involved in applying methyl iodide (driver, 1st shoveler, 2nd shoveler, 1st tarp monitor, 2nd tarp monitor), or conducting subsequent tasks (hole puncher at 5 days after application; 1st and 2nd planters at 7 days after application). One of the tarp monitors rode the sled, ensuring the plastic rolled out properly, while the second monitor walked along the side, or rode on the rear of the sled, checking the seal of the plastic (Figure 1- Photograph, used with permission of Arysta, was taken during the study.).

Workers wore long sleeved coveralls, or equivalent (long-sleeved shirt, long pants), socks, and non-rubber boots. Workers were each fitted with 2 air sample tubes (SKC 226-09 with Anasorb® coconut charcoal and a flow rate of 50 mL/min), and duplicate sets of data (with a couple of glitches when one or two air pumps stopped for a few minutes) were obtained from each worker. Two SKC Model 224-44XR personal air sampling pumps, equipped with adjustable low flow rate, were placed on each worker's belt. Tygon tubing attached the pumps to the air sampling tubes, which were clipped to the lapel, near the worker's breathing zone. Sampling tubes were divided into two portions, with approximately 400 mg of charcoal in the front portion and 200 mg in the back portion. Both the front and back portions were analyzed separately to determine if all of the methyl iodide was trapped in the front portion. The presence of MI in the rear section in amounts greater than 10% of the total would indicate "breakthrough" and the amount of MI measured in the sample would be considered indeterminate (Huey, 2002). The amount of breakthrough did not exceed 10% of the total, which is considered acceptable (Huey, 2002), in any sample in this study or in any subsequent study. Consequently, the residues measured in the rear portions were added to those of the front portions in each study. Air samples were collected for each worker during the work task. Tractor drivers and shovelers worked 8-8.5 hours. Holes were punched in the polyethylene tarpaulin 5 days after application using a tractor-mounted device. The hole puncher (driver of the tractor) was monitored for 138 minutes. Two workers planted strawberries 7 days after application, and were monitored for 302 minutes.

Figure 1. Tarp monitors and tractor driver performing tasks associated with tarped/raised bed/shank injection of methyl iodide[a].

[a] Photograph, used with permission of Arysta, was taken during an exposure monitoring study.

One shoveler was positioned at each end of the field to cut the plastic off and seal the end with soil, repair tears with tape, and apply additional soil if areas had been inadequately sealed (Figure 2 - Photograph, used with permission of Arysta, was taken during the study.).

Figure 2. Shovelers working at tasks associated with tarped/raised bed/shank injection of methyl iodide[a].

[a] Photograph, used with permission of Arysta, was taken during an exposure monitoring study.

Sample tubes were in frozen storage a maximum of five days from collection until extraction. Field spikes, generated by drawing 5 replicate, known air concentrations of methyl iodide at 0.7, 70 or 700 ppb through collection tubes for 1 hour at 50 mL/minute, indicated field recoveries of 75%, 79%, and 81%, respectively. The field spike recoveries in the range of concentrations encountered by workers were used to correct sample results. Field spike recoveries were different in each of the studies. All analytical samples collected from handlers were corrected for trapping efficiencies of 79% for handlers (medium air concentrations), and 75% for re-entry workers (low air concentrations). Little or no breakthrough of methyl iodide residues into the back-end charcoal of air sample tubes occurred. Residues of methyl iodide were desorbed from the charcoal with ethyl acetate, and quantified by gas chromatography using an electron-capture detector. The limit of quantitation (LOQ) for a flow rate of 50 mL/minute and duration of 2-hour trapping in a collection tube was approximately 0.56 ng/ml extract.

Quantitation limits arise from two distinct needs (Helsel, 2005). First, a threshold needs to be established above which reliable single numbers can be reported. These are generally computed at about 10 times the standard deviation of a low standard such as the one used to define the method detection limit. A concentration 10 times the background variability is considered large enough by most chemists that a single number might be comfortably reported. The result is a threshold that is a little over 3 times the value of the detection limit.

Second, a threshold is established that protects against false negatives. A false negative occurs when a measurement whose true concentration is at or above the detection limit is not reported.

The monitored air concentrations from the breathing zones of the workers involved in this study are given in Table 5. The conversion of an air concentration expressed in µg/L to an expression in ppm is done using the following equation:

Equation 1. Calculation of methyl iodide air concentration (ppm).

$$\text{Methyl Iodide (ppm)} = \frac{\mu g \times 24.45}{V_S \times 141.95} = \frac{\mu g \times 0.1722}{V_S}$$

where,

V_S is the volume of the sample in liters (one mole of methyl iodide occupies 24.45 liters at 25°C, and molecular weight of 141.95 g/mole).

Table 5. Measured worker body weights, air volumes collected, and amounts of methyl iodide associated with work tasks involving pre-plant field fumigation via tarpaulin covered/raised-bed/shallow shank injection in Guadalupe.

Work Task	Body Weight [kg]	Average Total Volume[a] [L]	Methyl Iodide (MI) [µg][b]	MI Air Concentration [µg/L] (ppm)[c]
Tractor Driver	98	25.8	7.88[d]	0.31 (0.05)
1st Shoveler	47	25.1	5.39[d]	0.21 (0.04)
2nd Shoveler	102	25.6	12.29[d]	0.48 (0.08)
1st Tarp Monitor	94	25.3	3.29[d]	0.13 (0.02)
2nd Tarp Monitor	86	25.4	21.84[d]	0.86 (0.15)
Hole Puncher	86	6.8	0.04[e]	0.01 (0.001)
1st Planter	86	14.9	0.14[e]	0.01 (0.002)
2nd Planter	47	14.9	0.09[e]	0.01 (0.001)

[a] The average volume collected from the two air monitoring devices rigged on the shoulder of each person.
[b] Average amount of methyl iodide trapped in the two collection tubes during the collection period. Concentration is calculated by dividing the amount MI collected by the total volume to pass through the collection tube.
[c] 1 ppm = 5.81 µg/L rounded to the nearest 1/100 µg/L.
[d] Corrected for 79% trapping efficiency.
[e] Corrected for 75% trapping efficiency.

Tarped/raised-bed/shank injection. A worker/applicator exposure study was conducted near Oxnard on the southern California coast (Baker *et al.*, 2003e). Monitored meteorological conditions indicated no rainfall during the period of the study, with an average air temperature ranging from 5°C to 22°C. The onshore breeze had an average hourly wind velocity varying between 2.4 and 5.7 m/s. The methyl iodide application was via tarpaulin (polyethylene, 1.5 mil) covered/raised-bed/shallow shank injection (two shanks, 16 inches apart, approximately 6 inches deep). Methyl iodide (99.7% purity) was applied to a 2.5 acre plot at a measured rate of 224.5 lbs a.i./treated acre; although the label for the product used in the study allowed a maximum of 235 lbs a.i./treated acre. The test was on bare ground, and the test subjects were workers involved in applying methyl iodide (driver, 1st shoveler, 2nd shoveler, 1st tarp monitor, 2nd tarp monitor), or conducting subsequent tasks (hole puncher at 5 days after application; 1st and 2nd planters at 7 days after application). The driver operated the tractor while the 1st tarp monitor sat in the shank injector seat. The 2nd tarp monitor walked along in the furrow to check the flow of the test substance and the seal of the plastic tarp. He added soil to the sides of the plastic on occasion. At the end of the pass, the 2nd tarp monitor helped the shoveler seal the end of the bed with soil. The shovelers were positioned at either end of the plot. The shovelers cut the tarp at the end of each pass, using the shovel, and then shoveled soil onto the ends of the tarp. Excess tarp was rolled up by the shovelers and removed from the plot. Workers wore long sleeved coveralls, or equivalent (long-sleeved shirt, long pants), socks, and non-rubber boots.

This study reported a situation that does not usually occur, but it is a situation that a pesticide handler may encounter during fumigation activities. The driver conducted two maintenance tasks during application, and these tasks required breach of the rig's closed application system. The 2nd tarp monitor was responsible for observing that the test substance delivery system was functioning correctly, and he walked on the plot alongside the rig during the entire application procedure. In addition, he performed as a shoveler at the ends of the row while the rig raised the shanks from the ground and made a 180° turn. Some of the test substance dripped from the shanks of the rig at the end of each pass during the turn-around procedure in the early portion of the application.

Workers were each fitted with 2 air sample tubes (SKC 226-09 with Anasorb® coconut charcoal and a flow rate of 50 mL/min), and duplicate sets of data were obtained from each worker. Air samples were collected for each worker during the work task. Tractor drivers and shovelers worked 411 minutes. Holes were punched in the polyethylene tarpaulin (5 days after application) using a tractor-mounted device. The hole puncher (driver of the tractor) was monitored for 192 minutes. Two workers planted strawberries (7 days after application), and were monitored for 326 minutes.

Sample tubes were in frozen storage a maximum of five days from collection until extraction. Field spikes, generated by drawing 5 replicate, known air concentrations of methyl iodide at 0.4, 43 or 422 ppb through collection tubes for 1 hour at 50 mL/minute, indicated field recoveries of 53%, 81%, and 79%, respectively. All analytical samples collected from handlers in this study were corrected for trapping efficiencies of 81% (medium air concentrations). Analytical samples collected for re-entry workers were corrected for a trapping efficiency of 53% (low air concentrations). Residues of methyl iodide were desorbed from the charcoal with ethyl acetate, and quantified by gas chromatography using an electron-capture detector. The limit of quantitation (LOQ) for a flow rate of 50 mL/minute and duration of 2 hours trapping in a collection tube was approximately 0.10 ng/ml extract.

The monitored air concentrations from the breathing zones of the workers involved in this study are given in Table 6.

Table 6. Measured worker body weights, air volumes collected, and amounts of methyl iodide associated with work tasks involving pre-plant field fumigation via tarpaulin covered/raised-bed/shallow shank injection in Oxnard.

Work Task	Body Weight [kg]	Average Total Volume[a] [L]	Methyl Iodide (MI) [µg][b]	MI Air Concentration [µg/L] (ppm)[c]
Tractor Driver	77	21.2	116[d]	5.47 (0.94)
1st Shoveler	86	21.6	54.4[d]	2.52 (0.43)
2nd Shoveler	95	21.4	92.3[d]	4.32 (0.74)
1st Tarp Monitor	91	21.0	73.8[d]	3.52 (0.60)
2nd Tarp Monitor	60	20.1	119.3[d]	5.94 (1.02)
Hole Puncher	95	9.7	5.8[e]	0.60 (0.10)
1st Planter	86	16.1	0.5[e]	0.03 (0.005)
2nd Planter	85	16.5	0.5[e]	0.03 (0.005)

[a] The average volume collected from the two air monitoring devices rigged on the shoulder of each person.
[b] Average amount of methyl iodide trapped in the two collection tubes during the collection period. Concentration is calculated by dividing the amount MI collected by the total volume to pass through the collection tube.
[c] 1 ppm = 5.81 µg/L rounded to the nearest 1/100 µg/L.
[d] Corrected for 81% trapping efficiency.
[e] Corrected for 53% trapping efficiency.

Tarped/flat-fume/shank injection. A worker/applicator exposure study was conducted near Manteca in the San Joaquin Valley, California (Baker *et al.*, 2001b). Monitored meteorological conditions indicated no rainfall during the period of the study, with average air temperatures ranging from 12°C to 25°C. Hourly wind velocity ranged from 0.9 m/s to up to a maximum of 4 m/s from the northwest. The application of methyl iodide was via broadcast, flat fume, shallow shank (approximately 11 inches) injection. Methyl iodide (99.7% purity) was applied to a 2.5 acre plot at a measured rate of 242 lbs a.i./treated acre although the label for the product used in the study allows a maximum of 235 lbs. a.i./treated acre. The test was on bare ground soil, and the test subjects were workers involved in applying methyl iodide (driver, driver's assistant, 1st shoveler, 2nd shoveler, 1st tarp monitor, 2nd tarp monitor), or conducting subsequent tasks (tarp cutter, tarp remover, and tarp remover driver 5 days after application; and a planter at 7 days after application). The driver and the driver's assistant, loaded cylinders and tarp rolls onto the application equipment. The driver's assistant stood on the side platform. The ventilation fan was on continuously during application. At the end of the pass, the driver's assistant stepped off the platform, cut the tarp, and assisted the shoveler with burying the tarp. Once the tarp was buried, the driver's assistant mounted the platform and continued with the application. The shovelers were positioned at the opposite ends of the plot. Workers wore long-sleeved coveralls, or equivalent (long-sleeved shirt, long pants), socks, and non-rubber boots. Workers were each fitted with 2 air sample tubes (SKC 226-09 with Anasorb® coconut charcoal and a flow rate of 50 mL/min), and duplicate sets of data were obtained from each worker. Air samples were collected for each worker during the work task. The tractor driver and his assistant worked 215 minutes. The shovelers worked 187 minutes. The tarp cutter was monitored for 68 minutes. The tarp remover and the tarp remover driver were monitored for 353 minutes. The planter of strawberries (7 days after application) was monitored for 65 minutes.

Sample tubes were in frozen storage a maximum of five days from collection until extraction. Field spikes, generated by drawing 5 replicate, known air concentrations of methyl iodide at 0.65, 62 or 643 ppb through collection tubes for 1 hour at 50mL/minute, indicated field recoveries of 66%, 66%, and 70%, respectively. In addition, field trapping efficiency levels were examined at 18-22 ppb under day and night conditions. During daytime, approximately 60% of the theoretical level was recovered in these low-level samples. All analytical samples collected from workers in this study were corrected for a trapping efficiency of 66%. Residues of methyl iodide were desorbed from the charcoal with ethyl acetate, and quantified by gas chromatography using an electron-capture detector. The limit of quantitation (LOQ) for a flow rate of 50 mL/minute and duration of 2 hours trapping in a collection tube was approximately 0.56 ng/ml extract. The monitored air concentrations from the breathing zones of the workers involved in this study are given in Table 7.

Table 7. Measured worker body weights, air volumes collected, and amounts of methyl iodide associated with work tasks involving pre-plant field fumigation via tarpaulin covered/flat fume/shallow shank injection in Manteca.

Work Task	Body Weight [kg]	Average Total Volume[a] [L]	Methyl Iodide (MI)[b] [µg]	MI Air Concentration [µg/L] (ppm)[c]
Tractor Driver	77	10.9	1.08[d]	0.10 (0.02)
Driver's Assistant	91	10.9	6.92[d]	0.64 (0.11)
1st Shoveler	86	9.4	5.30[d]	0.56 (0.10)
2nd Shoveler	80	9.4	1.07[d]	0.11 (0.02)
Tarp Cutter	95	3.4	0.10[d]	0.03 (0.005)
Tarp Remover	75	18.0	1.16[d]	0.06 (0.01)
Tarp Remover Driver	105	18.1	2.14[d]	0.12 (0.02)
Planter	80	3.2	0.11[d]	0.03 (0.006)

[a] The average volume collected from the two air monitoring devices rigged on the shoulder of each person.
[b] Average amount of methyl iodide trapped in the two collection tubes during the collection period. Concentration is calculated by dividing the amount MI collected by the total volume to pass through the collection tube.
[c] 1 ppm = 5.81 µg/L rounded to the nearest 1/100 µg/L.
[d] Corrected for 66% trapping efficiency.

Tarped/raised-bed/drip irrigation. A worker/applicator exposure study was conducted near Camarillo on the southern California coast (Baker, 2004). Monitored meteorological conditions indicated no rainfall during the period of the study, with an average temperature of 16.7°C. Each day, from 10:00 AM until 6:00 PM an onshore breeze increased in wind velocity from an hourly average of less than 1 m/s to up to a maximum of 13 m/s. The application of methyl iodide was via tarpaulin covered/raised-bed/drip irrigation. This method entails the laying down of plastic irrigation lines in the prepared raised-bed soil. The raised-bed is then covered with plastic tarpaulin. Methyl iodide (99.7% purity) was applied to a 2.5 acre plot at a measured rate of 175.4 lbs/treated acre (broadcast rate of 118.8 lb/acre). (Figure 3- Photograph, used with permission of Arysta, was taken during the study.) Water flow into the drip lines was monitored using a water meter. The test was on bare ground soil, and the test subjects were workers involved in applying methyl iodide (1st applicator, 2nd applicator), or conducting subsequent tasks (hole puncher at 5 days after application; 1st and 2nd planters at 7 days after application). Workers wore long sleeved coveralls, or equivalent (long sleeved shirt, long pants), socks, and non-rubber boots. Workers were each fitted with 2 air sample tubes (SKC 226-09 with Anasorb® coconut charcoal and a flow rate of 50 mL/min), and duplicate sets of data were obtained from each worker. Air samples were collected for each worker during the work task.

Figure 3. Activities associated with application of methyl iodide through drip irrigation in prepared, tarped/raised bed soil[a].

[a] Photograph, used with permission of Arysta, was taken during the exposure monitoring study.

Applicators walked the plot checking for leaks, repairing tarp holes, laying tarp over areas in which irrigation liquid accumulated in the burrows, or repairing drip tape. Applicators were monitored for 276 minutes. Holes were punched in the polyethylene tarpaulin (5 days after application) using a tractor-mounted device. The hole puncher (driver of the tractor) was monitored for 196 minutes. Two workers planted strawberries (7 days after application), and were monitored for 360 minutes.

Sample tubes were in frozen storage a maximum of five days from collection until extraction. Field spikes, generated by drawing 5 replicate, known air concentrations of methyl iodide at 0.7, 70 or 700 ppb through collection tubes for 1 hour at 50 mL/minute, indicated field recoveries of 70%, 72%, and 76%, respectively. All analytical samples collected from handlers in this study were corrected for trapping efficiencies of 72% (medium air concentrations), and 70% (low air concentrations) for re-entry workers. Residues of methyl iodide were desorbed from the charcoal with ethyl acetate, and quantified by gas chromatography using an electron-capture detector. The limit of quantitation (LOQ) for a flow rate of 50 mL/minute and duration of 2 hours trapping in a collection tube was approximately 0.17 ng/ml extract. The monitored air concentrations from the breathing zones of the workers involved in this study are given in Table 8.

Table 8. Measured worker body weights, air volumes collected, and amounts of methyl iodide associated with work tasks involving pre-plant field fumigation via tarpaulin covered/raised-bed/drip irrigation in Camarillo.

Work Task	Body Weight [kg]	Average Total Volume[a] [L]	Methyl Iodide (MI) [µg][b]	MI Air Concentration [µg/L] (ppm)[c]
1st Applicator	91	13.8	4.51[d]	0.33 (0.06)
2nd Applicator	100	14.0	10.29[d]	0.74 (0.13)
Hole Puncher	100	10.0	0.20[e]	0.02 (0.003)
1st Planter	91	17.9	0.06[e]	0.003 (0.0006)
2nd Planter	100	18.1	0.05[e]	0.003 (0.0005)

[a] The average volume collected from the two air monitoring devices rigged on the shoulder of each person.
[b] Average amount of methyl iodide trapped in the two collection tubes during the collection period. Concentration is calculated by dividing the amount MI collected by the total volume to pass through the collection tube.
[c] 1 ppm = 5.81 µg/L rounded to the nearest 1/100 µg/L.
[d] Corrected for 72% trapping efficiency.
[e] Corrected for 70% trapping efficiency.

Tarped/raised-bed/drip irrigation. A worker/applicator exposure study was conducted near La Selva Beach on the northern California coast (Baker *et al.*, 2003d). Monitored meteorological conditions indicated no rainfall during the period of the study, with an average temperature ranging from 16.1 to 18.2°C. Wind velocity averaged 2.8 m/s hourly. The application of methyl iodide was via tarpaulin covered/raised-bed/drip irrigation. Methyl iodide (99.7% purity) was applied to a 2.5-acre plot at a measured rate of 234.3 lbs a.i./acre (the broadcast rate was 162.2 lb a.i./acre). The test was on bare ground soil, and the test subjects were workers involved in applying methyl iodide (1st applicator, 2nd applicator), or conducting subsequent tasks (hole puncher at 5 days after application; 1st and 2nd planters at 7 days after application). Workers wore long sleeved coveralls, or equivalent (long sleeved shirt, long pants), socks, and non-rubber boots. Workers were each fitted with 2 air sample tubes (SKC 226-09 with Anasorb® coconut charcoal and a flow rate of 50 mL/min), and duplicate sets of data (with a couple of glitches in the pumps that did not affect the results) were obtained from each worker. Air samples were collected for each worker during the work task.

Applicators walked the plot checking for leaks, repairing tarp holes, and laying tarp over areas in which irrigation liquid accumulated in the burrows or repairing drip tape. Applicators were monitored for 377 minutes. Holes were punched in the polyethylene tarpaulin (5 days after application) using a tractor-mounted device. The hole puncher (driver of the tractor) was monitored for 186 minutes. Two workers planted strawberries (7 days after application), and were monitored for 262 minutes.

Sample tubes were in frozen storage a maximum of five days from collection until extraction. Field spikes, generated by drawing 5 replicate, known air concentrations of methyl iodide at 0.7, 71 or 706 ppb through collection tubes for 1 hour at 50 mL/minute, indicated field recoveries of 68.5, 75, and 75%, respectively. All analytical samples collected from handlers in this study were corrected for trapping efficiencies of 75% (medium air concentrations), and 69% (low air concentrations) for re-entry workers. Residues of methyl iodide were desorbed from the charcoal with ethyl acetate, and quantified by gas chromatography using an electron-capture detector. The limit of quantitation (LOQ) for a flow rate of 50 mL/minute and duration of 2 hours trapping in a collection tube was approximately 0.17 ng/ml extract. The monitored air concentrations from the breathing zones of the workers in this study are given in Table 9.

Table 9. Measured worker body weights, air volumes collected, and amounts of methyl iodide associated with work tasks involving pre-plant field fumigation via tarpaulin covered/raised-bed/drip irrigation in La Selva Beach.

Work Task	Body Weight [kg]	Average Total Volume[a] [L]	Methyl Iodide (MI) [μg][b]	MI Air Concentration [μg/L] (ppm)[c]
1st Applicator	91	19.0	7.9[d]	0.42 (0.07)
2nd Applicator	99	18.9	11.1[d]	0.59 (0.10)
Hole Puncher	99	9.4	0.66[e]	0.07 (0.01)
1st Planter	99	13.5	0.01[e]	0.001 (0.0001)
2nd Planter	82	13.2	0.04[e]	0.003 (0.0005)

[a] The average volume collected from the two air monitoring devices rigged on the shoulder of each person.
[b] Average amount of methyl iodide trapped in the two collection tubes during the collection period. Concentration is calculated by dividing the amount MI collected by the total volume to pass through the collection tube.
[c] 1 ppm = 5.81 μg/L rounded to the nearest 1/100 μg/L.
[d] Corrected for 75% trapping efficiency.
[e] Corrected for 69% trapping efficiency.

Tarped/raised-bed/drip irrigation. A worker/applicator exposure study was conducted near Guadalupe on the central California coast (Baker *et al.*, 2005a). Monitored meteorological conditions indicated no rainfall during the period of the study, with an average temperature ranging from 12.5 to 22.2°C. Average hourly wind velocity ranged from 0.2 m/s to 7.1 m/s. The application of methyl iodide was via tarpaulin covered/raised-bed/drip irrigation. Methyl iodide (99.7% purity) was applied to a 2.5-acre plot at a measured rate of 173.8 lbs a.i./treated acre (the broadcast rate was 139 lb a.i./acre). The test was on bare ground soil, and the test subjects were workers involved in applying methyl iodide (1st applicator, 2nd applicator), or conducting subsequent tasks (hole puncher at 5 days after application; 1st and 2nd planters at 7 days after application). Workers wore long sleeved coveralls, or equivalent (long sleeved shirt, long pants), socks, and non-rubber boots. Workers were each fitted with 2 air sample tubes (SKC 226-09 with Anasorb® coconut charcoal and a flow rate of 50 mL/min), and duplicate sets of data were obtained from each worker. Air samples were collected for each worker during the work task.

Applicators walked the plot checking for leaks, repairing tarp holes, and laying tarp over areas in which irrigation liquid accumulated in the burrows or repairing drip tape. Applicators were monitored for 298 minutes. Holes were punched in the polyethylene tarpaulin (5 days after application) using a tractor-mounted device. The hole puncher (driver of the tractor) was monitored for 134 minutes. Two workers planted strawberries (7 days after application), and were monitored for 310 minutes.

Sample tubes were in frozen storage a maximum of five days from collection until extraction. Field spikes, generated by drawing 5 replicate, known air concentrations of methyl iodide at 0.7, 70 or 700 ppb through collection tubes for 1 hour at 50 mL/minute, indicated field recoveries of 37, 65, and 73%, respectively. All analytical samples collected from handlers in this study were corrected for trapping efficiencies of 65% (medium air concentrations), and 37% (low air concentrations) for re-entry workers. Residues of methyl iodide were desorbed from the charcoal with ethyl acetate, and quantified by gas chromatography using an electron-capture detector. The limit of quantitation (LOQ) for a flow rate of 50 mL/minute and duration of 2 hours trapping in a collection tube was approximately 0.19 ng/ml extract. It should be noted that the recoveries from the field spikes at the low and medium concentrations were abnormally low, calling into question the values attributed to the worker samples. Because of the small number of replicates for each work task, though, it was decided to use the sample values in order to get enough replicates to be able to estimate an upper-bound of these handler exposures. The upward adjustment of the measured air concentrations of MI tends to be a health protective measure. The monitored air concentrations from the breathing zones of the workers involved in this study are given in Table 10.

Table 10. Measured worker body weights, air volumes collected, and amounts of methyl iodide associated with work tasks involving pre-plant field fumigation via tarpaulin covered/raised-bed/drip irrigation in Guadalupe.

Work Task	Body Weight [kg]	Average Total Volume[a] [L]	Methyl Iodide (MI) [µg][b]	MI Air Concentration [µg/L] (ppm)[c]
1st Applicator	94	14.9	19.2[d]	1.3 (0.22)
2nd Applicator	100	14.8	12.5[d]	0.85 (0.15)
Hole Puncher	125	6.7	0.58[e]	0.09 (0.01)
1st Planter	90	15.7	0.39[e]	0.02 (0.004)
2nd Planter	97	15.4	0.34[e]	0.02 (0.004)

[a] The average volume collected from the two air monitoring devices rigged on the shoulder of each person.
[b] Average amount of methyl iodide trapped in the two collection tubes during the collection period. Concentration is calculated by dividing the amount MI collected by the total volume to pass through the collection tube.
[c] 1 ppm = 5.81 µg/L rounded to the nearest 1/100 µg/L.
[d] Corrected for 65% trapping efficiency.
[e] Corrected for 37% trapping efficiency.

Treatment of Study data. DPR has a policy of using an upper-bound of work-task exposure to represent potential acute exposures (Frank, 2007). Although six occupational exposure studies were conducted (see above), the number of individuals engaged in each of the various work tasks was not sufficient, in some instances, to allow calculations of an upper-bound or averages of the data. Consequently, it was necessary to group workers engaged in similar activities to obtain a statistically relevant number of sampled individuals for estimating acute and longer term exposures associated with the various work tasks. The applicators (and co-pilots) in the shank injection studies, whether doing applications of methyl iodide to raised-beds or flat fields, had similar work activities and used the same application rates per treated acre. Consequently, these applicators were considered to have the same work tasks. Engineering controls were used in the Manteca study. According to the labels, either engineering controls or respiratory protection must be used when applying MI. It was assumed that engineering controls would produce at least a 10-fold reduction in driver exposure. The exposures of the applicators in the Manteca study were adjusted 10-fold upward to match those of the applicators in the other studies that were conducted without additional PPE. Shovelmen and shovelers were grouped; tarp cutters and hole punchers were combined; and planters, whether associated with raised-bed or flat-fume shank injections, had similar activities. Tarpaulin removers (driving tractors - Table 7) were grouped with the tarp cutters (Table 7) and hole punchers (Tables 5, 6), as they were all in the fields 5 days after the fields had been treated, and were engaged in activities related to the tarp covers. The various work tasks associated with drip irrigation has adequate numbers of individual workers for statistical analysis of the data.

As each pesticide handler was wearing the PPE prescribed by the label, all of the reported exposures were included in the analyses. Even though application equipment associated with shallow shank injections malfunctioned in one instance, it was assumed that the event was a normal part of their responsibilities/activities. Consequently, the handler exposures associated with this event are included.

WHS supports the U.S. EPA position that the distributions of environmental exposures tend to be lognormal (USEPA, 1992b). Even though the data are chemical specific, there are few replicates for each job category on which to base the estimated exposures. In calculating acute exposures, DPR uses an upper-bound estimate of the measured air concentrations (Frank, 2009). By convention, the upper-bound used is a point estimate of the 95th percentile of a lognormal distribution of MI concentrations as calculated by the following expression:

$$\exp\left[\hat{\mu} + Z_{(0.95)} \cdot \hat{\sigma}\right]$$

Where: $\hat{\mu}$ = the arithmetic mean of the natural logs of the values

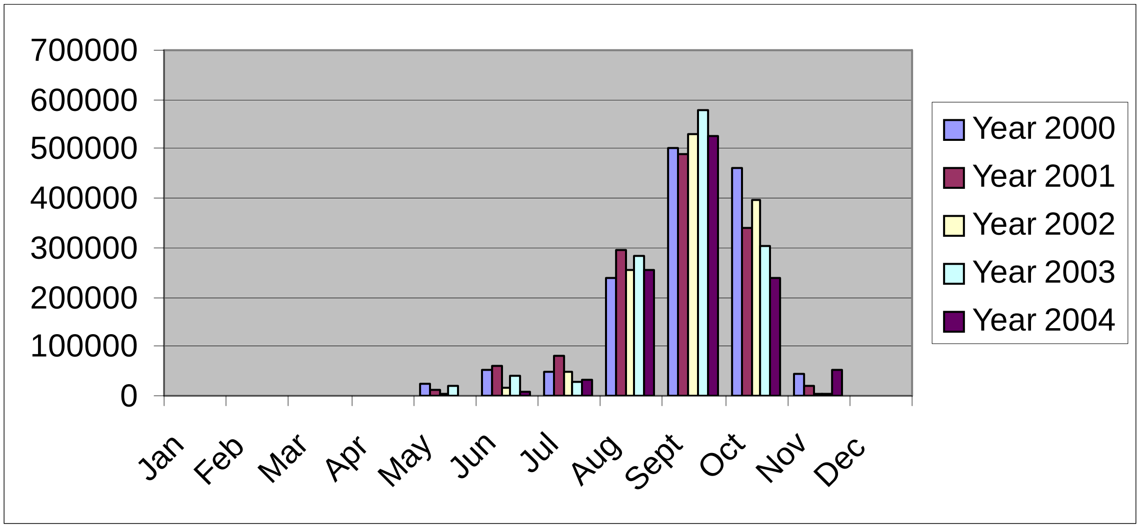
$Z_{(0.95)}$ = the standard normal deviate such that 95% of the distribution is less than that value

$\hat{\sigma}$ = the standard deviation of the natural logs of the values

The calculations are shown in Appendix II.

It was assumed that all workers would be exposed for a full, 8-hour workday. The arithmetic mean, 8-hour air concentrations of MI for each of the task categories was used to represent seasonal exposures for these workers. As methyl iodide is not yet registered in California, the annual use pattern is unknown. Since MI will be used in pre-plant soil fumigation activities similar to those associated with the chemical it is proposed to replace (methyl bromide), the MB use pattern was used as a surrogate. The annual use of methyl bromide in Monterey County (the county with 90% of the pre-plant fumigation use) was plotted for 5 years (Figure 4). Examination of this use pattern indicates an annual 3-month period of high application rates, principally on strawberries. Consequently, a similar use pattern will be assumed for methyl iodide.

Figure 4. Annual monthly use of methyl bromide in pounds during pre-plant field fumigation in Monterey County for the years 2000 through 2004.



Absorbed Dose

Inhalation Route. The preceding studies provided calculated air concentrations of methyl iodide in the breathing zone of applicators and re-entry workers. The application rates used in the studies were different than the maximum application rate on the proposed labels. DPR adjusted the exposures to reflect the maximum application rate. In order to estimate the absorbed dose a worker would experience for each job task through the inhalation route, it is necessary to use default inhalation factors (Andrews and Patterson, 2000) in the following equations.

Equation 2: Absorbed dose inhaled (AD_i), average:

$$AD_i = C_{mi} \times IR \times (1-PF) \times AF$$

where, C_{mi} = methyl iodide air concentration (µg/L)
IR = inhalation rate (L/hr) during activity (833L/hr; Andrews and Patterson, 2000)
PF = protection factor, 0.9 for respiratory protection
AF = absorption factor (100%)

Equation 3: Absorbed daily dosage (ADD), average:

$$ADD = AD_i \times \text{daily duration (hr/day)} / \text{body weight (kg)}$$

where, AD_i, = Absorbed dose inhaled (calculated in Equation 2)
daily duration is 8 hr.

An annual absorbed daily dose may be generated by amortizing the seasonal absorbed daily dose over the course of a year. The estimated acute, seasonal, annual, and lifetime exposures of workers through the inhalation route are summarized in Table 11.

Dermal Route. As noted earlier, there were no studies that provided an estimate of the amount of MI that could be absorbed dermally from measured air concentrations. Although the amount absorbed through the skin is likely to be substantially less than the amount retained/absorbed through the lungs, to be health protective there should be some indication of the significance of the dermal contribution. Examination of the literature suggests a possible approach to obtaining a theoretical estimate of dermal absorption of MI. In general, the permeability of a chemical through skin is related to the chemical's partitioning into air, blood, and lipids (McDougal *et al.*, 1990; USEPA, 1992a). Mattie *et al*. (Mattie *et al.*, 1994) determined skin-air partition coefficients for several volatile organic chemicals in an *in vitro* study using clipped, whole-thickness rat skin, and compared these partition coefficients with octanol-water partition coefficients reported by Leo *et al*. (Leo *et al.*, 1971), and rat skin permeability reported by McDougal *et al*. (McDougal *et al.*, 1985; McDougal *et al.*, 1986; McDougal *et al.*, 1990). Mattie *et al*. (Mattie *et al.*, 1994) found that skin-air partition coefficients correlated well with skin permeability ($r^2 = 0.93$), but that octanol-water partition coefficients did not ($r^2 = 0.09$). In its guidance for estimating dermal exposure, U.S. EPA (USEPA, 1992a) suggests that the fat/air partition coefficient for an airborne chemical may be used to estimate skin permeability. The formula, suggested by U.S. EPA, to make that estimate is as follows:

$$K_{p(est)} = (K_{f/a} \times 0.00049) - 0.0385$$

Where: $K_{p(est)}$ = the estimated skin permeability coefficient
$K_{f/a}$ = the fat/air partition coefficient

In the case of methyl iodide, the measured $K_{f/a}$ in rats is 88.8$\pm$2.3 (Gannon, 2004). Thus, substituting 88.8 for $K_{f/a}$ in the above formula yields an estimated K_p of 0.005 cm/hr. Dermal absorption of methyl iodide may then be estimated using dermal permeability coefficients, based on Fick's first law (McDougal *et al.*, 1990):

$$\text{Dermal intake} = K_p \times Conc_{exposure} \times Area_{skin} \times time_{exposure}$$

Where: K_p = measured or calculated skin permeability coefficient (cm/hr)
$Conc_{exposure}$ = concentration of the chemical in air (µg/m^3)
$Area_{skin}$ = area of skin exposed (cm^2)
$time_{exposure}$ = duration of exposure period (hr)

As indicated in Table 10 and Table 2, Appendix III (estimated absorbed dose of MI for handlers), applicators applying MI through drip irrigation are exposed to an air concentration up to 1,394 µg/m^3 MI. A generic adult is assumed to have a total body surface area of 18,150 cm^2 (USEPA, 1997). Thus, the amount of MI absorbed dermally by applicators in an 8-hour period would be:

$$\text{Dermal intake} = (0.005\ \text{cm/hr}) * (8\ \text{hr}) * (1{,}394\ \mu\text{g/m}^3) * (18{,}150\ \text{cm}^2) * 1\text{m}^3/(1 \times 10^6\ \text{cm}^3)$$
$$= 1.01 \mu\text{g}.$$

The dose of MI absorbed through the inhalation route by an applicator experiencing the same air concentration for 8 hours was estimated to be 9.66 µg/kg (Table 11). If we assume the generic adult weighs 70 kg (USEPA, 1997), the amount of MI absorbed through the dermal route would be 0.014 µg/kg. Consequently, the amount theoretically absorbed through the dermal route (0.014 µg/kg) constitutes 0.1% of the amount (9.66 µg/kg) absorbed through the inhalation route. This amount of exposure is considered insignificant (Donahue, 1996). This theoretical calculation depends upon the accuracy of the *in vitro* dermal absorption data. At the present time, DPR does not consider *in vitro* dermal absorption data to be reliably reproducible.

This theoretical estimate of dermal absorption suggests that the dermal absorption of MI might be significant if individuals with SCBA were exposed to high concentrations of MI for extended periods. However, in the context of pre-plant field fumigation, the contribution of MI through the dermal route to the total absorbed dose is probably negligible. Consequently, the potential dermal contributions of air concentrations of methyl iodide from pre-plant field fumigation were not calculated for workers or bystanders.

Table 11. Duration and frequency of acute and non-acute exposures for applicators and workers engaged in pre-plant field fumigation with methyl iodide (MI).

N	Work Task	Adjustment Rate[a] (lb. MI/FA)	Acute Hours	Acute ADD[b] (µg/kg-day) [ppm][f]	SADD[c] (µg/kg-day) [ppm][g]	AADD[d] (µg/kg-day)	LADD[e] (µg/kg-day)
	Shallow shank-tarped soil fumigation (broadcast and bedded)[h]						
4	Applicators (using shanks, 10-12")	175	8	120.4 [0.27]	26.2 [0.06]	6.6	3.5
6	Shovelmen and Shovelers	175	8	37.4 [0.08]	10.2 [0.02]	2.6	1.4
4	Tarp Monitors	175	8	141.7 [0.30]	24.8 [0.04]	6.2	3.3
5	Tarp Hole Punchers, Tarp Cutters, and Tarp Removers	175	8	44.1 [0.08]	11.6 [0.03]	2.9	1.5
5	Planters	175	8	3.6 [0.006]	1.9 [0.004]	0.5	0.3
	Tarped-bed fumigation drip irrigation						
6	Applicator	175	8	1.1 [0.003]	0.61 [0.001]	0.15	0.08
3	Hole Puncher	175	8	8.3 [0.015]	3.6 [0.001]	0.9	0.5
6	Planter	175	8	2.3 [0.004]	0.6 [0.001]	0.1	0.05

[a] The application rates used in the studies were different than the maximum application rate on the proposed labels. DPR adjusted the exposures to reflect the maximum application rate (pounds of MI/fumigated acre-FA).

[b] The acute absorbed daily dose (ADD), representing the 95th percentile of exposure for 8 hours, calculated from equations 2 and 3 assuming an inhalation rate of 833 L/hr (Andrews and Patterson, 2000), assumes 90% protection factor for use of air-purifying respirator for applicators (as is now required by the label), shovelmen, and tarp monitors, uses the measured body weights, and the 95th percentile of the 8-hour MI air concentration, $\exp\left[\hat{\mu} + Z_{(0.95)}\cdot\hat{\sigma}\right]$.

[c] The seasonal absorbed daily dose (SADD) represents the arithmetic mean of exposure for 8 hours, calculated from equations 2 and 3 assuming an inhalation rate of 833 L/hr (Andrews and Patterson, 2000), the measured body weights, and the average 8-hour MI air concentration.

[d] The annual absorbed daily dose (AADD) is calculated by dividing the SADD for 3 months by the 12 months in one year.

[e] The lifetime absorbed daily dose (LADD) is calculated by multiplying the AADD by 40 years working during a 75 year lifespan.

[f] The 95th percentile of 8-hour MI air concentrations.

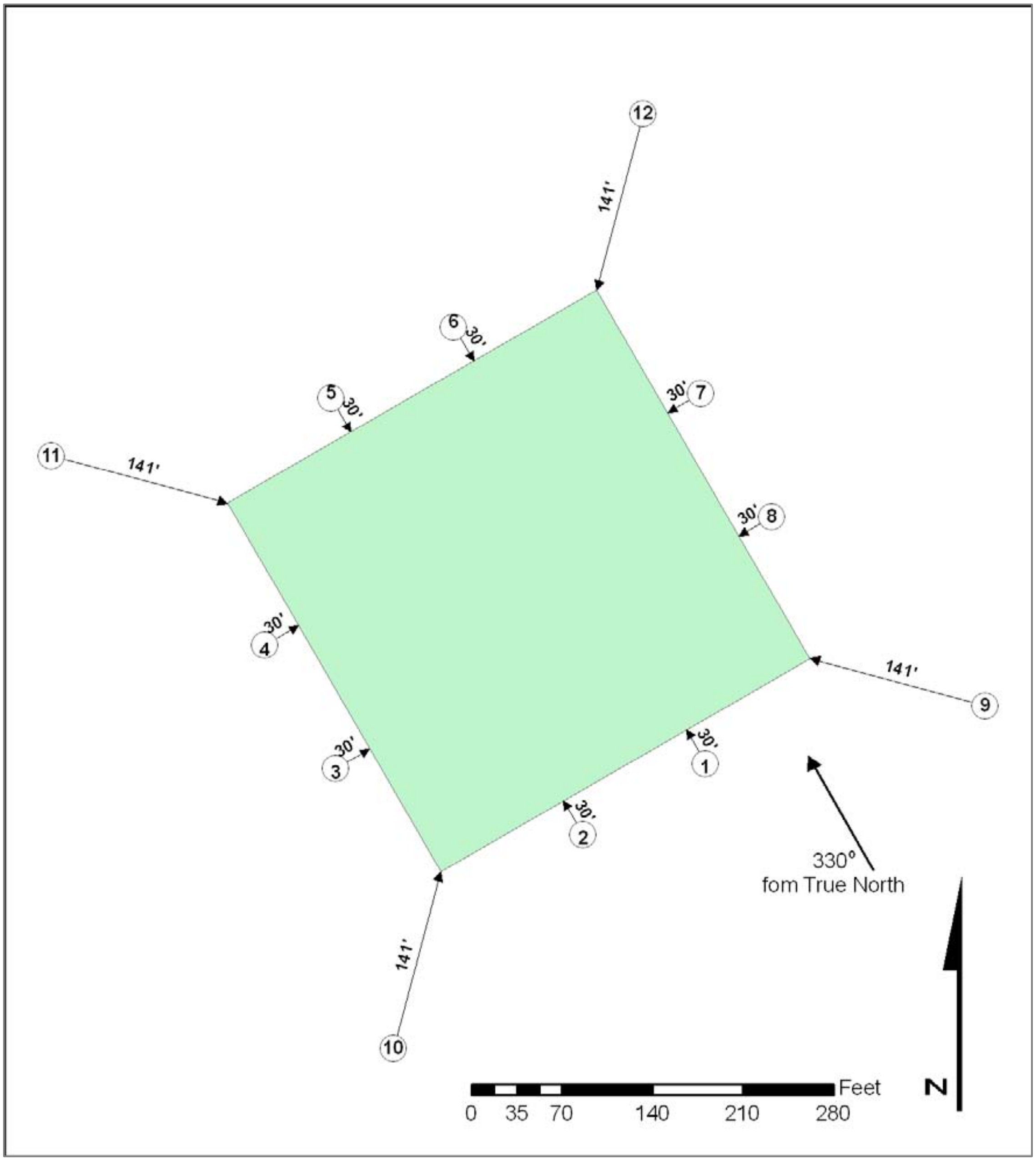
[g] Average concentration of MI in air for 8 hours.

[h] Data for shallow shank fumigation is calculated by grouping work tasks as stated on page 26.

B. Bystander Exposures (Application Site Air Monitoring Studies)

Field volatility of methyl iodide was measured in seven studies in California during a broadcast, flat fume and raised bed, tarped, shallow shank injection of methyl iodide. In addition, it was measured during a drip irrigation designed to prepare soil for growing various crops (Baker *et al.*, 2001a; Baker, 2002a; Baker *et al.*, 2002b; Baker *et al.*, 2003b; Baker *et al.*, 2003c; Baker *et al.*, 2003a; Baker *et al.*, 2004b; Baker *et al.*, 2004c; Baker *et al.*, 2003d; Baker *et al.*, 2005b). Air samples were collected for measured durations with air sample tubes placed on masts in the center and around the treated plots (Figure 5). The tubes were connected with pumps that drew air through the collection tubes at a measured rate. The analytical methods and techniques were the same as described in the worker exposure studies above. Methyl iodide residues were eluted from the collecting tubes and measured by gas chromatography/electron capture analyses. Measured levels of methyl iodide were corrected using field spikes to estimate trapping efficiency and extractability/transport stability. The studies were reviewed (Barry, 2003; Barry, 2004; Barry, 2005), and found to be adequate for estimating MI flux [loss of mass/unit area per unit time; (Sanders, 2004)] from fields associated with different types of applications.

Figure 5. A diagrammatic example of the field dimensions and sampling locations from the Camarillo drip irrigation study[a].



[a] Shaded area marks treated field. Circled numbers indicates the sampling stations with the nearest distance to the field indicated in feet.

The data collected were entered into the ISCST3 model (USEPA, 1995) to estimate the flux. The computer model uses an equation that makes the flux and the concentration directly proportional. In practice, the measured air concentrations around a particular field are taken and then the flux is back-calculated. The back-calculation procedure uses the on-site meteorology at the field and field geometry (locations of receptors or monitoring devices in relation to the field, and field dimensions) as inputs to the ISCST3 model to estimate the concentrations at the receptors (Johnson *et al.,* 1999). The estimated values are then compared to the measured values via regression analysis. The regression slope is used to adjust the flux in order to obtain a flux that, when used in the model with the geometry and meteorology at the time, gives the best estimate of the measured air concentrations.

This method is used on most site-specific monitoring studies where fumigant field applications are monitored, and there are off-site monitors ringing the field. Field geometry is also measured, and meteorological data are collected simultaneously with the monitoring data. This exposure assessment uses a screening level method to estimate air concentrations of methyl iodide by dispersion modeling (Segawa, 1997, Barry 2008a). Thus, the estimated off-site air concentrations are calculated using the flux obtained by the back calculation method together with the screening level meteorological conditions.

The meteorological conditions used for each averaging time were: 1 m/s wind speed and D stability (maximum daytime atmospheric stability) at 8 hours; and 1.44 m/s and C stability (DPR 24-hr screening meteorological conditions) at 24 hours (Segawa, 1997). The time-weighted-average (TWA) of maximum estimated methyl iodide soil flux densities at 8 hours and 24 hours are shown in Table 12, along with the application rates (Barry, 2008a). An 8-hour period corresponds to a work-day, and a 24-hour period applies to potential other bystanders who may be adjacent to treated fields for a full day.

Table 12. Time weighted average of maximum methyl iodide soil flux densities at various times from studies involving different application methods.

Application Method (DPR Data Volume)	Application Rate (lbs/Acre)[a]	8-Hour Flux (µg/m^2/s)	24-Hour Flux (µg/m^2/s)
Shallow Shank Broadcast/Tarp (52875-007)	252.0	234.2	120.9
Shank, Raised-Bed/Tarp (52875-007)	126.2	138	81.5
Shallow Shank Broadcast/Tarp (52875-026)	242.0	313.7	160.2
Shank, Raised-Bed/Tarp (52875-046)	171.1	265.6	186.4
Raised-Bed/Drip/Tarp (52875-056)	162.2	187.5	87.6
Raised-Bed/Drip/Tarp (52875-063)	118.8	153.4	81.4
Shank, Raised-Bed/Tarp (52875-064)	143.2	153.1	117.7
Raised-Bed/Drip/Tarp (52875-089)	139.0	296.1	131.1

[a] The effective broadcast application rate is found by dividing the total amount of methyl iodide applied to the field by the whole area of the field, rather than just the area treated. In the case of bedded applications, the treated area is the top of the bed only. The furrow area between the beds is untreated. The ratio of treated to untreated area will vary from field to field and depends on the bed width and the size of the furrows.

The estimated air concentrations (associated with each application method), calculated from the maximum estimated TWA MI soil flux and the standardized weather conditions, must be adjusted for the maximum broadcast application rate on the label (175 lb a.i./treated acre):

$$AC = (AC_1 * LR)/ER$$

Where: AC is the adjusted air concentration of methyl iodide in µg/m^3.
AC_1 is the air concentration calculated from the flux data.
ER is the effective broadcast application rate (lb s.i./acre).
LR is the maximum broadcast application rate on the label (lb a.i./acre).

The greatest, estimated, adjusted time-weighted average air concentrations of methyl iodide associated with different application techniques in a 40-acre field were generated from the flux estimates shown in Table 12. All of the U.S. EPA approved labels limit the use of methyl iodide in pre-plant field fumigation to 40 contiguous acres/day. The calculations used the highest flux from the studies for each of the three application types. The highest flux per application rate associated with flat fume, shank injection was from the study by Baker *et al.*, 2001 (Baker *et al.*, 2001a). The highest flux per application rate associated with raised-bed, shank injection was from the study by Baker *et al.*, 2002 and 2003 (Baker, 2002a; Baker *et al.*, 2003a). The highest flux of methyl iodide per application rate associated with drip irrigation was from the study by

Baker *et al.*, 2004 and 2005 (Baker *et al.*, 2004c; Baker *et al.*, 2005b). The estimated, maximum air concentrations of methyl iodide at 3 m, 15 m, 30 m, 91 m, and 152 m from a 40-acre treated field on the first day after treatment are given for 8 hours and 24 hours in Table 13 (Barry, 2008a).

The labels for methyl iodide carry required buffer zones for methyl iodide (USEPA, 2006; USEPA, 2007). Those legally required minimum buffer zones are in place for 48 hours after application, and no activity is allowed in that buffer zone during that period, unless that individual is wearing the appropriate PPE required for early re-entry into a treated field. Applicators wearing respiratory PPE as required for the initial application could fumigate contiguous 40-acre parcels on subsequent days wearing respiratory protection without regard to buffer zones. However, non-applicator handlers (planters, hole punchers, tarp cutters, tarp removers, and tarp remover drivers) cannot enter the buffer zones for 48 hours unless they are wearing the PPE required for early re-entry into a treated field.

Seasonal Exposure: As indicated by Figure 4, there is likely to be a seasonal exposure to MI once the fumigant is registered and used for the same pre-plant field fumigations as methyl bromide. The 24-hour TWA concentrations assume that an individual is located downwind throughout the exposure interval. For repetitive exposures over longer intervals of weeks or months, that assumption is probably not realistic. For repetitive bystander exposure estimates, concentrations are needed that reflect the reality of changing wind directions. Barry (2008b) estimated 2-week TWA concentrations to be used for estimating repetitive bystander exposures, by first calculating an average 24-hour flux over a 2 week period, then adjusting the flux with a time-scaling factor. The time-scaling factor is derived using peak-to-mean theory, based on both empirical and theoretical studies (Barry, 2008b). As bystanders can be no closer than 152 m for the first 48 hours, it was assumed that bystanders who may reside next to the treated field would be at 152 m for the entire 2-week period. The 2-week arithmetic mean air concentration of MI (averaged for all 7 air monitoring studies) was estimated to be **0.07 µg/L** (Barry, 2008b).

Table 13. Maximum, time-weighted-average first day air concentrations[a] of methyl iodide (MI) at different distances from a 40-acre fumigated field, normalized for the maximum application rate, for three different time periods.

Type of fumigation and distance	Maximum, estimated time-weighted-average MI air concentrations	
	8-hour[b] [µg/L] (ppm)	**24-hour[c] [µg/L] (ppm)**
Drip irrigation , Raised Bed		
3 m from field	19.3 (3.3)	4.2 (0.7)
15 m from field	18.0 (3.1)	3.8 (0.6)
30 m from field	16.6 (2.9)	3.2 (0.6)
91 m from field	11.9 (2.0)	2.2 (0.4)
152 m from field	9.5 (1.6)	1.7 (0.3)
Raised-Bed, Shank Injection[d]		
3 m from field	7.0 (1.2)	2.4 (0.4)
15 m from field	6.6 (1.1)	2.2 (0.4)
30 m from field	6.0 (1.0)	1.9 (0.3)
91 m from field	4.3 (0.71)	1.3 (0.2)
152 m from field	3.5 (0.6)	1.0 (0.2)
Flat-Fume Shank Injection		
3 m from field	11.7 (2.0)	2.9 (0.5)
15 m from field	10.9 (1.9)	2.6 (0.4)
30 m from field	10.0 (1.7)	2.3 (0.4)
91 m from field	7.2 (1.2)	1.5 (0.3)
152 m from field	5.8 (1.0)	1.2 (0.2)

[a] Derived from maximum flux rate data assuming 175 lb a.i./treated acre for the first day after fumigation.
[b] Assumes "D" conditions, maximum day-time atmospheric stability (Barry, 2008a).
[c] Assumes "C" conditions, atmospheric stability for 24-hours (Segawa, 1997).
[d] Derived from maximum flux rate data assuming 87.5 lb a.i./acre application rate (50% of max allowed 175 lb active ingredient/acre) to take into account 50% bed and 50% furrow.

C. Community Exposures (Ambient Air Concentrations)

As methyl iodide is not registered in California, no ambient air monitoring for methyl iodide has been conducted. Nonetheless, it is likely that the use of methyl iodide as a pre-plant, soil fumigant will lead to community-wide exposures. Such exposures are likely to eventually emulate those of the current pre-plant, soil fumigant, methyl bromide. However, application site exposures of residents to fumigants, acute and repetitive, are expected to be higher than those experienced by people living in nearby communities. The difference in proximity to a treated field between people living at the application site or living in a nearby community, makes the differences in acute exposures obvious. But, what about repetitive exposures?

For the purposes of comparison between application site exposure versus community repetitive exposures to ambient air concentrations of fumigants, methyl bromide could be considered a surrogate chemical for two reasons. First, methyl bromide and methyl iodide are similar chemically. Second, the measured air concentrations of the two chemicals from application site monitoring (24-hour TWA) and worker activities indicated comparability.

The estimated seasonal application site air concentration of methyl iodide, as stated earlier, was 0.07 µg/L. Ambient air data on methyl bromide concentrations was derived from Air Resources Board (ARB) monitoring studies conducted in 2000 (Thongsinthusak and Haskell, 2002). The highest ARB-measured community air concentration for a single day was 0.17 µg/L of methyl bromide. The highest measured community 2-week average air concentration (seasonal) was 0.046 µg/L MB. Bystanders living adjacent to application sites are considered to receive representative repetitive exposures to pre-plant field fumigants. Individuals living in nearby communities, exposed to ambient air concentrations of MI, are expected to receive exposures that are equal to or less than those of people living next to application sites.

D. Estimation of Absorbed Dose

As noted above, there are potentially two types of bystander exposures to MI. 1) Agricultural workers engaged in activities in fields adjacent to recently fumigated fields may be exposed. 2) Other bystanders near fields that have been fumigated may also be exposed.

Non-application workers may be exposed to MI from previously treated fields for the duration of their 8-hour workday. Other bystander exposures are not limited to exposures of 8-hour duration, as this may include residents who might be present in their homes for a full 24-hour period. All bystanders must be outside the 152 m label-approved buffer zone for the first 48 hours after a field has been fumigated unless they are equipped with label-approved PPE.

An absorbed daily dosage (ADD) refers to the estimated absorbed dose from performing a given activity for the indicated period of time, up to 24 hours. The body weights and inhalation rates of both genders were averaged to obtain a single value for each age group presented in Table 14. In the case of adult bystanders near application sites, the ADDs associated with a duration of exposure were calculated using Equations 2 and 3, the maximum air concentration of methyl iodide at 152 m (Table 13), and assumes a body weight of 71.8 kg, with an inhalation rate of

0.83 m^3/hr (Table 14). In the absence of data, the default inhalation retention/absorption of methyl iodide is assumed to be 100%.

A seasonal average daily dose (SADD) refers to an absorbed daily dosage greater than one week (short-term) but less than one year (annual). The maximum size field that can be treated is 40 acres, so the repetitive bystander exposures were estimated assuming the individuals were near a 40-acre field. Calculations used Equations 2 and 3 with the estimated 2-week average methyl iodide air concentration (0.07 µg/L at the edge of the buffer zone) multiplied by the inhalation rate, the duration of exposure, and divided by body weight. Again, the default inhalation retention/absorption of methyl iodide was assumed to be 100%.

Table 14. Default human inhalation rates and body weights for different aged individuals.

Age[a] (years)	Hourly Inhalation Rate[b] (m^3/hr)	Median Body Weight[b] (kg)
< 1	0.19	8
1-2	0.28	13
3-5	0.35	18
6-8	0.42	26
9-11	0.56	36
12-14	0.56	50
15-18	0.60	61
Adult	0.83	71.8

[a] Both genders are represented within each age group·
[b] Default values based on data from Layton, 1993 (Layton, 1993; Andrews and Patterson, 2000), averaged for both genders within each age group. These default values were used in the calculation of absorbed dosages of methyl iodide.

The estimated absorbed dosages of methyl iodide for non-applicator bystander workers engaged in agricultural practices in fields adjacent to previously fumigated fields are given in Table 15. Non-applicator workers were assumed to have the potential for repetitive, seasonal exposure to air levels of methyl iodide from treated fields.

Table 15. Estimated absorbed dosages of methyl iodide for bystander workers exposed to daily and seasonal air concentrations of methyl iodide at the 152 m buffer zone from different types of application sites.

Application Method	8-Hour ADD[a] (µg/kg-day)	SADD[b] (µg/kg-day)
Tarped		
Drip Irrigation, Raised Bed/40 acres	882	19
Raised-Bed, Shank Injection/40 acres	325	19
Flat-Fume Shank Injection/40 acres	538	19

[a] The 8-hour absorbed daily dose (ADD) for worker bystanders was calculated using Equations 2 and 3, the maximum air concentration of methyl iodide at the 152 m buffer zone (Table 13), assuming a body weight of 71.8 kg, an inhalation rate of 0.83 m^3/hr (Table 14) for 8 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

[b] The seasonal absorbed daily dose (SADD) for worker bystanders was calculated using Equations 2 and 3, the 2-week average air concentration of methyl iodide (0.07 µg/L) at 152 m (Barry, 2008b), assuming a body weight of 71.8 kg, an inhalation rate of 0.83 m^3/hr for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

Average and 24-hour acute application site air concentrations of methyl iodide at the edge of the buffer zone are assumed to be greater than those measured in communities. Consequently, families living on the farm are likely to receive acute exposures and seasonal exposures that are greater than those in local communities. The estimated absorbed dosages of methyl iodide for other bystanders (adults and children) who may be adjacent to fields undergoing pre-plant field fumigation for up to 24 hours are given in Tables 16-19.

Table 16. Estimated absorbed dosages of methyl iodide for non-worker bystander adults, and other bystander adults exposed to daily and seasonal air concentrations of methyl iodide at the 152 m buffer zone from different types of application sites.

Application Method	24-Hour ADD[a] (µg/kg-day)	SADD[b] (µg/kg-day)
Tarped		
Drip Irrigation, Raised Bed/ 40 acres	473	19
Raised-Bed, Shank Injection/ 40 acres	278	19
Flat-Fume Shank Injection/ 40 acres	334	19

.

[a] The 24-hour absorbed daily dose (ADD) for bystanders was calculated using Equations 2 and 3, the maximum air concentration of methyl iodide at the 152 m buffer zone (Table 13), assuming a body weight of 71.8 kg, an inhalation rate of 0.83 m^3/hr (Table 14) for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

[b] The seasonal absorbed daily dose (SADD) for bystanders was calculated using Equations 2 and 3, the 2-week average air concentration of methyl iodide (0.07 µg/L) at 152 m (Barry, 2008b), assuming a body weight of 71.8 kg, an inhalation rate of 0.83 m^3/hr for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

Table 17. Estimated absorbed dosages of methyl iodide for bystander children (3-5 yr) exposed to daily and seasonal air concentrations of methyl iodide at the 152 m buffer zone from different types of application sites.

Application Method	24-Hour ADD[a] (µg/kg-day)	SADD[b] (µg/kg-day)
Tarped		
Drip Irrigation, Raised Bed/ 40 acres	793	33
Raised-Bed, Shank Injection/ 40 acres	467	33
Flat-Fume Shank Injection/ 40 acres	560	33

.

[a] The 24-hour absorbed daily dose (ADD) for bystander children (3-5yrs) was calculated using Equations 2 and 3, the maximum air concentration of methyl iodide at the 152 m buffer zone (Table 13), assuming a body weight of 18 kg, an inhalation rate of 0.35 m^3/hr (Table 14) for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

[b] The seasonal absorbed daily dose (SADD) for bystander children (3-5yrs) was calculated using Equations 2 and 3, the 2-week average air concentration of methyl iodide (0.07 µg/L) at 152 m (Barry, 2008b), assuming a body weight of 18 kg, an inhalation rate of 0.35 m^3/hr for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

Table 18. Estimated absorbed dosages of methyl iodide for bystander infants (<1 yr) exposed to daily and seasonal air concentrations of methyl iodide at the 152 m buffer zone from different types of application sites.

Application Method	24-Hour ADD[a] (µg/kg-day)	SADD[b] (µg/kg-day)
Tarped		
Drip Irrigation, Raised Bed/ 40 acres	969	40
Raised-Bed, Shank Injection/ 40 acres	570	40
Flat-Fume Shank Injection/ 40 acres	684	40

[a] The 24-hour absorbed daily dose (ADD) for bystander infants (<1 yr) was calculated using Equations 2 and 3, the maximum air concentration of methyl iodide at the 152 m buffer zone (Table 13), assuming a body weight of 8 kg, an inhalation rate of 0.19 m^3/hr (Table 14) for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

[b] The seasonal absorbed daily dose (SADD) for bystander infants (<1 yr) was calculated using Equations 2 and 3, the 2-week average air concentration of methyl iodide (0.07 µg/L) at 152 m (Barry, 2008b), assuming a body weight of 8 kg, an inhalation rate of 0.19 m^3/hr for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

Once MI is registered, and comes into general use, people residing on farms and in communities near farms where pre-plant field fumigation is utilized are likely to be exposed to air levels of methyl iodide for up to 3 months each year (Figure 4). If it is assumed that the 2-week average air concentration of MI at the edge of the buffer zone would persist for the 3-month period, annual exposures may be estimated by amortizing the seasonal exposure (90 days) over the entire year (365 days) (Table 19).

Table 19. Daily, seasonal, annual and lifetime estimated absorbed dosages of methyl iodide for bystanders and residents adjacent to fields treated with methyl iodide as a pre-plant field fumigant.

Individual	ADD[a] (µg/kg-day)	SADD[b] (µg/kg-day)	AADD[c] (µg/kg-day)	LADD[d] (µg/kg-day)
Adult	473	19	5	5
Child (3-5 yrs)	793	33	8	NA
Infant < 1 yr	969	40	10	NA

[a] The 24-hour absorbed daily dose (ADD) for different age bystanders was calculated using Equations 2 and 3, the 95th percentile of 24-hour methyl iodide air concentration at 152 m from a drip-irrigated field (Table 13), assuming body weights, inhalation rates consistent with the individual ages (Table 14) for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

[b] The seasonal absorbed daily dose (SADD) for different age bystanders was calculated using Equations 2 and 3, the 2-week average air concentration of methyl iodide (0.07 µg/L) at 152 m (Barry, 2008b), assuming body weights, inhalation rates consistent with the individual ages for 24 hours, and 100% retention/absorption of methyl iodide through the inhalation route.

[c] The annual absorbed daily dose (AADD) for different age bystanders was calculated by taking the SADD, multiplying by 90 days/year, and dividing by 365 days/year.

[d] The lifetime absorbed daily dose (LADD) is for a lifetime of exposure, but it is not applicable (NA) to either infants or children.

III. EXPOSURE APPRAISAL

An exposure appraisal section contains information regarding the quality of the available exposure studies, the adequacy of submitted reports, and areas of uncertainty that occur in the estimation of human exposure. Thus, the reader can gain a better understanding of the limitations on the accuracy of the estimated numbers used to represent potential human exposure to pesticides. A comparison of DPR's methods with USEPA's approach to estimating exposures to methyl iodide is provided in Appendix III.

A. Physiological Assumptions

A published study reported that the inhalation retention/absorption of methyl iodide in human subjects varied between 53% and 92% (Morgan and Morgan, 1967). As the study also indicated the retention/absorption of MI can vary widely between individuals at rest or working, a default factor of 100% was used (Frank, 2008). It should be noted, though, that the absorption/retention of methyl bromide, which is chemically similar to methyl iodide, has been shown to be 52-54% in humans (Raabe, 1988), 40% in dogs (Raabe, 1986), and 48% in rats (Medinsky *et al.*, 1984). Thus, the dose estimated to be absorbed/retained through the inhalation route may be less than the assumed value.

Generic single value breathing rates and body weights representing the central tendency of the data were used in calculating bystander exposures (USEPA, 1997; Andrews and Patterson, 2000). Such generic assumptions, though reasonable, contribute to the uncertainties in estimating the amount of chemical absorbed through the respiratory route by individuals.

The inhalation route is not the only possible route of exposure to pesticide vapors. Pesticide vapors come in contact with the skin. However, as noted earlier in the text, no dermal absorption studies have been submitted to DPR. Consequently, the amount of methyl iodide absorbed through the dermal route cannot be quantified accurately. In the case of MI air concentrations associated with pre-plant field fumigation, the contribution of MI taken in by the dermal to the total absorbed dose is probably negligible, as the theoretical calculation indicated dermal absorption would only add 0.01% to the total absorbed dose.

B. Analytical Assumptions

It was assumed that the variability in collecting, storing, transporting, and analyzing samples was controlled by normalizing against field spike data. However, any monitoring technique for environmental chemicals will produce uncertainty in the estimates of air concentrations of a chemical. The variability in analytical estimates can be attributed to variability in assay technique, sample capture, storage stability, and sample elution efficiency. Comparison of field spike analyses with laboratory spike analyses provides an indication of this uncertainty. Intra- and inter-assay variability in any analytical technique used to measure environmental samples can routinely run 15% (Cochran *et al.*, 1979; Cochran, 1987).

C. Estimation of Application Site Air Concentrations

The direct sampling method for estimating application site air concentrations was not used because there are several uncertainties associated with the use of the method that limit its utility. First, air concentrations of methyl iodide were measured by fixed samplers that were positioned at various locations around the treated area (both downwind and upwind, as well as at points in between). Air concentrations of fumigants are highest in the predominant downwind direction because the fumigant plume will be pushed by the wind in that direction. Concentrations of fumigant upwind tend to be low, or close to zero, as a plume will be pushed by the wind in the opposite direction. Thus, there can be a very large difference between upwind and downwind air concentrations of a fumigant. In areas where there is a predominant wind direction, averaging of the air concentrations from these various samplers is not appropriate as persons around treated areas will generally be in one location relative to the wind. Consequently, they will not be exposed to an average of these concentrations. Second, samplers were positioned at specific distances from the treated area, and the measured concentrations represent air concentrations only at those distances. As air concentrations change as a function of downwind distance, the air concentrations estimated from direct measures represent a very narrow range of the possible levels to which people can be exposed. Finally, the measured air concentrations represent only those for the conditions under which the studies were carried out. Air concentrations around treated fields, buildings, or other areas are influenced by a number of factors including how a chemical is applied, application rates, techniques designed to control emissions (e.g., tarps), and weather conditions. Varying weather conditions, for example, can significantly change the air concentrations at specific sites around a treated area. As there is a large range of potential weather conditions that can exist, it is not possible for these studies to represent the entire range of potential exposures that can result from different weather conditions.

Screening level modeling with the ISCST3 model produces reasonable worst case estimates of air concentrations and resulting risks for a number of reasons. First, only downwind center-line air concentrations expected under reasonable worst case meteorological conditions for a particular averaging time scenario are considered. Thus, the screening level air concentrations estimated by the ISCST3 model would be found in the upper percentiles of air concentration distributions obtained from using historical weather data. However, the model does allow for estimation of air concentrations that reflect different conditions based on changing factors- such as application rate, field size, downwind distances, and weather conditions. These factors cannot be taken into account by using monitoring data alone. Consequently, the ISCST3 screening level results should be considered to represent potential exposures to the most highly exposed, upper percentile of the population. However, those results are not representative of exposures to most of the population situated around a treated field.

When all other factors are held constant, the ISCST3 model uses an equation that makes the flux and the concentrations directly proportional. A number of factors may affect the flux of methyl iodide from the fields where it has been applied. These factors contribute to the uncertainty in the estimates of the air concentrations near application sites. *Soil*. Field study results for other fumigants support the use of water applications to suppress flux by increasing soil moisture. Flux may also be a function of soil textures and temperatures. However, DPR does not have studies that adequately quantify the magnitude of the effect of those factors. *Farming Technique.* Generally, tarped soil shows lower flux than untarped soil. However, the magnitude of this effect depends on both the fumigant and the type of tarp used. Field study results indicate that tarped raised-bed applications show higher flux than tarped broadcast applications. Sometimes additives are used to fertilize the soil during drip irrigation applications. These additives may interact with the fumigant to change the fumigant flux.

Another area of uncertainty concerns the relationship between flux, concentration and *meteorological conditions.* Flux is usually lower at night. However, several field studies demonstrate that for some fumigants and/or application methods the highest flux occurs at night. Regardless of the magnitude of flux, air concentrations tend to be highest at night due to the very stable atmospheric conditions that are characteristic of nighttime hours. Thus, nightime flux may result in very high air concentrations even though that night flux appears to be relatively small in magnitude compared to daytime flux values. Atmospheric stability in this case refers to the degree of vertical atmospheric mixing. Atmospheric conditions during the day tend to be much less stable relative to night conditions. Vertical mixing during the day is increased due to heating of the earth’s surface. Any pollutants in the air are diluted as they are mixed upward into clean air. This leads to generally lower air concentrations of MI during the day.

Air dispersion modeling defines night as the period from one hour before sunset to one hour after sunrise. Atmospheric conditions during night tend to be stable to very stable (cold, dense air near the soil: warmer, lighter air at greater heights, little or no vertical mixing). Calm winds are associated with stable atmospheric conditions at night. Inversion conditions may also (but not always) be present. Under calm wind conditions, there is little or no horizontal (cross-wind) spreading of a pollutant plume. Pollutant plumes tend to stay intact and concentrated for great distances beyond the source edge when there is little vertical or horizontal dilution of the pollutant plume under these calm wind and stable atmospheric conditions,. Thus, even if flux is lowest at night, nighttime stable conditions can lead to very high air concentrations. The location of the highest off-site air concentrations is uncertain because the crosswind direction movement of the pollutant plume under calm winds is erratic and unpredictable. These factors cause air concentrations associated with fumigants to be highest at night. Several large residential fumigant exposure incidents have occurred under nightime conditions, particularly at or shortly after sunset.

Finally, air concentration is proportional to flux in the Gaussian plume model. DPR also assumes that flux is proportional to application rate but that flux does not vary with application size (Segawa, 1997). These assumptions together permit the use of the ISCST3 model to estimate off-site air concentrations for application sizes other that those directly monitored.

D. Occupational Exposures

The activities of the workers involved in the experimental studies were assumed to be typical activities associated with the application techniques. In one case, there was the unexpected circumstance of an equipment failure that led to a much greater exposure of some of the handlers. This introduced a substantial amount of variability, and led to higher upper-bound estimates of acute exposure. However, equipment failure of that nature is a probable, even if infrequent, occurrence. Consequently, it is appropriate to use acute exposure estimates that include the potential episodes of equipment problems. None-the-less, for those handlers that do not experience equipment failures, exposures will be substantially less.

In each of the studies, the number of acres treated (2.5) was approximately 1/10 of a typical day's fumigation efforts (Thongsinthusak and Haskell, 2002). In the absence of chemical specific data, a linear relationship between the number of acres treated and worker exposure was assumed. Such an assumption contributes to the uncertainty of the exposure estimate. Current pesticide handler activities associated with pre-plant field fumigation involving methyl bromide are limited by regulations and permit conditions (CCR, 2004). Such limitations on activities and duration of exposure, if applied to methyl iodide use, would likely reduce handler exposures.

The general problem of gauging the long-term (annual) risks of intermittent exposure to toxic chemicals was addressed in a symposium conducted by U.S. EPA (USEPA, 1998). The participants generally agreed that the toxicological databases for chemicals are not adequate to fully deal with estimating the long-term risks of intermittent exposures. However, two factors appear to be paramount in deciding whether there will be any long-term effects of intermittent dosing. First, if the biological half-life of the toxic chemical in the body is greater than the intervening time between doses, then chemical accumulation may result in damage. As the half-life of methyl iodide in laboratory animals is less than 48 hours (Sved, 2002), it is unlikely methyl iodide will accumulate on a chronic (annual) basis in the body. The second consideration is irreparable damage, occurring as a result of an initial dose that may carry over to the next dose. There are oncogenicity concerns associated with the toxicity of methyl iodide. Oncogenicity may result from cumulative tissue damage. As it is the absorbed dose that may result in permanent damage, the amortization of the short-term absorbed dose over the rest of the year may be appropriate. Nonetheless, the intermittent nature of long-term exposure to MI contributes to the uncertainty in estimating the effective dose.

E. Bystander Exposures

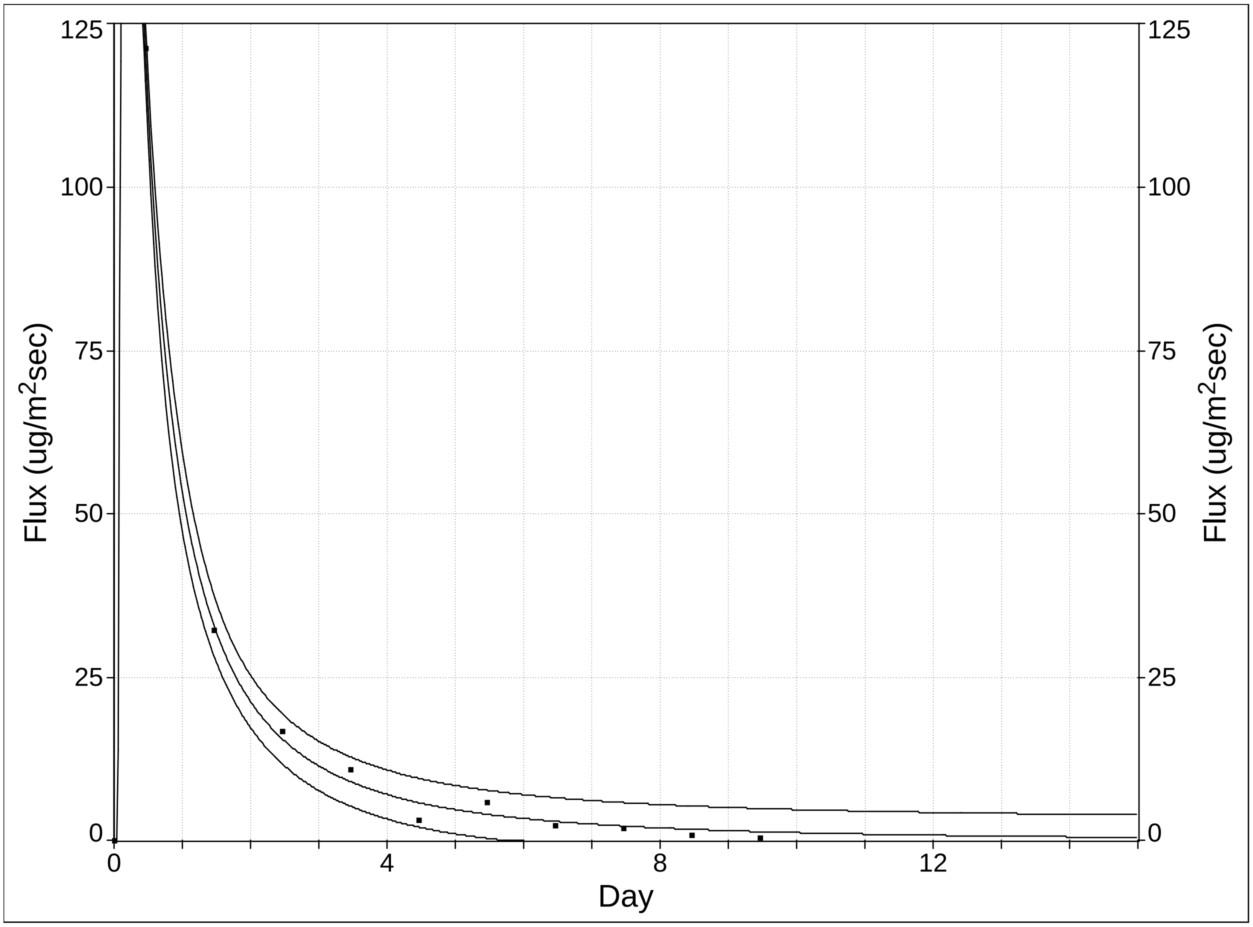
Acute Exposures: In most versions of an exposure assessment for airborne pesticides, a simplified exposure scenario is used, being termed "reasonable worst case". That scenario implicitly assumes that individuals stay at a site with the highest measured air concentration of MI for up to 24 hours. However, the California Air Resources Board has conducted a study that indicates that peoples' activity patterns are more complicated (Phillips *et al.*, 1991; Jenkins *et al.*, 1992). This may cause estimates of bystander exposure to be exaggerated for those individuals who do not remain continuously at that location. Also, it is assumed that the indoor/outdoor air concentrations of methyl iodide are not different. In some instances, though, indoor and outdoor air concentrations of contaminants can be different when the source of the chemical is from outdoors (Sheldon *et al.*, 1992). An example of such a difference comes from a study in which both the indoor and outdoor air concentrations of a phosphorothioate insecticide, malathion, were monitored during an outdoor spraying program (Segawa *et al.*, 1991). That study indicated that in more than 30 homes, the indoor air concentrations of malathion was only an average of 25% of the measured outdoor concentrations in the same areas. However, in the absence of chemical specific data, no quantitative adjustments in the indoor air concentrations of MI can be made. Further, even if there were chemical specific data, there are no regulations that require homes to be closed during and immediately after pesticide applications. Consequently, DPR cannot assume that the homes would remain closed. Because the homes can be open, the health protective assumption is that no differences exist between indoor and outdoor air concentrations of MI.

In the case of worker bystanders, the air concentrations of MI at the edge of the label-required buffer zone (152 m) were used to estimate exposures. As air concentrations of MI vary, and workers will not always be at the edge of the buffer zone for the duration of their work activities, the exposure values calculated represent a worst-case scenario.

Repetitive Exposures: Repetitive exposures were estimated because the use-pattern of a chemically similar pre-plant field fumigant (methyl bromide) indicated at least a 3-month use season (Figure 4). However, those data also indicated that fields are likely to be fumigated only once per year. As bystanders living adjacent to fumigated fields seemed likely to receive the highest repetitive exposures, a 2-week average air concentration (0.07 µg/L) was used to simulate seasonal exposure of these individuals. However, virtually all of the MI is gone from treated fields by day four (Figure 6), and the 2-week average air concentration of MI represents averaging the initial few days of high concentrations with the remaining days of non-detectable levels of MI. Consequently, it is not surprising that the 2-week average application site air concentration (0.07 µg MI/L) was approximately the same as the highest 2-week average ambient air concentration of methyl bromide (0.046 µg MB/L) measured by the ARB (Thongsinthusak and Haskell, 2002).

In order to generate an LADD, it was assumed that a resident bystander would live in a home adjacent to the field for 70 years. However, this assumption may lead to an overestimate of exposure to a resident, as the average stay at a given residence in California was calculated to be 7 years (Liu *et al.*, 1993). The use of an LADD to approximate lifetime exposure from intermittent doses of a chemical may either underestimate or overestimate exposure to varying degrees according to several authors (Murdoch *et al.*, 1992; Murdoch and Krewski, 1988; Kodell *et al.*, 1987).

Figure 6. Average methyl iodide flux over the course of two weeks from fields treated by shank injection or drip irrigation [a].



[a] Barry, 2008b

IV. REFERENCES

ACGIH 1986. *Documentation of the threshold limit values and biological exposure indices*. 5th ed. Cincinnati, OH: American Conference of Governmental and Industrial Hygienists.

AER. 2000. Estimates of the atmospheric lifetime, global warming potential and ozone depletion potential of iodomethane (CH_3I). Atmospheric and Environmental Research Inc MRID 45593712. (DPR Vol. No. 52875-009 Record No. 185660).

Andrews, C., and Patterson, G. 2000. Interim guidance for selecting default inhalation rates for children and adults HSM-00010 Sacramento, CA Worker Health and Safety and Medical Toxicology Branches, Department of Pesticide Regulation, California Environmental Protection Agency.

Aryesta. 2000. Estimates of the atmospheric lifetime, global warming potential, and ozone depletion potential of iodomethane (CH_3I). (DPR Vol. No. 52875-029 Record No. 185660).

Aryesta. 2002. Henry's Law Constant. (DPR Vol. No. 52875-036 Record No. 200878).

Baker, F., Estigoy, L., Gillis, M., and Belcher, T. 2001a. Environmental (off-site) monitoring and direct flux/indirect flux determination of iodomethane (TM-425) under field conditions. PTRL Report No. 975W-1. (DPR Vol. No. 52875-026 Record No. 185705).

Baker, F. C., Estigoy, L., and Belcher, T. I. 2001b. Worker and applicator exposure under field conditions during application of the fumigant iodomethane (TM-425). PTRL West Inc. Report No. 974W-1. (DPR Vol. No. 52875-0025 Record No. 185703).

Baker, F. C., Estigoy, L., Reiss, R., Nelson, M. D., and Bolda, M. 2002a. Volatility of iodomethane (TM-425) under field conditions in California and Florida. PTRL Report #893-W1. (DPR Vol. No. 52875-007 Record No. 185658).

Baker, F. C., Estigoy, L., and Belcher, T.I. 2002b. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions. PTRL Report #11420-W. MRID 45879101. (DPR Vol. No. 52875-046 Record No. 204110.).

Baker, F. C., Estigoy, L., and Belcher, T. I. 2003a. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions. PTRL Report #1142-1. (DPR Vol. No. 52875-046 Record No. 204110).

Baker, F. C., Estigoy, L., and Belcher, T. I. 2003b. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions following tarped/raised bed/drip irrigation application. PTRL Report #1198W-1. (DPR Vol. No. 52875-056 Record No. 209311).

Baker, F. C., Estigoy, L., and Belcher, T. I. 2003c. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions following tarped/raised bed/drip irrigation application, amended. PTRL Report #1198W and 1198W-1. (DPR Vol. No. 52875-074 Record No. 215556).

Baker, F. C., Hiler, R. L., and Belcher, T. I. 2003d. Worker and applicator exposure under field conditions during drip irrigation application of the fumigant iodomethane. PTRL West Inc. Report No. 1197W. (DPR Vol. No. 52875-0055 Record No. 209310).

Baker, F. C., Hiler, R. L., and Belcher, T. I. 2003e. Worker and applicator exposure under field conditions during tarped/raised bed/shank injection application of the fumigant iodomethane. PTRL West Inc. Report No. 1140W-1. (DPR Vol. No. 52875-0047, Record No. 204111).

Baker, F., Hiler, R.L., and Belcher, T. 2004. Worker and applicator exposure under field conditions during tarped/raised bed/drip irrigation application of the fumigant iodomethane (TM425). PTRL West Inc. Study Project No. 1255W. (DPR Vol. No. 52875-0065 Record No. 214833).

Baker, F., Hiler, R. L., and Belcher, T. 2004a. Worker and applicator exposure under field conditions during tarped/raised bed/ shallow shank injection application. PTRL West Inc. Study Project No. 1253W. (DPR Vol. No. 52875-0064 Record No. 204111).

Baker, F. C., Estigoy, L., and Belcher, T. I. 2004b. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions following tarped/raised bed/shallow shank injection application. PTRL Report #1254W-1. (DPR Vol. No. 52875-064 Record No. 214832).

Baker, F. C., Estigoy, L., Belcher, T. I., and Lange, B. 2004c. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions following tarped/raised bed/drip irrigation application. PTRL Report #1315W-1. (DPR Vol. No. 52875-089 Record No. 214831).

Baker, F. C., Hiler, R., Estigoy, L., and Belcher, T. I. 2004d. Environmental (off-site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions following tarped/raised bed/drip irrigation application. PTRL Report #1256W-1. (DPR Vol. No. 52875-063 Record No. 214831).

Baker, F., Hiler, R. L., and Lange, B. 2005a. Worker and applicator exposure under field conditions during tarped/raised bed/drip irrigation application of the fumigant iodomethane (TM-425). PTRL Report No. 1314W-1. (DPR Vol. No. 52875-0090, Record No. 216498).

Baker, F. C., Estigoy, L., Hiler, R. L., and Lange, B. 2005b. Environmental (Off-Site) monitoring and indirect flux determination of iodomethane (TM-425) under field conditions following tarped/raised bed/drip irrigation application. PTRL West Inc. Study Project No. 1315W-1. (DPR Vol. No. 52875-0089 Record No. 216495).

Barry, T. 2003. Review of iodomethane I.D. NO. CR-192893-N: Data volumes 52875-007 and 52875-026. Memorandum to K.S. Goh, Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. 95812, dated March 14, 2003.

Barry, T. 2004. Review of iodomethane I.D. No. CR-192892-N: Data Volume 52875-051. rro0409.pdf. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. 95812.

Barry, T. 2005. Review of iodomethane I.D. NO. CR-192892-N: Data Volumes 52875-046; -049; -056/074; -063; -064; -089. Document rro0506.pdf. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. 95812.

Barry, T. 2008a. Screening level air concentration estimates for Worker Health and Safety Exposure Appraisals. Memorandum to Randy Segawa dated August 21, 2008. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA.

Barry, T. 2008b. Development of sub-chronic air concentration estimates associated with a single fumigant application. Sacramento, CA: Environmental Monitoring, Department of Pesticide Regulation, California Environmental Protection Agency.

Barry, T., and Johnson, B. 2008. Analysis of the relationship between percentiles of the whole field buffer zone distribution and the maximum direction buffer zone distribution. Sacramento, CA.

Bonnette, K. L. 2001a. A dermal sensitization study in Guinea Pigs with iodomethane (TM-425). SLI Study No. 3527.7 (DPR Vol. No. 52875-016 Record No. 185691).

Bonnette, K. L. 2001b. A primary eye irritation study in rabbits with iodomethane (TM-425). SLI Study No. 3527.5 (DPR Vol. No. 52875-016 Record No. 185689).

Bonnette, K. L. 2001c. A primary skin irritation study in rabbits with iodomethane (TM-425). SLI Study No. 3527.6 (DPR Vol. No. 52875-016 Record No. 185690).

Brookman, J. J., and Curry, K. K. 2002a. Product properties Group B TM425-02. MRID 45593704. (DPR Vol. No. 52875-004 Record No. 185651).

Brookman, J. J., and Curry, K. K. 2002b. Product properties Group B TM425-03. MRID 45594102 (DPR Vol. No. 52875-004 Record No. 185712).

Budavari, S., O'Neil, M. J., Smith, A., Heckelman, P. E., and Kinneary, J. F., Eds. 1996. *The Merck Index. An Encyclopedia of Chemicals, Drugs, and Biologicals*. 12 ed. Whitehouse Station, NJ: Merck Research Laboratories, Merck & Co., Inc.

CCR 2004. California Code of Regulations. Division 6. Pesticides and Pest Control Operations. Chapter 3. Pest Control Operations. Subchapter 3. Pesticide Worker Safety. Article 4. Fumigation. Section 6784. Field Fumigation.

Cochran, R. C. 1987. Serum androgens during the annual reproductive cycle of the male mummichog, Fundulus heteroclitus. *Gen Comp Endocrinol* 65:141-148.

Cochran, R. C., Darney, K. J., Jr., and Ewing, L. L. 1979. Measurement of testosterone with a high-performance liquid chromatograph equipped with a flow-through ultraviolet spectrophotometer. *J Chromatogr* 173:349-355.

Donahue, J. 1996. Revised policy on dermal absorption default for pesticides. HSM-96005. Sacramento, CA: Worker Health and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency.

Frank, J. P. 2008. Default Inhalation Retention/Absorption Values to be used for Estimating Exposure to Airborne Pesticides. HSM 08011. Worker Helath and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency. September 18, 2008. http://www.cdpr.ca.gov/docs/whs/memo/hsm08011.pdf.

Frank, J. 2009. Method for Calculating Short-Term Exposure Estimates. HSM-09004. Sacramento, CA: Worker Health & Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency. February 13, 2009. http://www.cdpr.ca.gov/docs/whs/memo/hsm09004.pdf

Gannon, S. A. 2004. Iodomethane: *In vitro* partition coefficients in rat and rabbit tissues and human blood. DuPont Project #15617. (DPR Vol. No. 52875-0079 Record No. 216073).

Hahn, G. J., and Meeker, W. Q. 1991. *Statistical Intervals: A Guide for Practitioners*. New York: John Wiley & Sons, Inc.

Helsel, D. R. 2005. *Nondetects and Data Analysis: Statistics for Censored Environmental Data*. Hoboken, NJ: John Wiley & Sons, Inc.

Huey, M. A., Materna, B.L. . 2002. Air Sampling. In *Fundamentals of Industrial Hygiene, 5th Edition*, edited by B. A. . Plog, and Quinlan, P.J. : National Safety Council Press, pp. 526.

Jenkins, P., Phillips, T., Mulberg, E., and Hui, S. 1992. Activity patterns of Californians: Use of and proximity to indoor pollutant sources. *Atmospheric Environment* 26A(12):2141-2148.

Johnson, B., T. Barry, and P. Wofford. 1999. Workbook for Gaussian modeling analysis of air concentration measurements. Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, California. EH99-03.

Kodell, R., D. Gaylor, and J. Chen, 1987. Using average lifetime dose rate for intermittent exposures to carcinogens. *Risk Anal*. 7:339-345.

Layton, D. W. 1993. Metabolically consistent breathing rates for use in dose assessments. *Health Phys* 64:23-36.

Leo, A., Hansch, C., and Elkins, D. 1971. Partition coefficients and their uses. *Chem. Rev*. 71:525-616.

Liu, K, Y. Chang, S.B. Hayward, A.J. Gadgil, and A.V. Nero, 1993. The distribution of lifetime cumulative exposures to radon for California residents. *J. Exposure Anal. Environ. Epidem*. 3:165-179.

Loizou, G. D., Jones, K., Akrill, P., Dyne, D., and Cocker, J. 1998. Estimation of the dermal absorption of m-xylene vapor in humans using breath sampling and physiologically based pharmacokinetic analysis. *Toxicol. Sci.* 48:170-179.

Mattie, D. R., Bates Jr., G. D., Jepson, G. W., Fisher, J. W., and McDougal, J. N. 1994. Determination of skin:air partition coefficients for volatile chemicals: experimental method and applications. *Fund. Appl. Toxicol.* 22:51-57.

McDougal, J. N., Jepson, G. W., Clewell III, H. J., and Andersen, M. E. 1985. Dermal absorption of dihalomethane vapors. *Toxicol. Appl. Pharm.* 79:150-158.

McDougal, J. N., Jepson, G. W., Clewell III, H. J., MacNaughton, M. G., and Andersen, M. E. 1986. A physiological pharmacokinetic model for dermal absorption of vapors in the rat. *Toxicol. Appl. Pharm.* 85:286-294.

McDougal, J. N., Jepson, G. W., Clewell III, H. J., Gargas, M. L., and Andersen, M. E. 1990. Dermal absorption of organic chemical vapors in rats and humans. *Fund. Appl. Toxicol.* 14:299-308.

McFadden, J. J., and Landphair, C. R. 2001. Adsorption and desorption of [^{14}C]-iodomethane (TM-425) on five soils. Project ID 013136. MRID 45593709. (DPR Vol. No. 52875-006 Record No. 185657).

Medinsky, M. A., Dutcher, J. S., Bond, J. A., Henderson, R. F., Mauderly, J. L., Snipes, M. B., Mewhinney, J. A., Cheng, Y. S., and Birnbaum, L. S. 1984. Uptake and excretion of [^{14}C]-methyl bromide as influenced by exposure concentration. *Toxicol. Appl. Pharmacol.* 78:215-225.

Meister, R. T. 2004. *Crop Protection Handbook*. Willoughby, OH: Meister Publishing Company.

Morgan, D. J., and Morgan, A. 1967. Studies on the retention and metabolism of inhaled methyl iodide- I. Retention of inhaled methyl iodide. *Health Physics* 13:1055-1065.

Murdoch, D.J., and D. Krewski, 1988. Carcinogenic risk assessment with time-dependent exposure patterns. *Risk Anal.* 8:521-530.

Murdoch, D.J., D. Krewski, and J. Wargo, 1992. Cancer risk assessment with intermittent exposure. *Risk Anal.* 12:569-577.

NIOSH 1987. Respirator Decision Logic. (National Institute for Occupational Safety and Health, Ed.). National Institute for Occupational Safety and Health.

Ohr, H. D., Sims, J. J., Grech, N. M., Becker, J. O., and McGriffen, M. E. 1996. Methyl iodide, an ozone-safe alternative to methyl bromide as a soil fumigant. *Plant Dis.* 80(7):731-735.

Phillips, T. J., Jenkins, P. L., and Mulberg, E. J. 1991. Children in California: Activity patterns and presence of pollutant sources. California Resources Board, Sacramento, CA.

Raabe, O. G. 1986. Inhalation uptake of selected chemical vapors at trace levels. Report to the Calif. Air Res. Bd., CARB Contract #A3-132-33. Sacramento, CA.

Raabe, O. G. 1988. Retention and metabolism of toxics. Inhalation uptake of xenobiotic vapors by people. The Biological Effects Research Section, California Air Resources Board. CARB Contract No. A5-155-33. Sacramento, CA.

Riihimaki, V., and Paffli, P. 1978. Percutaneous absorption of solvent vapors in man. *Scand. J. Work Environ. Health* 4:73-85.

Sanders, J. S. 2004. General guidance for conducting fumigant field studies. Letter to Environmental Monitoring Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA 95812., dated June 20, 2005.

Segawa, R. 1997. Description of computer modeling procedures for methyl bromide. Memorandum to J. Sanders, Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA, dated September 4, 1997.

Segawa, R. T., Sitts, J. A., White, J. H., Marade, S. J., and Powell, S. J. 1991. Environmental monitoring of malathion aerial applications used to eradicate Mediterranean fruit flies in Southern California, 1990., California Department of Food and Agriculture, Environmental Hazards Assessment Program, Sacramento, CA.

Sheldon, L., Clayton, A., Jones, B., Keever, J., Perritt, R., Smith, D., Whitaker, D., and Whitmore, R. 1992. Indoor pollutant concentrations and exposures. Final report contract no. A833-156 prepared for California Air Resources Board., Research Triangle Institute, Research Triangle Park, NC.

Sims, J. J., Grech, N. M., Becker, J. O., McGiffen, M. E., and Ohr, H. D. 1995. Methyl iodide: a potential alternative to methyl bromide. Proc. Of the Second Annual Int. Res. Conf. On Methyl Bromide Alternatives and Emissions Reductions, November 6-8, 1995, at San Diego, CA. p 46.

Sved, D. W. 2002. A comparative oral (gavage) and inhalation metabolism and toxicokinetic study with iodomethane in male rats. Wil Institute, Report No. WIL-418007. (DPR Vol. No. 52875-033 Record No. 186475).

Thongsinthusak, T., and Haskell, D. 2002. Estimation of exposure of persons to methyl bromide during and/or after agricultural and nonagricultural uses. HS-1659. Sacramento, CA.: Worker Health and Safety Branch, Department of Pesticide Regulation, California Environmental Protection Agency.

UNEP. 1995. The Montreal protocol on substances that deplete the ozone layer. *1994 Report of the Methyl Bromide Technical Option Committee. United Nations Environmental Programmes*

UNEP. 1998. Methyl Bromide Technical Options Committee; 1998 Assessment of Alternatives to Methyl Bromide. . *United Nations Environment Programme*. http//www.org.teap.org.

USEPA. 1992a. Dermal Exposure Assessment: Principles and Applications. *Office of Health and Environmental Assessment, United States Environmental Protection Agency*. EPA/600/8-91/011B.

USEPA. 1992b. Guidelines for Exposure Assessment. *Office of Research and Development, United States Environmental Protection Agency*. EPA/600/Z-92/001.

USEPA. 1993. Protection of Stratospheric Ozone *Federal Register* 58(51), no. 15014-15049.

USEPA. 1995. User's guide for the Industrial Source Complex (ISC3) dispersion models. Volume I – User's Instructions. O*ffice of Air Quality Planning and Standards. Emissions, Monitoring, and Analysis Division. U.S. Environmental Protection Agency*. Research Triangle Park, North Carolina 27711. EPA-454/B-95-003a.

USEPA. 1997. Exposure Factors Handbook. Volume 1, General Factors. *Office of Research and Development, United States Environmental Protection Agency*.

USEPA. 1998. Summary of the U.S. EPA Workshop on the Relationship Between Exposure Duration and Toxicity. *National Center for Environmental Assessment, Office of*

Research and Development, United States Environmental Protection Agency. EPA/600/R-99/081.

USEPA. 2006. Iodomethane: Revised HED Human Health Risk Assessment; DP Barcode: D324458, PC Code: 000011. *Office of Prevention, Pesticides and Toxic Substances, United States Environmental Protection Agency*.

USEPA. 2007. Iodomethane: Revised HED human health risk assessment which incorporates results of human iodine monitoring. *Health Effects Division (7509P), Office of Pesticide Programs*. (August 23, 2007).

Wieczorek, H. 1985. Evaluation of low exposure to styrene. II. Dermal absorption of styrene vapors in humans under experimental conditions. *Int. Arch. Occup. Environ. Health* 57:71-75.

Wujcik, C. E. 2001a. Aerobic soil metabolism of [14C]-iodomethane (TM-425). Project ID 012520. MRID 45573707. (DPR Vol. No. 52875-006 Record No. 185655).

Wujcik, C. E. 2001b. Anaerobic aquatic metabolism of [^{14}C]-iodomethane (TM-425). Project ID 013072. MRID 45593708. (DPR Vol. No. 52875-006 Record No. 185656).

APPENDIX I

RESTRICTED USE PESTICIDE

DUE TO ACUTE TOXICITY

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

Midas® 98:2

Only For Pre-Plant Fumigations of Fields Intended for Commercial Production of Listed Crops and Field-Grown Ornamentals, for the Control of Soil-Borne Pests Including Weed Seeds, Nematodes, Insects, and Diseases

ACTIVE INGREDIENTS:	
Iodomethane	97.80%
Chloropicrin	1.99%
OTHER INGREDIENTS:	0.21%
TOTAL:	100.00%

One gallon weighs 18.9 pounds
(18.5 pounds Iodomethane and 0.4 pounds Chloropicrin).

KEEP OUT OF REACH OF CHILDREN

DANGER / PELIGRO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail).

SEE INSIDE BOOKLET FOR ADDITIONAL PRECAUTIONARY STATEMENTS

For Product Information Call: 1-866-761-9397

FIRST AID	
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, and then continue rinsing. • Call a poison control center or doctor for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, and then give artificial respiration, preferably mouth-to-mouth if possible. • Call a poison control center or doctor for further treatment advice.
If swallowed	• Call a poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give anything to an unconscious person.

HOT LINE NUMBERS

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

FOR 24-HOUR EMERGENCY MEDICAL ASSISTANCE CALL:
1-866-303-6952 or 1-651-632-8946

NOTE TO PHYSICIAN

Probable mucosal damage may contraindicate the use of gastric lavage. Symptoms of overexposure may include irritation to eyes, skin, and respiratory system, shortness of breath, nausea, vomiting, dizziness, ataxia, slurred speech, drowsiness, blurred vision, staggering gait and mental imbalance, with probable recovery after period of no exposure. Treatment is symptomatic.

Manufactured for:
Arysta LifeScience North America Corporation
15401 Weston Parkway, Suite 150 • Cary, NC 27513

EPA Reg. No. 66330-43
EPA Est. No. 29516-NC-001Ⓐ
29516-FL-004Ⓑ

Superscript corresponds to the first letter of the lot number for this package

AD101107
20789

NET CONTENTS:____________LBS.

Arysta LifeScience™

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

Danger. Corrosive. Causes irreversible eye damage. Corrosive to skin. Causes skin burns. May be fatal if inhaled or swallowed. Harmful if absorbed through skin. Do not get in eyes, on skin or on clothing. Do not breathe vapor. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

SPECIAL NOTE: This product contains chloropicrin, a poisonous liquid or vapor. Inhalation of vapors may be fatal. Chloropicrin is readily identified by smell. Exposure to very low concentrations of vapor will cause irritation of eyes, nose and throat. Continued exposure after irritation is evident or higher concentrations may cause painful irritation to the eyes or temporary blindness. Liquid will cause chemical burns to skin or eyes. Do not get on skin, in eyes, or on clothing. Chloropicrin fumigant has the capacity to cause marked irritation to the upper respiratory tract and is a strong lachrymator (tear producing eye irritant). Low concentrations, below those necessary to cause serious systemic intoxication, are capable of causing severely painful eye irritation, hence will not be voluntarily tolerated. However, the effect may be so powerful that a person may become temporarily blinded and panic-stricken and that in turn may lead to accidents.

AIR CONCENTRATION LEVEL

Air concentrations of chloropicrin are measured with direct reading colorimetric detector devices, such as Kitagawa tubes, certified for chloropicrin at 0.1 to 16 ppm. Persons involved in the application of MIDAS 98:2 or in reentry into treated fields must wear an air-purifying respirator when required by the restrictions given in the AGRICULTURAL USE REQUIREMENTS section below. In case of spills or leaks, additional respiratory protection must be worn as detailed under Spill and Leak Procedures.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and other handlers (to include tractor drivers, co-pilots, shovelers, and tarp monitors) **must wear:**

- Loose fitting or well ventilated long-sleeved shirt and long pants.
- Shoes plus socks.
- Full face shield or safety glasses with brow, temple and side protection is required. DO NOT wear goggles.
- An air-purifying respirator with a 3M Brand No. 60928 cartridge filter, or equivalent (MSHA/NIOSH approved number prefix TC-23C). For tractor drivers and co-pilots the following can be used in lieu of an air-purifying respirator:
  - A tractor equipped with a working-area air-fan dilution system consisting of a ducted fan/blower which provides air flow to the breathing zone of the tractor driver and co-pilot. The fan/blower must be mounted so that the fan/blower intake is at least 126 inches from the ground, and the fan/blower must be capable of operating at a minimum of 1,600 revolutions per minute and producing a minimum flow rate of 3,000 cubic feet of air per minute.

Other handlers (to include planters, hole punchers, tarp cutters, tarp removers, and tarp remover drivers) **must wear:**

- Loose fitting or well ventilated long-sleeved shirt and long pants.
- Shoes plus socks.
- Full face shield or safety glasses with brow, temple and side protection is required. DO NOT wear goggles.

ENGINEERING CONTROL REQUIREMENTS

MIDAS 98:2 must be transferred through connecting hoses, pipes, and/or couplings sufficiently tight to prevent workers or other persons from coming in contact with the liquid.

- All hoses, piping, and tanks used in connection with this product shall be of a type appropriate for use under the pressure and vacuum conditions to be encountered.
- External sight gauges, if applicable, shall be equipped with valves so that pipes to sight gauge can be shut off in case of breakage or leakage.
- The mechanical transfer system must be adequate to make necessary measurements of the pesticide being used.
- Shut-off devices must be installed on the exit end of all cylinder connections and at all disconnect points to prevent leakage of product when the transfer is stopped and hose is removed or disconnected.
- The pressure in hoses used to move the product must not exceed the manufacturer's maximum pressure specifications.
- Check equipment to ensure good condition and integrity prior to each use.

-2-

1

User Safety Requirements

- Do not wear jewelry, gloves, goggles, tight clothing or any rubber protective clothing/boots that can trap iodomethane or chloropicrin vapors against your skin. Iodomethane and chloropicrin vapors can be trapped inside clothing and cause skin injury.
- Remove all clothing that comes in contact with liquid material at once.
- Aerate all affected clothing thoroughly outdoors prior to washing with hot water and detergent.
- Discard any clothing or absorbent materials (e.g. leather), that have been drenched or heavily contaminated with this product. Do not reuse them.
- Respirator Requirements: When a respirator is required for use with this product, the following criteria must be met consistent with the Worker Protection Standard: (a) Cartridges or canisters must be replaced daily or when odor or irritation from this product becomes apparent, whichever is sooner; (b) Respirators must be fit-tested and fit-checked using a program that conforms to OSHA's requirements (described in 29 CFR Part 1910.134); (c) Respirator users must be trained using a program that conforms to OSHA's requirements (described in 29 CFR Part 1910.134); (d) Respirator users must be examined by a qualified medical practitioner to ensure physical ability to safely wear the style of respirator to be worn.
- Follow PPE manufacturer's instructions for cleaning/maintaining protective eyewear and respirators.

USER SAFETY RECOMMENDATIONS

User should:

- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if pesticide gets inside, then wash skin thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment wash waters.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat, open flames, or sparking electrical equipment. Do not use application devices containing natural rubber, aluminum, magnesium or their alloys.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Read all Directions for Use carefully before applying this product.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only Certified Applicators (certified by both the state and Arysta) trained in the proper handling, worker protection, and application of MIDAS 98:2 soil fumigant and workers under their direct supervision may be present in the treatment area during application. An Arysta and state Certified Applicator must be on site and within the line of sight to observe handlers during the application. Handling tasks to be performed under the direct supervision of a Certified Applicator include, but are not limited to the tractor driver, co-pilot, tarp dispenser and shoveler. All such handlers must have appropriate protective equipment, as described in the PERSONAL PROTECTIVE EQUIPMENT section. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

Buffer Zone

The area adjacent to the treated area is referred to as the buffer zone. The buffer zone shall extend from the edge of the treated area in all directions. See Buffer Zone Table. The minimum buffer zone distance shall be 25 feet.

The Certified Applicator supervising the soil fumigation is responsible for the following:

1. Calculating the appropriate size of the buffer zone that must be maintained during the first 48 hours following the end of the application;
2. Establishing and maintaining the buffer zone during the 48 hours following the end of the application; and
3. Ensuring that unprotected workers and bystanders do not enter the buffer zone during the 48 hours following the end of the application. Exception: Unprotected workers and bystanders may travel through (but not engage in any activity in) the buffer zone during the 48-hour period, provided their total exposure time in any 24-hour period is 15 minutes or less. However, travel by unprotected workers or bystanders through the fumigated area itself is prohibited during the entire 5-day Entry-Restricted period. Handlers protected with Personal Protective Equipment (PPE) required for early entry into a treated area may work in buffer zones.
4. Ensuring application site has a distinctive buffer zone. The buffer zone of the field to be treated cannot overlap the buffer zone of another field treated within the last 48 hours.
5. The Certified Applicator supervising the soil fumigation must document how the buffer zone was determined, the location of unoccupied sensitive sites within 1/4 mile of the fumigated area, and how persons in occupied structures located within the buffer zone were protected. These records must be maintained by the Certified Applicator and by the owner/operator of the fumigated site for at least two years following the fumigation and must be made available, upon request to Federal, State, Tribal, and local enforcement personnel.

1

Determining Buffer Zone Distance

- Determine the size of the buffer zone using the following Buffer Zone Table.
- The size of the buffer zone will be dependant on the following three factors:
  - o The number of field acres that are being treated with MIDAS 98:2.
  - o The pounds of MIDAS 98:2 that are being applied per treated acre.
  - o Buffer zone reduction credits.

Buffer Zone Table

MIDAS 98:2 Application Rate (Lbs per Treated Acre)[4]	SIZE OF FIELD IN ACRES (Buffer zone distance in feet)[1, 2]							
	Up to 5 Acres	6 – 10 Acres	11-15 Acres	16- 20 Acres	21-25 Acres	26-30 Acres	31-35 Acres	36-40[3] Acres
80	25	45	90	135	160	180	205	225
90	25	50	100	150	180	205	230	255
100	30	60	115	170	200	225	255	280
120	35	70	135	200	235	270	305	335
125	35	70	140	210	245	280	315	350
150	45	85	170	255	300	340	380	420
175	50	100	200	295	345	395	445	490

1. For rates not listed on this table, use the buffer zone for the next highest rate, or use the following calculation to determine the exact buffer zone:

   Buffer Zone for Application Rate Not Listed = <u>Known Buffer Zone on Table X Application Rate Not Listed</u>
   Rate of Application for Known Buffer Zone

2. **Buffer Zone Reduction Credits:**
   Reduce buffer zone by 10% for each factor listed below:
   - Use of flat fume / broadcast application
   - Use of High Barrier films. High Barrier films for which credit can be applied must be on an Arysta approved list. Examples of Arysta approved films are Canelit Brand Metalized 1.3 ml, Pliant Blockade® VIF 1.25 ml, and Pliant Metalized 1.0-1.25.
   - Application to soils having >3% organic matter. Refer to the USDA or USGS Soil Survey Maps for the treated area that identify the range of organic matter and / or a documented soil survey report that lists range of % organic matter for the treated area. Collection of samples for analysis of soil in the treated area should follow procedures as per USDA's Natural Resource Conservation Services methods. Information on soil sampling can be found at www.soil.usda.gov.

   For example, if the Buffer Zone is 50 feet and the application qualifies for a buffer zone reduction credit such as use of Metalized film, then the buffer zone can be reduced by 10%, i.e. reduced by 5 feet based on the following calculation: 50 ft – (50 ft X 10%) = 45 feet.

   If the application qualifies for two buffer zone reduction credits such as use of a high barrier film and soil with >3% organic matter, then the buffer zone can be reduced by 20%, i.e. reduced by 10 feet based on the following calculation: 50 ft – (50 ft X 20%) = 40 feet.
3. Applications are limited to 40 contiguous acres or less per day on a single site.
4. For raised bed applications, the treated area is the raised bed not the untreated furrows. As an example, if a raised bed field is 50% raised bed (treated) and 50% furrow (untreated), and 350 lbs of MIDAS 98:2 is applied to the field, then the effective application rate to the treated raised bed is 350 lbs per treated acre; and that is the rate that would determine the buffer zone.

Note: Minimum allowable buffer zone is 25 feet regardless of buffer zone reduction credits.

Buffer Zone for Pre-Plant Deep Injection Auger

- 25 feet if the application rate is less than 50 lbs MIDAS 98:2 per acre.
- 50 feet if application rate is 50 to 124 lbs MIDAS 98:2 per acre, and
- 100 feet if the application rate is 124 to 175 lbs MIDAS 98:2 per acre.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), restricted entry intervals, and notification to workers. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard (WPS).

Entry Restrictions

Entry into the treated area (including early entry that would otherwise be permitted under the WPS) by any person, other than a correctly trained and equipped handler who is performing a task that is permitted by this labeling, is PROHIBITED from the start of the application until 5 days after application and the air concentration of chloropicrin is measured to be less than 0.1 ppm. Early entry under the WPS is limited to tarp inspection and repair. Non-handler entry is prohibited while tarps are being removed.

See the Buffer Zone section of the label for additional Entry Restrictions.

Notification at Entrances to Treated Areas

Notify all workers of the fumigation verbally and by posting warning signs at all likely entrances to the treated area for no less than 5 days after application. The signs must bear the skull and crossbones symbol and state:

(1) "DANGER/PELIGRO"
(2) "Areas under fumigation, DO NOT ENTER/NO ENTRE"
(3) Iodomethane and Chloropicrin Fumigants In Use
(4) Date and time of fumigation
(5) MIDAS 98:2
(6) Name, address, and telephone number of the Certified Applicator in charge of the application.

Post these fumigant warning signs for treated areas instead of the WPS signs for these applications but follow all WPS requirements pertaining to location, legibility, size and timing of posting and removal.

PPE for Reentry during the Entry-Restricted Period

The PPE required for reentry during the entry-restricted period are:

- Loose fitting or well ventilated long-sleeved shirt and long pants.
- Shoes plus socks.
- An air-purifying respirator with a 3M Brand No. 60928 cartridge filter, or equivalent (MSHA/NIOSH approved number prefix TC-23C).

GENERAL INFORMATION AND INSTRUCTIONS

This fumigant is a highly hazardous material. All uses of this fumigant are covered under the Worker Protection Standard, and must be conducted in accordance with all of the requirements of the Worker Protection Standard (40 CFR Part 170). It is a restricted use pesticide that must only be used by or under the direct supervision of individuals trained and certified in its proper use. Before using, read the entire label and follow all use directions and precautions. All persons working with this fumigant must be knowledgeable about the hazards and trained in the use of required air-purifying respirator equipment and detector devices, emergency procedures and proper use of the fumigant.

GENERAL USE PRECAUTIONS

- Follow all local government instructions for posting of treated areas and post all treated areas with warning signs.
- Comply with all local ordinances and regulations.
- Do not apply within 1/4 mile of any occupied sensitive site such as schools, day care facilities, nursing homes, hospitals, prisons, and playgrounds.
- Applications are limited to 40 contiguous acres or less per day on a single site.
- Do not apply this product in the presence of ground fog, inversion layers or when the potential for an inversion layer is likely to occur as this may result in product drift outside the treated area. A smoke generator can be used to indicate the presence of an inversion layer if the smoke column does not rise in a vertical pattern. In addition, consult the local weather forecast in the surrounding region for reports of expected inversion layers the day of application and within the 24 hour period following applications of MIDAS 98:2.
- Never fumigate alone. A minimum of two trained employees must be present during handling and application of soil fumigants.
- Certified Applicators are responsible for providing information to all workers involved with the fumigation about precautions and procedures in the safe handling, worker protection and application of MIDAS 98:2 for soil fumigation.
- Additional instructions must be made available to workers in the mechanical operation of the tractor and how to safely work with the operator while fumigating.

1

- Always handle this product in the open, with all workers positioned "upwind" from the container and/or where there is adequate ventilation.
- Check the fumigation system for leaks or worn out equipment prior to soil injection.
- When fumigating from a tractor, it is required that 5 gallons of water be carried on the tractor and readily available for rinsing and cleaning purposes. An additional 5 gallons of water must be available in the service truck. This water must be potable and in containers marked "Decontamination water not to be used for drinking."
- For broadcast/flat fume applications, keep all pets, livestock and other domestic animals out of the treated areas until tarps have been removed.
- For raised bed applications, keep all pets, livestock and other domestic animals out of the treated areas for 5 days and/or until the air concentration for chloropicrin is less than 0.1 ppm at the edge of the treated area. Most raised bed applications will not result in tarp removal.
- Tarp removal requires a minimum of two trained employees to be present during the operation. Non-handler personnel are prohibited from being present during tarp removal.
- See AGRICULTURAL USE REQUIREMENTS box for details regarding posting and placement of warning signs.
- Do not allow entry by unprotected persons into the fumigated area until the re-entry signs are removed. Such signs must only be removed when the air concentration of chloropicrin is measured to be less than 0.1 ppm at the edge of the treated area and no sooner than 5 days following application. Signs must remain legible during entire posting period. Also, do not cut tarps for planting until these conditions have been met.
- To determine whether aeration is complete, each fumigated site must be tested and shown to contain less than 0.1 ppm chloropicrin in the air space around the treated site as determined by 3 consecutive measurements taken at the down wind edge of the treated site at least 15 minutes apart.

SPILL AND LEAK PROCEDURES

- Cease all operations if any leak develops in the fumigation system.
- Evacuate everyone from the immediate areas of the spill or leak.
- Approach the area from the upwind side. Work upwind to repair leak(s), if possible.
- For entry into the area to correct the problem, trained personnel must wear loose fitting or well ventilated long-sleeved shirt and long pants, shoes plus socks and either (a) a supplied-air respirator (MSHA/NIOSH approval number prefix TC-19C) or (b) a self-contained breathing apparatus (SCBA)(MSHA/NIOSH approval number prefix TC-13F).
- Only correctly trained and PPE-equipped handlers are permitted to enter. Do not permit entry into the spill or leak area by any other person until the concentration of chloropicrin is measured to be less than 0.1 ppm as specified in section above.
- Allow spilled fumigant to evaporate or to absorb onto vermiculite, dry sand, earth, or similar absorbent material. Such material should be disposed of on site or at an approved disposal facility.
- Contaminated soil, water and other cleanup debris may be hazardous waste. Report any spill that exceeds 102 lbs (5.4 gallons of product) to the National Response Center at 1-800-424-8802.

PROCEDURES PRIOR TO, DURING AND AFTER ALL APPLICATIONS

CONTROL OF SOIL BORNE PESTS: MIDAS 98:2 controls soil-borne pests including nematodes, insects, weed seeds, and diseases.

Midas 98:2 will control the following pests when present in soil at the time of treatment:

Weed Seeds, including broadleaf weeds such as nutsedge, pigweed, broomrape and lambsquarters, and grasses such as bermudagrass, and annual bluegrass. Effectiveness against hard seed weeds, such as mallow, dodder, morning glory, and certain leguminous weeds may be variable.

Plant-parasitic Nematodes, such as root-knot, root lesion (meadow), cyst, citrus, burrowing, false root-knot, lance, spiral, ring, sting, stubby root, dagger, awl, sheath and stung (stylet) nematodes.

Soil-borne Insects, such as wireworms, cutworms, grubs, rootworms, ants and garden symphylans.

Soil-borne Diseases, such as *Verticillium, Pythium, Rhizoctonia, Phytophthora,* and *Fusarium.*

MIDAS 98:2 is not to be used as a preventative treatment for pests that may be introduced after the fumigant has been applied and/or tarps removed. To reduce the potential for the re-introduction of pests (nematodes, weed seed and disease); avoid the use of irrigation water, transplants or equipment that could carry pests into the planting area. Avoid moving infested soil back into the treated area through cultivation or other means.

Soil Preparation: The soil should be worked to the depth that is desirable for the fumigant to penetrate. Plant refuse should be worked into the soil and allowed enough time to decompose prior to treatment. Little or no plant refuse should be present on soil surface. Prior to application, the soil must be sufficiently moistened to allow seeds to swell (imbibe) in preparation for germination.

-8-

1

Prior to All Applications:

- Ensure that application equipment does not contain components made of natural rubber, aluminum, magnesium or their alloys.
- Soil in the treatment area should be reasonably free of trash and in good tilth prior to soil treatment.
- Do not apply to wet or cold soils (<55°F at a depth of 8 inches).

During All Applications:

- Immediately cover treated areas with a plastic tarpaulin for a minimum of 5 days.
- Allow time for complete voiding of material in the buried shanks following closure of the shutoff valve and before removing shanks from the soil.
- In the event that trash is pulled up with the shanks after completing a treatment pass, the trash must be covered with plastic film and the edges of the film buried under at least 4 inches of compacted soil before making the next pass through the field.
- Do not change cylinders when the fumigant system is under pressure. Change cylinders with all cylinder valves in the off position.

Following All Applications:

- To minimize the potential for crop injury, allow the fumigant to dissipate before planting a crop. Seeds may be used as a bioassay to determine if MIDAS 98:2 is present in the soil at concentrations sufficient to cause plant injury. DO NOT PLANT if the odor of the chloropicrin is detectable. See fumigation tables for planting requirements specific to the different application methods.
- Fumigation of highly acidic soils or those high in organic matter can cause ammonia toxicity to plants and or elevated levels of soluble salts in the soil causing phytotoxicity. Analyze soil following fumigation and fertilize as indicated.

MIDAS 98:2 PRE-PLANT FIELD FUMIGATION METHODS

Fumigations with MIDAS 98:2 shall only be performed in accordance with the following three application techniques: 1) Raised Bed Application, 2) Broadcast/Flat Fume Application, or 3) Deep Injection Auger Probe Application (stone fruit, nut trees, vines, and field-grown ornamentals only). Application methods and rates of application for each of these methods are discussed in detail below.

RAISED BED APPLICATION

- Use tractor mounted chisels spaced no more than 12 inches apart and at a depth of no less than 6 inches below the soil surface. The treated ground must be sealed using either:
  - Closing shoes and compaction roller: The closing shoes shall cover the chisel marks with soil just ahead of the compaction roller, and the tarpaulin shall be laid down simultaneously (with fumigant injection) by tarpaulin-laying equipment mounted on the application tractor; or
  - Bed shaper: The chisels shall be placed with the injection point under the bed shaper, and the tarpaulin shall be laid down simultaneously (with fumigant injection) by tarpaulin-laying equipment mounted on the application tractor; or
  - Combination bed former and bed shaper: The chisels shall be placed between the bed former and the bed shaper. The tractor with the tarpaulin-laying equipment shall immediately follow the application tractor.
- Injection depth of between 6 and 15 inches. The injection depth in preformed beds must not be below the bed furrow.
- Injection spacing of 12 inches or less typically performed with a multiple shank applicator.
- Planting shall not occur for at least 10 days after application (refer to RAISED BED SOIL FUMIGATION TABLE below).

Application Rates for Raised Bed Fumigation: Rates in the table below are given in pounds of MIDAS 98:2 per broadcast acre.The amount of product applied will be proportionate to the row spacing and width of the raised bed. To calculate the amount of product to be applied, multiply the application rate in lbs MIDAS 98:2/broadcast acre by the appropriate modifier from the Field Rate Modifier Table below.

RAISED BED SOIL FUMIGATION TABLE

CROP	MIDAS 98:2 Per Broadcast Acre[1]	Time Between Application and Planting
Field-Grown Ornamentals Peppers Strawberries Tomatoes	**Standard Film** 100 - 175 lbs/Broadcast Acre (5.3 - 9.3 gal/Broadcast Acre)	10 – 14 days [2, 3]
	Highly Retentive Film The rates may be reduced when used in combination with high retentive plastics. Consult your Arysta LifeScience representative for film selection and rate reduction recommendations.	14 - 21 days when using highly retentive film [4, 5]

NOTE:

[1] For fields infested with Nutsedge and Malva, apply a minimum of 150 lbs/acre (7.9 gal/acre) of MIDAS 98:2.

[2] Use the longer planting restriction period under conditions of high soil moisture, heavy soils, or rain or persistence of chloropicrin odor in the soil.

[3] If standard tarpaulins are NOT removed, plant a minimum of 10 days after application, which includes the minimum 24 hours of aeration once the tarps have been cut. If tarpaulins are not cut or aerated prior to planting, the odor of chloropicrin must not be detectable. If odor of chloropicrin is detectable, wait a minimum of 14 days before planting to avoid possible plant injury.

[4] Use of highly retentive films (e.g. VIF and approved Metallic) will require a rate reduction of up to 40-50% of the maximum use rate. Contact your Arysta LifeScience representative for rate recommendations and approved films.

[5] If highly retentive films are not removed, plant a minimum of 14 days after application, which includes the minimum 24 hours of aeration once the tarps have been cut. If the tarpaulins are not cut or aerated, prior to planting, the odor of chloropicrin must not be detectable. If odor of chloropicrin is detectable, wait a minimum of 21 days before planting to avoid possible plant injury.

Field Rate Modifier Table for Raised Bed Applications

Row Spacing (inches)	Bed Width (inches)	Field Rate Modifier
72	40	0.55
72	36	0.50
72	32	0.44
72	30	0.42
72	28	0.39
66	32	0.48
66	30	0.45
66	28	0.42
66	24	0.36
60	30	0.50
60	28	0.47
48	28	0.58

BROADCAST / FLAT FUME APPLICATION

- Use tractor mounted chisels spaced no more than 12 inches apart and at a depth of 6 to 15 inches below the soil surface.
  - o Closing shoes and compaction roller: The treated ground must be sealed using closing shoes and compaction roller. The closing shoes shall cover the chisel marks with soil just ahead of the compaction roller, and the tarpaulin shall be laid down simultaneously (with fumigant injection) by tarpaulin-laying equipment mounted on the application tractor.
- Planting shall not occur for at least 10 days after application (refer to BROADCAST / FLAT FUME APPLICATION TABLE).
- This product may be applied by broadcast/flat fume application with standard polyethylene films or highly retentive films, as they become available. Contact your Arysta LifeScience North America representative for information on film selection and rate reduction recommendations.

Application Rates For Broadcast/Flat Fumigation:

BROADCAST/FLAT FUME PRE-PLANT SOIL FUMIGATION TABLE

CROP	MIDAS 98:2 Per Acre[1]	Time Between Application and Planting
Field-Grown Ornamentals Peppers Strawberries Tomatoes Turf	100 - 175 lbs/Acre (5.3 - 9.3 gal/Acre)	10 – 14 days
Stone Fruits (Apricot, Sweet Cherry, Tart Cherry, Nectarine, Peach, Plum, Chickasaw Plum, Damson Plum, Japanese Plum, Plumcot, Fresh Prune) Tree Nuts (Almond, Beech Nut, Brazil Nut, Butternut, Cashew, Chestnut, Chinquapin, Filbert (Hazelnut), Hickory Nut, Macadamia Nut (Bush Nut), Pecan, Pistachio, Black Walnut, English Walnut) Vines (Table, Raisin and Wine Grapes)	120 - 175 lbs/Acre (6.3 – 9.3 gal/Acre)	10 – 14 days[2]
Nurseries (including strawberries, stone fruits, tree nuts and conifer trees)	175 lbs/Acre (9.3 gal/Acre)	10 – 14 days[2]

NOTE:

[1] For fields infested with Nutsedge and Malva, apply a minimum of 150 lbs/acre (7.9 gal/acre) of MIDAS 98:2.

[2] If tarpaulins are removed, planting can occur 10 days after application, which includes the minimum 5-day treatment period before tarps are cut plus the minimum of 24 hours of aeration after tarps are cut and before they are removed. Use the longer planting restriction period under conditions of high soil moisture, heavy soils, or rain or persistence of chloropicrin odor in the soil.

Tarpaulin Cutting and Removal for Broadcast / Flat Fume Applications: Following the completion of the application of MIDAS 98:2, the tarpaulin shall not be cut for a minimum of 5 days (120 hours) following completion of injection to the application block.

If the tarpaulin is removed from the field, removal shall begin no sooner than 24 hours after tarpaulin cutting has been completed (a task which cannot occur until a minimum of 5 days after application, as stated above).

PREPLANT DEEP INJECTION AUGER-PROBE APPLICATION

For Stone Fruit, Tree Nuts, Vines, and Field Grown Ornamental Trees and Shrubs, use 2 lbs of MIDAS 98:2 per injection site, typically to a depth of between 18 to 36 inches below the soil surface, though deeper injections may be made as appropriate. Use 1 injection site per 100 square feet (i.e., one injection site every 10 feet in a standard grid pattern). Planting or replanting of Stone Fruits, Tree Nuts, Vines, and Field Grown Ornamentals may begin 14 days after the period of exposure. DO NOT PLANT if the odor of chloropicrin is detectable.

Do not treat more than 230 trees per acre per day.

Buffer Zones

- 25 feet if the application rate is less than 50 lbs MIDAS 98:2 per acre.
- 50 feet if application rate is 50 to 124 lbs MIDAS 98:2 per acre, and
- 100 feet if the application rate is 125 to 175 lbs MIDAS 98:2 per acre.

FOOD CROP ROTATION RESTRICTIONS

Food crops other than strawberry, tomatoes and peppers require a 4 month plant back rotation restriction from the date of fumigant application. Crop rotation to non-food crops or non-bearing fruit or nut trees is not restricted.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage and disposal.

Pesticide Storage: Store in a dry, cool, well-ventilated area under lock and key. When appropriate to prevent tipping, store cylinders upright, secured to a rack or wall. Post as a pesticide storage area.

Handling: Product cylinders shall not be subjected to rough handling or mechanical shock such as dropping, bumping, dragging or sliding. Do not use rope slings, hooks, tongs, or similar devices to unload cylinders. Transport cylinders using hand truck, fork truck or other device to which the cylinder can be firmly secured.

Do not remove valve protection bonnet and safety cap until immediately before use. When cylinder is not in use, close valve by turning clockwise until hand tight, screw safety cap onto valve outlet, and replace protection bonnet.

Pesticide Disposal: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

Return of Containers: This pesticide container, whether full or partially used, is the property of the manufacturer or distributor where it was purchased and must be returned to the distributor of origin. Do not ship containers without safety caps or valve protection bonnets. Containers shall never be refilled by the consumer or used for any other product or purpose.

FOR 24-HOUR CHEMICAL EMERGENCY (spill, leak, fire or accident) ASSISTANCE:
Call CHEMTREC at 1-800-424-9300

Warranty and Disclaimer Statement

The directions for use of this product are believed to be adequate and must be followed carefully. However, it is impossible to eliminate all risks associated with the use of this product. Such risks may arise from weather conditions, soil factors, off-target movement, unconventional farming techniques, the presence of other materials, the manner of use or application, or other unknown factors, all of which are beyond the control of Arysta LifeScience North America Corporation ("Arysta"), and can cause crop injury, injury to non-target crops or plants, ineffectiveness of the product, or other unintended consequences. To the extent consistent with applicable law, all such risks shall be assumed by the user or buyer.

Arysta warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated in the Directions for Use, subject to the inherent risks described above, when used in accordance with the Directions for Use under normal conditions. This warranty does not extend to the use of this product contrary to label instructions or under conditions not reasonably foreseeable to Arysta, and is subject to the inherent risks described above.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, ARYSTA DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, ARYSTA, MANUFACTURER, AND SELLER DISCLAIM AND SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE, HANDLING, APPLICATION, STORAGE, OR DISPOSAL OF THIS PRODUCT OR FOR DAMAGES IN THE NATURE OF PENALTIES, AND THE USER AND BUYER WAIVE ANY RIGHT THAT THEY MAY HAVE TO SUCH DAMAGES. NO AGENT, REPRESENTATIVE OR EMPLOYEE OF ARYSTA IS AUTHORIZED TO MAKE ANY WARRANTY, GUARANTEE OR REPRESENTATION BEYOND THOSE CONTAINED HEREIN OR TO MODIFY THE WARRANTIES CONTAINED HEREIN.TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE TOTAL LIABILITY OF ARYSTA, MANUFACTURER, AND SELLER, SHALL BE LIMITED TO THE PURCHASE PRICE PAID, OR AT ARYSTA'S ELECTION, THE REPLACEMENT OF THE PRODUCT.

APPENDIX II

Table 1. Calculation of occupational exposures associated with shallow-shank, tarped-bed injections of methyl iodide.

Task	Air Concentration (µg/L)	Breathing Rate (L/hr)	Hours Worked	Body Weight (kg)	Absorbed Daily Dose[a] (µg/kg-d)	Natural Log (Absorbed DailyDose)[b]	Average Natural Log ADD (µ)	Standard Deviation Ln ADD[c] (σ)	Z(.95)[d]	ADD[e] (µg/kg-d)
Driver (ff)	1.00	833	8	77	8.65	2.16	2.65	1.50	1.645	168
Co-Pilot (ff)	6.40	833	8	91	46.87	3.85				
Applicator	0.31	833	8	98	2.11	0.75				
Applicator	5.47	833	8	77	47.34	3.86				
Shovelmen (ff)	0.56	833	8	86	4.34	1.47	1.67[g]	1.30	1.645	45
Shovelmen (ff)	0.11	833	8	80	0.92	-0.09				
Shovelers	0.21	833	8	47	2.98	1.09				
Shovelers	0.48	833	8	102	3.14	1.14				
Shovelers	2.52	833	8	86	19.53	2.97				
Shovelers	4.32	833	8	95	30.30	3.41				
Tarp Monitor	0.13	833	8	94	0.92	-0.08	2.31[h]	1.85	1.645	213.2
Tarp Monitor	0.86	833	8	86	6.66	1.90				
Tarp Monitor	3.52	833	8	91	25.78	3.25				
Tarp Monitor	5.94	833	8	60	65.97	4.19				
Tarp Cutter (ff)	0.03	833	8	95	0.21	0.74	1.59[i]	1.50	1.645	57
Tarp Remover (ff)	0.06	833	8	75	5.33	1.67				
Tarp Remover (ff)	0.12	833	8	105	7.62	2.03				
Hole Puncher	0.01	833	8	86	0.77	-0.26				
Hole Puncher	0.6	833	8	95	42.09	3.74				
Planter (ff)	0.03	833	8	80	2.50	0.92	0.54[j]	0.50	1.645	4
Planter	0.01	833	8	86	0.77	-0.26				
Planter	0.01	833	8	47	1.42	0.35				
Planter	0.03	833	8	86	2.32	0.84				
Planter	0.03	833	8	85	2.35	0.86				

[a] The absorbed daily dose (ADD) is calculated by multiplying the air concentration; the 90% protection factor required by the labels, the adult breathing rate; the hours worked and dividing by the body weight (numbers rounded to nearest 1/100).

[b] The natural log (Ln) of the absorbed daily dose (numbers rounded to nearest 1/100).

[c] The arithmetic standard deviation of the natural logs for the absorbed doses (σ).

[d] The 95th percentile of the standard normal distribution.

[e] The 95th %ile of exposure calculated as $\exp\left[\hat{\mu} + Z_{(0.95)} \cdot \hat{\sigma}\right]$

where: µ = arithmetic mean, Z = the 95th percentile of the standard normal deviation), σ = arithmetic standard deviation

[f] The arithmetic average of the natural log of the absorbed daily dose for tractor drivers- flat fume (ff) driver, copilot; and raised bed applicators.

[g] The arithmetic average of the natural logs of the absorbed daily doses for shovelmen- flat fume (ff) shovelmen; and raised bed shovelers.

[h] The arithmetic average of the natural logs of the absorbed daily doses for tarp monitors.

[i] The arithmetic average of the natural logs of the absorbed daily doses for tarp handlers- flat fume (ff) tarp cutters and removers; and raised bed hole punchers.

[j] The arithmetic average of the natural logs of the absorbed daily doses for planters.

Table 2. Calculation of occupational exposures associated with drip irrigation, tarped-bed applications of methyl iodide.

Task	Air Concentration (μg/L)	Breathing Rate (L/hr)	Hours Worked	Body Weight (kg)	Absorbed Daily Dose [a] (μg/kg-d)	Natural Log (Absorbed Daily Dose)[b]	Average Natural Log ADD (μ)	Standard Deviation Ln ADD[c] (σ)	Z(.95)[d]	ADD[e] (μg/kg-d)
Applicator	0.33	833	8	91	0.30	-1.20	-0.59[f]	0.47	1.645	1.21
Applicator	0.74	833	8	100	0.62	-0.48				
Applicator	0.42	833	8	91	0.38	-0.96				
Applicator	0.59	833	8	99	0.50	-0.70				
Applicator	1.3	833	8	94	1.15	-0.14				
Applicator	0.85	833	8	100	0.71	-0.35				
Hole Puncher	0.02	833	8	100	1.33	0.29	1.14[g]	0.73	1.645	10.41
Hole Puncher	0.07	833	8	99	4.71	1.55				
Hole Puncher	0.09	833	8	125	4.80	1.57				
Planter	0.003	833	8	91	0.22	-1.52	-1.13[h]	1.29	1.645	2.71
Planter	0.001	833	8	100	0.05	-3.01				
Planter	0.003	833	8	99	0.23	-1.47				
Planter	0.003	833	8	82	0.23	-1.48				
Planter	0.02	833	8	90	1.48	0.39				
Planter	0.02	833	8	97	1.37	0.32				

[a] The absorbed daily dose (ADD) is calculated by multiplying the air concentration; the adult breathing rate; the hours worked and dividing by the body weight (numbers rounded to nearest 1/100).

[b] The natural log (of the absorbed daily dose (numbers rounded to nearest 1/100).

[c] The arithmetic standard deviation of the natural logs for the absorbed doses (σ).

[d] The 95th percentile of the standard normal distribution

[e] The 95th %ile of exposure calculated as $\exp\left[\hat{\mu} + Z_{(0.95)}\hat{\sigma}\right]$

where: μ = arithmetic mean, Z = the 95th percentile of the standard normal deviation), σ = arithmetic standard deviation

[f] The arithmetic average of the natural logs of the absorbed doses for drip irrigation applicators working on tarped raised beds.

[g] The arithmetic average of the natural logs of the absorbed doses for drip irrigation hole punchers.

[h] The arithmetic average of the natural logs of the absorbed doses for drip irrigation planters.

Table 3. One-hour daytime air concentrations of methyl iodide at various distances from a 40-acre field treated at 175 lb/acre.

Distance (m)	Guadalupe Shank Bed/Tarp (µg/L)	Manteca Shank/Broadcast/Tarp (µg/L)	Oxnard Shank/Bed/Tarp (µg/L)	LaSelva Beach Drip/Tarp (µg/L)	Camarillo Drip/Tarp (µg/L)	Guadalupe Drip/Tarp (µg/L)
3	10.8	17.9	28.3	11.1	18.4	28.1
15	10.1	16.8	26.4	10.3	17.2	26.2
30	9.3	15.4	24.3	9.5	15.8	24.1
91	6.6	11.0	17.3	6.8	11.3	17.2
152	5.3	8.9	14.0	5.5	9.1	13.9
760	2.2	3.6	5.7	2.2	3.7	5.7

Table 4. Eight-hour daytime air concentrations of methyl iodide at various distances from a 40-acre field treated at 175 lb/acre.

Distance (m)	Guadalupe Shank/Bed/Tarp (µg/L)	Watsonville Shank/Broadcast/Tarp (µg/L)	Manteca Shank/Broadcast/Tarp (µg/L)	Oxnard Shank/Bed/Tarp (µg/L)	LaSelva Beach Drip/Tarp (µg/L)	Camarillo Drip/Tarp (µg/L)	Guadalupe Drip/Tarp (µg/L)
3	9.7	8.4	11.7	14.1	10.5	11.7	19.3
15	9.0	7.8	10.9	13.1	9.8	10.9	18.0
30	8.3	7.2	10.0	12.1	9.0	10.0	16.6
91	5.9	5.1	7.2	8.6	6.4	7.2	11.9
152	4.8	4.1	5.8	6.9	5.2	5.8	9.5
760	2.0	1.7	2.4	2.8	2.1	2.4	3.9

Table 5. Twenty-four-hour air concentrations of methyl iodide at various distances from a 40-acre field treated at 175 lb/acre.

Distance (m)	Guadalupe Shank/Bed/Tarp (µg/L)	Watsonville Shank/Broadcast/Tarp (µg/L)	Manteca Shank/Broadcast/Tarp (µg/L)	Oxnard Shank/Bed/Tarp (µg/L)	LaSelva Beach Drip/Tarp (µg/L)	Camarillo Drip/Tarp (µg/L)	Guadalupe Drip/Tarp (µg/L)
3	3.7	2.2	3.0	4.9	2.4	3.1	4.3
15	3.4	2.0	2.7	4.5	2.2	2.8	3.9
30	2.9	1.7	2.3	3.8	1.9	2.4	3.3
91	2.0	1.1	1.6	2.6	1.3	1.6	2.3
152	1.6	0.9	1.2	2.1	1.0	1.3	1.8
760	0.5	0.3	0.4	0.7	0.4	0.4	0.6

APPENDIX III

Comparison of DPR's Exposure Estimates with the Exposure Estimates in U.S. EPA's Registration Eligibility Documents

Occupational Exposure Estimates

U.S. EPA utilized 11 job categories for estimating occupational exposures to MI as a pre-plant soil fumigant (USEPA, 2006). The U.S. EPA approach to estimating occupational exposures was somewhat different than DPR's. (1) In the studies submitted by the methyl iodide registrant, each worker wore duplicate samplers. DPR considered the average of the two samplers as a single replicate. U.S. EPA used each sampler as a replicate. (2) The application rates used in the studies were different than the maximum application rate on the proposed labels. DPR adjusted the exposures to reflect the maximum application rate. U.S. EPA did not adjust for the maximum application rate. (3) DPR used the field spikes to make its own adjustment for recovery and analytical technique. U.S. EPA used the registrant's calculated field spike adjustments. (4) DPR calculated an upper-bound for an acute 8-hour exposure for workers. DPR uses a statistical approach to exposure rather than using just the high values because worker exposures are repetitive as well as acute. Consequently, a statistical treatment is necessary to estimate the average repetitive exposure. In some instances the upper-bound values exceeded the highest measured value. U.S. EPA used the maximum measured air concentration of MI to represent the acute 8-hour exposure for workers. (5) DPR used the arithmetic mean air concentration of MI to represent the seasonal exposure of workers. U.S. EPA also calculated intermediate-term exposures, based on average values, but did not present them. (6) U.S. EPA estimated the protective effect of respiratory protection on the exposure of workers to the maximum measured air concentration of MI. DPR factored in respiratory protection in the exposure estimates for workers once the required PPE was on the labels. Worker exposures estimated by U.S. EPA are presented in Table 1. A comparison of the 8-hour acute air concentrations, estimated by DPR and U.S. EPA, is presented in Table 2.

Table 1. Methyl iodide (MI) worker exposure associated with pre-plant agricultural field fumigation. [a]

Application method	Work Task	Maximum MI Conc. (ppm)	Maximum MI Concentration with PPE[b] (ppm)
Raised Bed	Tractor driver	1.029	0.103
Raised Bed, Flat Fume	Co-pilot	0.648	0.065
Raised Bed	Shoveler	0.76	0.076
Raised Bed	Tarp monitor	1.11	0.111
Raised Bed	Hole puncher	0.07	0.007
Raised Bed, Flat Fume, Drip Irrigation	Planter	0.007	0.0007
Flat Fume	Tractor driver	0.024	0.0024
Flat Fume	Shoveler	0.117	0.012
Flat Fume	Tarp cutter	0.006	0.0006
Flat Fume	Tarp remover	0.013	0.0013
Flat Fume	Tarp remover friver	0.024	0.0024
Drip Irrigation	Drip applicator	0.240	0.024
Drip Irrigation	Drip line tender	0.147	0.0147
Drip Irrigation	Hole puncher	0.017	0.0017

[a] From Table 12 in (USEPA, 2006). PPE = personal protective equipment
[b] Assumes an applicator is wearing air purifying organic vapor removing respirators with a 10-fold protection factor.

Table 2. Comparison of acute occupational exposures to methyl iodide in pre-plant field fumigation as estimated by DPR and U.S. EPA.

Work Task	DPR Estimated Exposure Concentration; No PPE (ppm) [a]	U.S. EPA Estimated Exposure Concentration; No PPE (ppm) [a]
Shallow shank-tarped soil fumigation (broadcast and bedded)		
Applicators (using shanks, 10-12")	1.51	1.03
Shovelmen and Shovelers	1.09	0.76
Tarp Monitors	3.75	1.11
Tarp Hole Punchers, Cutters, and Removers	0.16	0.07
Planters	0.01	0.007
Tarped-bed fumigation drip irrigation		
Applicator	0.25	0.24
Hole Puncher	0.02	0.02
Planter	0.01	0.007

[a] Assumes 8 hours of exposure at the indicated concentrations. PPE = personal protective equipment

Comparison of Calculated Air Concentrations

U.S. EPA used both the ISCST3 model and the Probabilistic Exposure and Risk model for Fumigants (PERFUM) to evaluate distributional bystander exposure from data derived from fumigation studies conducted in California, Florida, and Michigan (USEPA, 2006). U.S. EPA used ISCST3 as the basis to estimate the margins of exposure at various distances from fumigated fields of either 1 acre or 40 acres at distances of 25 to 1000 meters, assuming various atmospheric conditions. The MOEs were estimated from the calculated air concentrations of methyl iodide at various study sites. Table 3 presents the U.S. EPA estimated air concentrations of methyl iodide at 25 meters (~81 ft) from fumigated fields at each of the study sites.

Table 3. U.S. EPA estimated 24-hr time weighted average air concentrations of methyl iodide (MI) at 25 meters from 40 acre fumigated fields at various California study sites.

Study Site	Application Method	Margin of Exposure[a]	MI Concentration[b] (ppm)
Manteca	Broadcast, shank injection, flat fume	17	0.17
Watsonville	Broadcast, shank injection, flat fume	10	0.29
Oxnard	Raised bed, shank injection	9	0.32
La Selva	Drip irrigation, raised bed	12	0.24

[a] Assumes C atmospheric conditions (wind speed of 1.4 m/s).
[b] Back calculated from the margin of exposure using U.S. EPA's toxicological endpoint of a No Observed Effect Level = 2.9 ppm (USEPA, 2006).

Thus, the U.S. EPA estimated 24-hour time-weighted-average MI air concentration is 0.26 ppm at 80 feet from a fumigated 40-acre field, while DPR estimated the 24-hour time weighted average air concentration at 0.6 ppm at 100 feet. The difference in the estimated 24-hour time weighted average air concentrations between DPR and U.S. EPA is due in part, but not entirely to differences in the calculated 24-hour emission ratios (the highest proportion of the applied mass lost in a 24-hour period). DPR's emission ratios for Manteca, Watsonville, Oxnard and La Selva were 0.51, 0.37, 0.84, and 0.42, respectively. U.S. EPA's emission ratios for the same locations were 0.47, 0.35, 0.37, and 0.51, respectively. Further, the difference in methods (U.S.EPA used the whole field approach) also caused differences in the respective estimates.

Why DPR Does Not Use the PERFUM Model

ISCST3 is an integral part of the PERFUM model. As a result, many of the inputs used for PERFUM are similar to those used for the ISCST3 analysis (e.g., field sizes and back-calculated flux rates). The key difference is that PERFUM incorporates 5 years of meteorological data to generate a distribution of daily average concentrations that represent the possible range of downwind air concentrations based on changing wind vectors from the measured data in a series of receptor locations.

The U.S. EPA Science Advisory Panel (SAP) concluded in their review that, in concept, the PERFUM model was reasonable. However, the SAP did not perform an in-depth assessment of the reliability of the PERFUM front and back end processing code as it was not their charge. DPR has made a practice of thoroughly evaluating air dispersion models before utilizing them in risk assessment. Although the ISCST3 model has been thoroughly evaluated at DPR, the PERFUM components had not at the time this exposure assessment was completed. Therefore, only screening level air concentration estimates have been used for the DPR methyl iodide exposure assessment.

Buffer Zones

In a second iteration of a draft risk assessment for MI (USEPA, 2007), U.S. EPA estimated "whole field" buffer zone distances near 40-acre fields using the PERFUM model and "target concentrations" derived from various acute toxicological endpoints. The U.S. EPA buffer zone distances were expressed as the distance from the edge of a treated field to a point chosen at random where there was a 99% probability that the TWA air concentration of MI would be less than or equal to a target concentration. A target concentration was defined as that air concentration of MI which when divided into a toxicological No Observed Adverse Effect Level (NOAEL) from a laboratory animal study, yielded a number equal to or greater than the appropriate uncertainty factors.

This whole field, probabilistic approach differs from DPR's maximum direction approach (Barry and Johnson, 2008). The two approaches were compared using air concentration data from 20-acre field fumigations with methyl bromide (24-hr TWA), metam sodium (8-hr TWA), and chloropicrin (4-hr TWA). With each set of data, the PERFUM model was used to establish the whole field buffer zones where any random point on the periphery had a 99% probability that the fumigant air concentration would be equal to or less than a target concentration. The PERFUM model was also used for the maximum direction approach for each of these fumigants. This latter analysis indicates that a 99% whole field buffer zone only guarantees that over 5 years, at 1 application per year, if a single receptor is picked at random from the generalized distribution of air concentrations at the whole field buffer zone distance (independent of the individual applications), there will be a 1% chance that the air concentration at that receptor will be greater than the threshold concentration. The whole field buffer zone method does not control the per application buffer zone failure rate. That per application failure rate is unknown and depends upon the application method, the flux profile of the fumigant, the averaging time of the threshold, and the application size. The 99% whole field buffer zone per application failure rates were 12 to 14% for methyl bromide (24-hr TWA), 7.5% to 22% for metam sodium (8-hr TWA), and 10% to 29% for chloropicrin (4-hr TWA).

Intermediate and Annual Bystander Exposure Estimates

U.S. EPA did not include an estimate of potential community exposures from area-wide applications (USEPA, 2006; USEPA, 2007). However, USEPA did remark that "…HED (U.S. EPA's Health Effects Division) has compared iodomethane to the ambient air levels that were quantified for methyl bromide using physical chemical properties and environmental fate characteristics. Based on this comparison, HED believes there is less potential for exposure with iodomethane than with methyl bromide because of the environmental fate characteristics of iodomethane relative to methyl bromide (i.e., iodomethane dissipates/degrades faster in the environment)."

DPR used a 2-week average air concentration of MI from a treated field at the buffer zone to simulate a resident bystander's seasonal exposure. This estimated air concentration, 70±18 ng/L, was close to the measured average (2 week) air concentration of methyl bromide (46 ng/L) in communities where methyl bromide is used as a pre-plant field fumigant (Thongsinthusak and Haskell, 2002).