National Management Strategy

For Methyl Bromide

United States of America
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National Management Strategy Contents

Chapter I. Introduction

The United States has supported the objectives of the Montreal Protocol on Substances that Deplete the Ozone Layer (Protocol, or Montreal Protocol) since before the inception of this landmark environmental treaty in 1987. The United States developed this strategy on methyl bromide (MeBr) in accordance with Decision Ex. I/4 (3) which requests a Party nominating a Critical Use Exemption (CUE) after 2005 to provide a national management strategy on the use of MeBr. The information upon which this strategy was developed is the result of a collaborative research effort at the national, state, and local levels. The relevant provision of this decision taken in March 2004 requests "*each Party which makes a critical-use nomination after 2005 to submit a national management strategy for phase-out of critical uses of methyl bromide to the Ozone Secretariat before 1 February 2006.*"

The criteria for the critical use exemption are delineated in Decision IX/6. In that Decision, the Parties agreed that "a use of methyl bromide should qualify as 'critical' only if the nominating Party determines that: (i) The specific use is critical because the lack of availability of methyl bromide for that use would result in a significant market disruption; and (ii) there are no technically and economically feasible alternatives or substitutes available to the user that are acceptable from the standpoint of environment and public health and are suitable to the crops and circumstances of the nomination." The Critical Use Nomination for which this strategy has been developed involved careful review of the circumstances and research surrounding the individual conditions and sectors identified.

In this document, the United States will describe the policies, procedures and regulations that are in place to show how, as a Party to the Montreal Protocol, we are addressing the elements in Decision Ex. I/4 (3), including how we:

- Avoid increases of MeBr except under unforeseen circumstances
- Encourage the use of alternatives
- Provide information on the potential market penetration of alternatives
- Promote implementation of emissions reductions measures
- Provide a description of phase-in process once an alternative is determined to be feasible, in particular with respect to research programs

Through the applications for CUEs, applicants and the United States Government (USG) have provided detailed information on efforts to explore and implement alternatives to MeBr for control of pests in pre-plant and post-harvest situations. This document is not intended to be a technical recitation of these submissions, but rather, is an overview for the Parties to understand the comprehensive analysis and regulatory scheme that has been implemented by the United States domestically to meet the terms of the Montreal Protocol.

This document describes the following elements of the U.S. strategy to minimize the dependence on MeBr and thereby reduce its requests for MeBr for each sector for which a CUE may be necessary after 2007:

- Develop information on the technical and economic feasibility of alternatives
- Share information from research trials with MeBr users

- Confirm the viability of alternatives under commercial-scale conditions
- Promote an orderly transition from MeBr to the alternative

This document was prepared in the context of domestic efforts that have taken place in the United States over the last decade that have implemented viable replacements for MeBr where it was possible to do so. Uses for which alternatives have already been implemented have not been included in CUE nominations submitted by the USG. Through its assessment of the CUE applicant requests, the USG has reviewed the substantial problems or "limiting factors" that exist in transitioning the remaining critical uses to viable alternatives. These problems may be technology related, economically based, or may be based on regulatory constraints. The decision to submit Critical Use Nominations does not mean that the commitment to transition to alternatives is any less important; however, it is a statement of practical reality which the USG believes the Parties should continue to keep in mind as this Strategy is implemented.

Chapter II Aims of the Strategy

In developing this strategy, the USG used the following criteria described by the Parties in their decision taken at the First Extraordinary Meeting of the Parties. Decision Ex. I/4 (3) requests a Party to develop a management plan that should aim, among other things:

(a) To avoid any increase in methyl bromide consumption except for unforeseen circumstances;

(b) To encourage the use of alternatives through the use of expedited procedures, where possible, to develop, register and deploy technically and economically feasible alternatives;

(c) To provide information, for each current pre-harvest and post-harvest use for which a nomination is planned, on the potential market penetration of newly deployed alternatives and alternatives which may be used in the near future, to bring forward the time when it is estimated that methyl bromide consumption for such uses can be reduced and/or ultimately eliminated;

(d) To promote the implementation of measures which ensure that any emissions of methyl bromide are minimized;

(e) To show how the management strategy will be implemented to promote the phase-out of uses of methyl bromide as soon as technically and economically feasible alternatives are available, in particular describing the steps which the Party is taking in regard to subparagraph (b) (iii) of paragraph 1 of decision IX/6 in respect of research programmes in non-Article 5 Parties and the adoption of alternatives by Article 5 Parties;

A. Avoid increases of MeBr

To avoid any increase in methyl bromide consumption except for unforeseen circumstances;

As a broad spectrum fumigant, MeBr has been used to prepare areas for planting high value crops to protect against diseases, nematodes, insects, and weeds. This practice has been the accepted grower standard for production for over 40 years. Occasionally, remnants of a previous crop may also constitute an unwanted contaminant of a successive crop and become a weed. While most pre-plant MeBr alternatives are capable of controlling one or two classes of plant pests, few are effective in controlling all at the same time as effectively as MeBr. As part of the CUE process, the United States has identified key criteria that limit the technical and economic feasibility of MeBr alternatives. Table 1 includes a listing of CUE sectors and the critical limiting factors. Table 2 lists the principal pre-plant alternatives to MeBr that are in use in the United States, or have been determined as potentially suitable, along with their strengths and relative limitations.

For post-harvest uses, the range of pests includes various diseases in or on commodities, adult insects and their immature forms (including eggs), rodents, and plant propagules (seeds, buds, corms, and such).

Recognizing that the interaction of crop and pest distribution, geographic location of crop growing areas, and regulatory constraints on the use of alternatives is exceedingly complex, the USG implemented a comprehensive review of the CUE applications in 2002 utilizing over 45 technical experts to evaluate the various requests for MeBr. After establishing that these uses were indeed critical in accordance with the criteria in Decision IX/6 under the circumstances that they were produced, an effort was undertaken by the U.S. Environmental Protection Agency

(USEPA) to identify the extent of the critically limiting factors. By combining available data on the size of crops grown between 2000 and 2001, a baseline of crop area was determined. For post-harvest uses, production data were analyzed to estimate the volume of commodity or facility treated, number of treatments, and factors impacting the relative efficiency of such uses including such variables as the age of facilities, suitability of equipment for various alternative treatments, and time constraints for treatments.

An important way that the United States addresses the issue of avoiding increases in MeBr use is our policy to disallow any increases in acreage or throughput that CUE applicants might include in their CUE request. Requests are compared to historical use and acreage data where available to ensure accuracy and consistency of data. Applicant requests to increase treatment of a larger acreage, commodity volume, or additional facilities are disallowed by the USG unless corroborating information is provided indicating that our estimates of MeBr require a correction. An increase in MeBr need could also be justified in a case where an applicant shifted to an alternative, but found it necessary to submit a CUE request because the alternative consistently provided insufficient pest control after transition. This policy was established to limit further expansion within a sector using MeBr, even in the presence of critical limiting factors, as a means to avoid increases in MeBr usage. As a result of this policy, additional acreage or production volume of a commodity must be accomplished using a MeBr alternative.

Even with the adoption of this strong domestic policy aimed at avoiding increases in MeBr use, unforeseen circumstances could arise that could impact estimates of actual MeBr need. These circumstances include the loss of a technically and economically feasible MeBr alternative due to changes in its state or federal regulatory status for health, environmental or safety reasons, loss of efficacy due to pest resistance, or an emergency, such as the introduction of an economically damaging pest not otherwise controlled by MeBr alternatives. There have also been cases where a MeBr user reduced their need for MeBr by switching to an alternative, but after suffering a failure of pest control from the alternative, was forced to go back to MeBr use in the following year. In the event of an unforeseen circumstance, it may be necessary to use MeBr for pest control, but all criteria of the CUE process will be examined on a case-by-case basis to avoid the potential for allocating more MeBr than is justified by the technical and economic circumstances of the particular situation.

B. Encourage use of alternatives

> To encourage the use of alternatives through the use of expedited procedures, where possible, to develop, register and deploy technically and economically feasible alternatives;

Since MeBr was listed as an ozone-depleting substance in 1995, the USG has promoted research on new and existing pesticidal active ingredients to determine their potential as MeBr alternatives. Numerous compounds have been tested as candidate alternatives in programs funded in part by the USG through the Agricultural Research Service (ARS), Cooperative State Research Education and Extension Service (CSREES), the Inter-regional Project 4 (IR-4) programs or private industry. It is estimated that over $400 million dollars has been spent since 1995 by the private sector, state agricultural universities, and the USG towards development of

MeBr alternatives. The USG is committed to continue funding MeBr alternatives research to address ongoing CUE requirements, and is seeking continued funding of these programs beyond 2006. Ongoing research supported by the U.S. Government (USG) is being conducted by the Agricultural Research Service (ARS) and the Cooperative State Research, Education, and Extension Service (CSREES). One of the programs that has been funded by ARS and CSREES is the IR-4 Program, which has conducted MeBr alternatives research in conjunction with alternatives manufacturers. Since 1997, the IR-4 MeBr alternatives program has evaluated iodomethane, furfural, propylene oxide (PPO), and sodium azide as potential stand-alone treatments, as well as fosthiazate (nematode control), trifloxysulfuron sodium and halosulfuron methyl (herbicides for nutsedge control) as companion treatments for other alternatives.

Beginning in 1995, the USEPA initiated an expedited registration scheme for MeBr alternatives. A description of this program is found in Chapter IV. Through EPA, the USG encourages the registration of MeBr alternatives by expediting the regulatory review process for those products identified by industry as potential MeBr alternatives that were subsequently determined to qualify for this designation by the USEPA. Because of the considerable number of pesticide applications, there is typically some delay between the date of the application and time of initial review. Because USEPA has made MeBr replacements a priority, these applications immediately enter the review process, in which they are subjected to a full review to ensure adequate protection of human health and the environment.

In addition, the USG recognized that the task we faced was not only to expedite the registration of new alternatives, but to seek a level playing field for fumigants with respect to their human health and environmental impacts. Some fumigants, such as MeBr, 1,3-dichloropropene, metam-sodium and chloropicrin, were registered over 30 years ago at a time when the risk analysis and exposure methodology was different than the current review methodology. For this reason, USEPA initiated a comprehensive review of all pre-plant fumigants to ensure that there was no unintentional regulatory partiality towards these fumigants simply because they were registered a number of years ago. This review is ongoing, and until it comes to conclusion it is not possible to ascertain how it will impact the amounts and patterns of use in the United States given the wide range of possible regulatory constraints that could be placed on any of the fumigants under consideration.

C. Potential market penetration of alternatives

> To provide information, for each current pre-harvest and post-harvest use for which a nomination is planned, on the potential market penetration of newly deployed alternatives and alternatives which may be used in the near future, to bring forward the time when it is estimated that methyl bromide consumption for such uses can be reduced and/or ultimately eliminated;

The goal of the USG is to eliminate the use of MeBr where it is technically and economically feasible to do so. Under the terms of the Montreal Protocol, and especially Decision IX/6 allowing for critical use exemptions, the USG has worked with affected users to seek alternatives. During the phase-out period of 1999-2004, users were able to reduce their reliance on MeBr from the 1991 baseline of over 25,000 metric tons of MeBr to approximately 10,000 metric tons. This reduction was driven by market forces associated with the regulatory phase-out

of MeBr and was accomplished in part by the introduction of greater levels of chloropicrin (PIC) to MeBr/PIC blends by formulators, by reductions in application rates, and by the shifting of some uses to MeBr alternatives. Even within sectors that could accomplish some shifts, MeBr use remained critical as anticipated in Decision IX/6. As part of the CUE process, applicants have been required to identify the impediments to adoption of alternatives.

In the United States, it is important to note that most MeBr alternatives that are registered have been in the market over 30 years, long before the Montreal Protocol identified MeBr as an ozone depleter and sought to limit its use (Table 4). As the price of MeBr has increased, the market has allowed for the transition of uses away from MeBr to alternatives when it was already technically and economically feasible. Prior to the end of the phase-out period in 2004, the readily-achieved transition to MeBr alternatives was accomplished. This can be determined indirectly as the use of MeBr continued in certain areas despite the lower cost of alternatives for comparable uses. (Although two or more products may be registered for control of a pest, their efficacy may not be equal, or perhaps, not even comparable. In an open-market situation, users will consider many factors such as price, timeliness and efficacy in making their selection of a pest control option.) Price differentials between products serve as natural incentives for transition away from MeBr where it is technically and economically feasible; however, lower input costs resulting in a high level of yield loss, quality loss, or planting delays may result in a negative economic result if revenue falls faster than expenses.

Decision IX/6 allows for continued use of MeBr where no technically and economically feasible alternatives are available; this provision ensures that users are not forced into unsustainable economic losses if adequate alternatives are unavailable in the particular circumstances of the nomination. Through the CUE process, the USG has evaluated research data and information provided by users concerning the efficacy of MeBr and alternatives to determine the current extent to which registered alternatives may substitute for MeBr. It is extremely difficult to ascertain the adoption rate of newly-registered alternatives because the process of registration by its very nature typically imposes safety requirements such as the use of personal protective equipment (PPE), buffers, or regional caps that inherently limit the use of an alternative. In the United States, this is true both at the national, state and local levels. For example, States may impose more restrictive requirements than the federal government to ensure protection of human health and the environment. Such restrictions may hinder the adoption of a MeBr alternative. In fact, concerns over human health/environmental impacts in the State of California led them to adopt township caps on the use of a key MeBr alternative. Imposing such a cap was deemed to be important to environmental protection in California, but has prevented users in a number of sectors from phasing-in an alternative that is otherwise efficacious. For these reasons, it is not possible to estimate with any precision the extent of the adoption of alternatives, or the timing involved in it, and they must be considered on a case by case, sector by sector basis taking into account the circumstances of the individual nomination.

To further complicate the status of alternatives, the pre-plant fumigant alternatives as well as MeBr are currently being reviewed by EPA to determine their eligibility for registration (iodomethane), reregistration (MeBr, metam sodium and chloropicrin) or label changes (1,3-dichloropropene). This review is not scheduled for completion until the end of 2006. The review may impose additional restrictions on the use of these products beyond 2008. Any

changes in the use of these products, which are unknown at this time, will be factored into the assessment of MeBr CUE nominations as such information becomes available.

Despite the dynamic and unpredictable nature of these circumstances, the chapters contain information on the individual sectors providing the best-available information impacting the adoption of MeBr alternatives.

D. Promote implementation of emissions reductions measures

> To promote the implementation of measures which ensure that any emissions of methyl bromide are minimized;

U.S. CUE users take important steps to reduce emissions of MeBr. In general, U.S. pre-plant users either use deep-shank injection to insert MeBr 12 inches under the surface of the ground, or apply tarps over treated areas. Both of these methods reduce emissions of MeBr. For post-harvest applications, best efforts are required to improve building seals and minimize MeBr leakage/emissions during treatment. During the reregistration process for MeBr, the USEPA will evaluate research results on the use of low permeability films and other measures for their effectiveness in reducing emissions, and their potential for reducing rates, along with their technical and economic feasibility.

As part of the domestic review of CUE applications, the USG imposed dose rate reductions where we believed lower doses would maintain adequate pest control. Many users moved to dramatically lower dosage rates, in part due to the existing U.S. regulatory approach and the progressive tightening of the market for available MeBr. As an example, the food processing facilities sector has effectively reduced dose rate to one-quarter or one-third of the approved label rate for routine applications. The frequency of these applications has also been cut by about 50%. These measures have already provided a significant benefit to ozone layer protection.

Scientists of the Agricultural Research Service (ARS), the University of California, and the University of Florida have explored the use of emissions reducing films for pre-plant MeBr uses. Although earlier work focused on virtually impermeable films (VIF), regulatory restrictions prohibiting their use (California) and operational difficulties in adapting the films to commercial conditions (e.g. speed of laying film, differences in application equipment, and such) experienced in the United States (Florida), have resulted in growers being unable to broadly adopt VIF. Growers and researchers in Florida and California have continued to work with plastics manufacturers to find other alternatives for emissions reduction, and have in recent years identified several candidates, including metallized films and newer types of trilayer film, that may be more amenable to commercial application. Growers are conducting trials in 2005 on over 3000 acres to ascertain the effectiveness of such barriers. Should the results of these tests and trials planned for 2006 demonstrate their effectiveness, it is anticipated that this could benefit all fumigants by further reducing use rates and their resulting emissions. Wide-scale adoption of these technologies may be limited by the logistics associated with production of the

requisite barrier films. As research results become clearer, the direction for commercialization of these technologies will become apparent.

For post-harvest sectors, increased costs for MeBr have provided market-based incentives to improve the sealing of structures treated with MeBr. The USG recognizes that a number of older buildings are inherently more difficult to seal than facilities built in recent years; however, U.S. MeBr label requirements compel applicators to take efforts to seal buildings, and the reduced costs of fumigant material provide both a regulatory and a cost incentive for sealing facilities to minimize MeBr emissions. Emissions have also been cut wherever possible by fumigating less frequently and, when fumigations are necessary, by using quantities that are less than the approved label rate.

E. Promoting the methyl bromide phaseout, particularly with respect to R&D.

> To show how the management strategy will be implemented to promote the phase-out of uses of methyl bromide as soon as technically and economically feasible alternatives are available, in particular describing the steps which the Party is taking in regard to subparagraph (b) (iii) of paragraph 1 of decision IX/6 in respect of research programmes in non-Article 5 Parties and the adoption of alternatives by Article 5 Parties;

Efforts by the United States in this area include a variety of regulatory, policy, and programmatic activities aimed at reducing the need for MeBr. A robust and well-funded U.S. alternatives research program has invested hundreds of millions of dollars to find, evaluate, and facilitate the commercialization of alternatives. The U.S. pesticide registration process has made efforts to ensure that MeBr alternatives are given prioritized consideration for immediate review. The recent registration of sulfuryl fluoride has provided direct and measurable benefits in reducing the need for MeBr in certain post-harvest sectors, and several other alternatives in the registration queue have the potential for further benefit. The U.S. allocation rulemaking process includes additional restrictions, requirements, and limitations to users of MeBr from CUEs, and takes into account information on newly registered pesticides to further reduce the amount of MeBr allowed for use in the United States below the amount approved by the Parties where this is appropriate.

As a non-Article 5 Party to the Montreal Protocol, the United States has had an active ongoing research program to support users in identifying suitable alternatives to MeBr, and then to work with the users and universities to identify conditions under which the research results could be adapted into commercial production systems. Federally funded research has been conducted by ARS and university scientists at locations that are typically representative of the MeBr users. A large portion of the national research program was devoted to long term solutions and basic understanding of the role of fumigants in critical crop production systems; in contrast, the cooperative research between growers and the Universities at the state level has been in support of specific commodity needs and has been more directed toward local production practices. A description of the overall research program is found in Chapter 3.

Several challenges exist in adapting the findings of research trials into commercial production. Since 1995, products have been identified as potential MeBr replacements but due to the cost of

conducting required health and safety testing for registration, the product was not developed (e.g. propargyl bromide). In other instances, multiple steps were needed to replace a single MeBr application, for example where plastic was laid simultaneously (in-bed application) – such multi-step approaches were determined to be technically feasible, but not economically practicable.

As part of the CUE application process, the USG evaluates whether research data supporting a MeBr alternative has been demonstrated repeatedly within the same plot and at multiple locations, and if the alternative has been evaluated on a commercial scale under the time constraints experienced by the sector. Experience with VIF films, for instance, has shown that efforts to apply VIF at speeds necessary to maintain an effective planting schedule were not possible using commercial equipment. Reductions in speed resulted in significant, and costly, delays resulting in the potential need for large capital expenditures for additional application equipment.

Factors considered in determining the technical and economic feasibility of an alternative include:

- Efficacy against target pest(s) and impact on yield, quality and timeliness of harvest
- Reliability of treatment in controlling pests
- Direct/indirect costs of delays in making applications on treated crop (and subsequent crop if part of a multi-crop rotation scheme) or commodity (e.g. missed market window)
- Costs of application for multiple products
- Regulatory constraints on the use of alternatives
- Soil type, geological origin, and environment

Once these factors have been evaluated and an alternative is determined to be technically and economically feasible, adoption by users is not instantaneous or linear. Agricultural economists describe adoption rates as fitting an S-curve. Adoption of new technologies, when deemed to be superior to existing practice, may take 6-10 years to take a significant share of a market and 10-15 years to achieve maximum market penetration. In the instance where a product is merely comparable to existing products, the time to maximum market penetration is longer under open-market (unconstrained) conditions. The USG is cognizant of the investment that manufacturers have made in expanding pesticide labels or to obtain new registrations as MeBr alternative. It is the intent of the USG to work towards a phase-in of a MeBr alternative within eight years after the determination is made that it is technically and economically feasible. Such a timeframe represents an acceleration of the time it would normally take to phase in alternatives, but this amount of time is required to accommodate regulatory conditions between various states, and to ensure that users have ample time to adopt the technology within the confines of their specific operation. This phase-in schedule is accomplished by analyzing the regulatory status by jurisdiction, and reducing the CUE allocation in accordance with the expected phase-in level. If other factors are determined to impact the potential for a sector to adopt an alternative, for example, if there are shifts in pest spectrum that were not foreseen from the use of an alternative, then the phase-out schedule will be amended.

The USG has an additional regulatory tool to implement downward corrections to the amounts approved by the Parties to the Montreal Protocol. This tool is the annual notice and comment rulemaking used to allocate amount of MeBr to critical users. When a rule is proposed,

stakeholders are asked to provide information that the USEPA can utilize to revise the amount of MeBr allocated to users. This process can accommodate information such as the registration of an alternative prior to a control period, but after the time that the Parties have decided on a nominated amount. Since the regulatory process can take up to one year, it continues to be important to the United States for decisions of the Parties are made a year in advance of the control period where the CUE allocation will be used.

The recently published proposed rule for the 2006 MeBr allocation does this by accounting for the recent registration of sulfuryl fluoride in California, and the expansion of the federal registration to include ingredients. While this rule has not been finalized, it proposes a reduction in the amount of MeBr that will be allocated to users as compared to what was approved by the Parties. This notice and comment rulemaking process is a key element in the U.S. strategy to promote the phase out of MeBr by incorporating information on newly developed alternatives so that less MeBr will be allocated as feasible alternatives become available. While the allocation rule is a useful tool to apply more recent information to reduce amounts of MeBr below the levels authorized by the Parties, there is currently no effective method to make changes in the CUE in the event of changed circumstances warranting an increase in the allocated amount of MeBr due to changes in pest pressure, weather, or other such circumstances.

Finally, some of the elements noted above are important parts of our overall efforts to phase out the use of MeBr as technically and economically feasible alternatives become available. Our prioritization of MeBr alternatives in our domestic registration process helps move forward the time at which new alternatives can be registered, thereby moving forward the time at which they begin to penetrate the market. Our re-review of the pre-plant fumigants will create a level playing field from a regulatory perspective that ensures MeBr and its alternatives are considered with the same methodology and analysis in developing appropriate regulations to protect human health and the environment.

Chapter III. MeBr Alternatives Research Overview

Agricultural Research Service Research and Outreach Strategy

RESEARCH

After implementation of the U.S. Clean Air Act, as amended, and 1992 amendments to the Montreal Protocol, the USDA Agricultural Research Service (ARS), recognizing that the uses of MeBr in agriculture and forestry would be significantly reduced, initiated efforts to develop a research agenda. In view of the time required to produce alternative technologies and substitute chemicals, USDA ARS began developing a strategic plan and research agenda in February 1992 at a workshop with partners, customers, and stakeholders that identified important areas and priorities to use in initiating research to find alternatives for agricultural use. Specific research components necessary for both pre-plant soil fumigation, post-harvest and quarantine treatments were discussed. In the summer of 1993 ARS provided leadership to hold a workshop to further examine research needs and priorities. Approximately 250 persons from government, academia, and the private sector attended the meeting. The workshop consisted of nine working groups that were organized by commodities; four considered alternatives for post-harvest commodity and quarantine treatment, and five considered alternatives for soil fumigation treatment. In October of 1993 the Crop Protection Coalition, in cooperation with the USDA, convened a conference for the assessment of research and Extension needs and priorities in reducing atmospheric emissions and finding replacements for MeBr. Following the success of this meeting, USEPA joined as a cosponsor in 1994 and the annual meetings have been known as the Methyl Bromide Alternatives Outlook (MBAO) Conference.

Based on the output from the workshops and conference, ARS initiated research to meet the needs of MeBr users. In 1998 when ARS research was organized into National Programs, this research was incorporated into the Methyl Bromide Alternatives National Program (NP 308). National Programs function on a specific five-year cycle. Preparatory to beginning this cycle, NP 308 held two customer/stakeholder workshops to prioritize research for the next five years, one in December 1998 in Gainesville, FL and one in April 1999 in Monterey, CA. From these workshops an action plan for research was developed. The action plan continued the ARS strategy of using model commodities, an approach first agreed upon by researchers and commodity groups at the summer 1993 workshop. This plan may be accessed on the ARS web site: www.ars.usda.gov. An outline of the plan follows:

National Program 308 – Methyl Bromide Alternatives Action Plan: Components and Problem Areas

Component I – Pre-plant Soil Fumigation Alternatives

The following problem areas are to be considered as constituent parts that can be integrated into sustainable management systems.

Problem Area Ia – Chemical Controls

Problem Area Ib - Biorationals

Problem Area Ic – Cultural Controls

Component II – Post-harvest Commodity Treatment (Including Structural)

Problem Area II a - Methodologies to maintain quality of stored durable commodities.

Problem Area II b - Quarantine treatments for export of commodities and provision of technical assistance to APHIS to gain acceptance of these procedures by trading partners.

Problem Area II c - Technology to capture/recycle methyl bromide used in post-harvest fumigations to reduce or eliminate emissions to the atmosphere.

Problem Area II d - Physical or chemical detection systems for stored product and quarantine pests.

Problem Area II e - Replacements for fumigating food processing plants, flour and other mills, food storage facilities, and transportation carriers such as ships and railcars.

Problem Area II f - Emergency technology that will allow movement of commodities out of emergency quarantine areas caused by accidental introduction of exotic pests such as fruit flies.

Problem Area II g - Methods to prevent the spread of quarantine pests into and within the United States including population suppression, trapping and surveillance, and eradication.

ARS scientists working on MeBr alternatives prepared their research projects based on the action plan. These projects were reviewed by a peer panel organized through the ARS Office of Scientific Quality Review in 2002. Once projects were approved, research was initiated. Currently NP 308 is preparing to undergo a peer panel assessment to evaluate whether the research priorities in the action plan were met and what research needs remain. This will take place in December 2005. In February, 2006 customer/stakeholder workshops will be held to set priorities for future ARS MeBr alternatives research.

OUTREACH

Outreach is an important part of all ARS research, and the circumstances in the case of MeBr alternatives research necessitated working more closely with grower groups than many of the other ARS research programs. Outreach includes field days, on-farm demonstrations, presentations to grower groups, and peer-reviewed publications. ARS earmarked $500,000/year for seven years to support on-farm demonstration projects in California and Florida of the most promising alternatives. These funds supported a number of projects in conjunction with university and commodity organization scientists on strawberries, tomatoes, peppers and perennial crops.

These are some selected examples of ARS outreach related to MeBr alternatives.

- ARS research in Hawaii was the first in quarantine treatment research and development to demonstrate the use of hot-water immersion, forced hot-air technology (ARS patent), and high-temperature MeBr fumigation as efficacious quarantine treatments against tephritid fruit flies infesting fruits. This led to new quarantine treatments that expanded international trade in fresh fruit and vegetables.

- ARS scientists demonstrated that resistance to root-knot nematodes controlled by the N gene was effective in the bell peppers "Charleston Belle" and "Carolina Wonder" when grown in fields highly infested with southern root-knot nematode. This information was transferred to plant breeders, plant pathologists, and extension personnel for use in developing nematode resistant hybrid bell peppers and for developing management methods for root-knot nematodes in pepper.

- Research demonstrated that the mango seed weevil could be sterilized in mangoes with a 300 Gy irradiation dose, which allows mangoes to be exported from Hawaii for the first time in 50 years.

- Six commercial scale of-farm field trials demonstrated to growers the performance of selected herbicides, alone and in combination, when used as part of an alternative program based on Telone C-35® broadcast application. In addition, field days were conducted at multiple on-farm research sites.

- ARS Ft. Pierce scientists participated in a grower field day explaining a long-term land management project targeting organic vegetable producers that needed non-chemical alternatives to MeBr.

- Large-scale field trials conducted in commercial tomato and pepper fields in cooperation with growers have validated the use of 1,3-dichloropropene and chloropicrin (Telone C-35®) as a technically feasible alternative to the soil fumigation with MeBr. Trials were conducted using broadcast applications of Telone C-35® in combination with the herbicides Devrinol® and Treflan® and an additional application of chloropicrin in the bed. In a 50 acre trial that was conducted four consecutive years in the same field, yields in the fourth year under the alternative were higher than in adjacent fields fumigated with MeBr and the incidence of soilborne diseases was lower than in adjacent fields fumigated with MeBr. Additional large-scale field trials were conducted with Telone C-35® applied under VIF using the `Under Bed Fumigator'.

- To facilitate sweet potato exports from Hawaii and provide an alternative quarantine treatment to MeBr fumigation, the U.S. Pacific Basin Agricultural Research Center in Hilo, in collaboration with Hawaii Pride, LLC (a local quarantine x-ray irradiation facility) developed dose/mortality data for West Indian sweet potato weevil and sweet potato vine borer, two major quarantine pests associated with sweet potatoes in the islands. These data resulted in USDA-APHIS approval of a 400 Gy irradiation quarantine treatment for Hawaii-grown sweet potatoes exported to U.S. mainland markets. Sweet potato exports using the new irradiation quarantine treatment, which began in July, 2003, have helped to increase agricultural diversity in Hawaii following the decline of its sugar and pineapple industries.

- Field research and demonstration plots have been established to evaluate the yield potential of different strawberry cultivars (public and private cultivars) when grown in nonfumigated soil. Since there have not been disease problems with Verticillium wilt in these soils, these trials allow the evaluation of tolerance to other, nonlethal soilborne pathogens. Results have been made available to the California Strawberry Commission and local growers via field days and presentations at local commission and grower meetings.

- Field research and demonstration plots were used to evaluate remote sensing technologies for assessing the efficacy of control provided by alternative fumigants. Results from this research (approximately 170 acres in 2003) have been made available to the scientific and grower community through presentations at grower field days, individual meetings with participating growers, and professional scientific meeting.

- ARS scientists involved in MeBr alternatives research have been active participants in grower field days at two test plot locations, one in Watsonville that is managed by the California Strawberry Commission, and one in Salinas that is managed by ARS/USDA. The results of their research program were presented and discussed.

- ARS worked with engineers on the design and machine performance of a commercial CATTS (various combinations of controlled atmospheres and elevated temperatures). This unit was shown to be suitable for large-scale quarantine treatments of apples, pears, peaches, and nectarines both in bins and in packed boxes.

- Major technologies were transferred to growers in Hawaii and to fruit fly researchers worldwide, including the importance of sanitation, GF-120 spinosad bait sprays, male annihilation treatments, sterile flies, and parasitoids.

- ARS scientists at Parlier, California demonstrated that peaches and nectarines could be subjected to treatment with high temperatures combined with controlled atmospheres and maintain fruit quality. This work provided the foundation for further ongoing work in this area which may result in an alternative non-chemical treatment to substitute for MeBr fumigation.

- Large-scale commercial tests were conducted in cooperation with the National Hay Association to confirm the efficacy of bale compression combined with hydrogen phosphide fumigation to control Hessian fly in large-size, polypropylene fabric-wrapped bales. The results of this test fulfilled specific requirements by the Japan Ministry of Agriculture, Forestry, and Fisheries for a certified treatment. Approval of the quarantine treatment will support a $340 million annual hay export market to Pacific Rim countries.

- Large-scale tests of the use of ozone combined with carbon dioxide and vacuum showed the orange industry that bean thrips that cause rejections of lots of oranges in Australia could be eliminated with this treatment. This technology could save oranges from being rejected by allowing them to be exported under a phytosanitary certificate.

Cooperative State Research, Education and Extension Service Research and Outreach Strategy

RESEARCH

The USDA Cooperative State Research, Education and Extension Service (CSREES) sponsors research through competitive grants. Their MeBr Transitions Integrated Grants for fiscal year 2006 (FY06) will support the discovery and implementation of alternatives through commercial/field scale (not small plot) research on short to medium-term solutions to develop, register or apply new alternatives, or to minimize MeBr emissions. Comprehensive economic information on the impact of alternatives on crop yields and profitability will be required to assess both the economic and technical feasibility of alternatives.

CSREES Methyl Bromide Transitions Integrated Grants for fiscal year (FY) 2006
The Cooperative State Research, Education and Extension Service (CSREES) sponsors research through competitive grants. The Methyl Bromide Transitions Integrated Grants for fiscal year 2006 (FY06) will support the discovery and implementation of alternatives through commercial/field scale (not small plot) research on short to medium-term solutions to develop, register or apply new alternatives, or to minimize MeBr emissions. Comprehensive economic information on the impact of alternatives on crop yields and profitability will be required to assess both the economic and technical feasibility of alternatives. The proposed projects will support practical pest management alternatives for uses which the U.S. is requesting critical use

exemptions. Proposals addressing critical use nominations for which there is not an extensive database, e.g. cucurbits and eggplant, are encouraged.

- The projects will focus on commercial/field scale (not small plot/small scale) research on short- to medium-term solutions to develop, register and apply new alternatives or to minimize MeBr emissions and must be repeated for two or more research periods (years, crop cycles, etc).
- Comprehensive economic information on the impact of alternatives on crop yields and profit margins compared with MeBr fumigation is required to provide comprehensive information on the impact of alternatives on crop yields and profit margins.
- The proposed projects must address the potential application of the alternative methods and quantify MeBr use that might be replaced by the alternative methods or the reduction in MeBr emissions.
- The proposal must include the potential timeline for replacement of the current critical use or application methods by the proposed alternative methods.
- Formal extension and/or education programs to expedite adoption of proposed alternatives must be clearly delineated in the proposal.

Since 2000, the CSREES Methyl Bromide Transition Program has made the following funds available:

Year	Available Research Funding million U.S. dollars
2000	2.0
2001	2.495
2002	2.498
2003	3.229
2004	3.131
2005	3.106
2006	3.106*

* anticipated

Since 2000, CSREES has awarded and managed 32 Methyl Bromide Transition grants (for abstracts, see: http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1107). In addition, USDA CSREES has indirectly funded MeBr transition research and extension through other spending authorities. Expanded examples of results and impacts of CSREES funded research, extension and education are presented in Chapter Six, Critical Use Sectors. A review of USDA funded research related to MeBr alternatives is presented by the USDA CSREES Current Research Information System (CRIS) at http://cris.csrees.usda.gov/ .

IR-4 Methyl Bromide Alternatives Program

Research

IR-4 began addressing MeBr alternatives in 1998. Under the direction of the IR-4 New Technology Team, work began on a project to identify safe products and new technologies that have potential to replace MeBr. Several MeBr alternative programs for specialty crops are

underway. These programs include soil fumigation studies in production strawberries, fresh market tomatoes, strawberry nurseries, and in cut flowers. IR-4's role is to form alliances with university and USDA scientists, grower organizations, pesticide company representatives and producers to conduct research leading to acceptable MeBr replacements. IR-4 has been active in the development of MeBr alternatives for controlling pests in stored food products including raisins, other dried fruits, and tree nuts.

IR-4 is also facilitating cooperative efforts between pesticide manufacturers and university researchers in Florida to address the critical problems facing specialty crop producers. Research on metam sodium will be conducted to determine the causes of inconsistent performance under Florida conditions. This research, funded by the Metam Sodium Task Force, will be conducted by scientists at the University of Florida, Gainesville. Another project involves pesticide companies with selective herbicides used solely in vegetable crops. Dow AgroSciences will be cooperating with University of Florida weed scientists to superimpose herbicide treatments over Telone C-35® (1,3-D) fumigated plots and evaluate the herbicides for control of weeds not controlled by 1,3-D. Companies funding this research have a vested interest in registering their products as MeBr alternatives. IR-4 assists these companies in obtaining fast-track registration status for promising products by running residue (MRL) studies needed to meet registration requirements.

OUTREACH

Ongoing support for State Cooperative Extension activities is a fundamental element of the annual support that CSREES provides to the State Land Grant Universities. State programs have been developed to support the transfer of research information to growers through publications, meetings and field days. State, regional and national events are supported financially or in-kind by Cooperative Extension personnel to facilitate the dissemination of MeBr alternatives information to growers, applicators and pest control professionals.

Chapter IV. EPA MeBr Alternatives Registration Process

Pesticide registration is the process through which the USEPA examines the ingredients of a pesticide; the site or crop on which it is to be used; the amount, frequency and timing of its use; and storage and disposal practices. EPA evaluates the pesticide to ensure that it will not have unreasonable adverse effects on humans, the environment and non-target species. A pesticide cannot be legally used in the United States if it has not been registered with EPA's Office of Pesticide Programs. Most states also have state registration programs which preclude the sale, distribution, or use of a pesticide unless the pesticide is registered in that specific state.

Since 1995, the EPA has made the registration of alternatives to MeBr a high registration priority. MeBr alternatives enter the science review process as soon as EPA receives the application and supporting data rather than waiting in turn for the EPA to initiate its review. Under the new Pesticide Registration Improvement Act, in 2006, applications for registration of new active ingredients must be reviewed within 24 months of the receipt of a complete application. Applications for registration of new uses of already-registered active ingredients must be reviewed within 21 months of receiving a complete application.

An additional incentive for the pesticide industry to develop alternatives to MeBr, the Agency has worked to reduce the burdens on data generation, to the extent feasible, while still ensuring that the Agency's registration decisions meet the Federal statutory safety standards. Where appropriate, the Agency has refined the data requirements for a given pesticide application, allowing a shorter research and development process for the MeBr alternative. Furthermore, Agency scientists routinely meet with prospective MeBr alternative applicants, counseling them through the registration process to increase the probability that the data is done right the first time and rework delays are minimized

Since 1997, the United States has registered several alternatives for "niche" uses of MeBr. These registrations include:

- 2000: Phosphine to control insects in stored products
- 2001: Halosulfuron to control weeds in melons
- 2001: Indian Meal Moth Granulosis Virus to control insects in stored products
- 2001: 1,3-Dichloropropene to be applied via drip applications
- 2002: Halosulfuron to control weeds in selected fruiting vegetables
- 2003: s-Metolachlor to control weeds in tomatoes
- 2003: Trifloxysulfuron-methyl to control weeds in tomatoes
- 2004: Sulfuryl Fluoride to control insects in stored grains, dried fruit, nuts, and grain mills
- 2004: Fosthiazate to control nematodes in tomatoes
- 2005: Sulfuryl Fluoride to control insects in food processing facilities

MeBr alternatives that are currently under consideration in the EPA registration process include:

- Iodomethane as a pre-plant soil fumigant for tomato, strawberry, pepper, and ornmentals.
- Dazomet as a pre-plant soil fumigant for strawberries and tomatoes.
- Furfural as a pre-plant soil fumigant for cut flowers, propagative materials, ornamentals, turfgrass, golfcourses, sod farms, ad sports fields.

- Sodium azide as a pre-plant soil fumigant for ornamental nurseries, sod farms, and turf renovation on golf courses.

It is important to note that some of the existing MeBr alternatives are undergoing evaluation by US EPA. EPA's goal in evaluating the soil fumigants is to ensure safety and maintain their benefits to agriculture. EPA plans to develop risk management decisions for five soil fumigant pesticides:

- chloropicrin
- dazomet
- metam sodium
- methyl bromide, and
- a new active ingredient, iodomethane

These decisions, which are expected in late 2006, may affect the use of MeBr and these other alternatives.

Chapter V. Clean Air Act Regulation of MeBr

Methyl bromide was added to the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) as an ozone depleting substance in 1992 through the Copenhagen amendment to the Protocol. The Parties agreed that each industrialized country's level of MeBr production and consumption in 1991 should be the baseline for establishing a freeze in the level of MeBr production and consumption for industrialized countries. Through subsequent Decisions, the Parties have authorized critical use exemptions.

The domestic implementation of the Montreal Protocol is through the Clean Air Act (CAA). The current regulatory requirements of the Stratospheric Ozone Protection Program that limit production and consumption of ozone depleting substances can be found at 40 CFR Part 82 Subpart A. The regulatory program was originally published in the Federal Register on August 12, 1988 (53 FR 30566), in response to the 1987 signing and subsequent ratification of the Montreal Protocol on Substances that Deplete the Ozone Layer (Protocol). The U.S. was one of the original signatories to the 1987 Montreal Protocol and the U.S. ratified the Protocol on April 12, 1988. The Clean Air Act Amendments of 1990 (CAAA of 1990) were enacted and signed into law. They included Title VI on Stratospheric Ozone Protection, codified as 42 U.S.C. Chapter 85, Subchapter VI, to ensure that the United States could satisfy its obligations under the Protocol. EPA issued new regulations to implement this legislation and has made several amendments to the regulations since that time.

Methyl bromide is controlled under the CAA as a Class I ozone depleting substance (ODS). Additional details about the uses of MeBr can be found in the proposed rule on the phase-out schedule for MeBr published in the Federal Register on March 18, 1993 (58 FR 15014) and the final rule published in the Federal Register on December 10, 1993 (58 FR 65018).

At their 1995 meeting, the Parties made adjustments to the MeBr control measures and agreed to reduction steps and a 2010 phase-out date for industrialized countries with exemptions permitted for critical uses. At that time, the U.S. continued to have a 2001 phase-out date in accordance with the CAAA of 1990 language. At their 1997 meeting, the Parties agreed to further adjustments to the phase-out schedule for MeBr in industrialized countries, with reduction steps leading to a 2005 phase-out for industrialized countries. In October 1998, the U.S. Congress amended the CAA to prohibit the termination of production of MeBr prior to January 1, 2005, to require EPA to bring the U.S. phase-out of MeBr in line with the schedule specified under the Protocol, and to authorize EPA to provide exemptions for critical uses. These amendments were codified in Section 604 of the CAA, 42 U.S.C. 7671c. On November 28, 2000, EPA issued regulations to amend the phase-out schedule for MeBr and extend the complete phase-out of production and consumption to 2005 (65 FR 70795).

The revised phase-out schedule was again amended to allow for an exemption for quarantine and preshipment purposes on July 19, 2001 (66 FR 37751) with an interim final rule and with a final rule (68 FR 238) on January 2, 2003.

Starting in 2002, EPA began notifying applicants as to the availability of an application process for a critical use exemption to the MeBr phase-out. The Agency published a notice in the

Federal Register (68 FR 24737) announcing the deadline to apply, and directing applicants to announcements posted on EPA's MeBr website at *www.epa.gov/ozone/mbr*. This process has been repeated on an annual basis since then. The critical use exemption is designed to meet the needs of MeBr users who do not have technically and economically feasible alternatives available to them.

In response to the yearly requests for critical use exemption applications published in the Federal Register, applicants have provided information supporting their position that they have no technically and economically feasible alternatives to MeBr available to them. Applicants for the exemption have submitted information on their use of MeBr, on research into the use of alternatives to MeBr, on efforts to minimize use of MeBr and efforts to reduce emissions and on the specific technical and economic research results of testing alternatives to MeBr.

On December 23, 2004 (69 FR 76982), EPA published a final rule in the Federal Register that established the framework for the critical use exemption; set forth a list of approved critical uses for 2005; and specified the amount of MeBr that could be supplied in 2005 from available stocks and new production or import to meet approved critical uses. In EPA's recently published regulation describing the operational framework for the critical use exemption (69 FR 76982) the majority of critical uses for the 2005 calendar year were established.

Similar efforts will occur for successive control periods for which a CUE nomination is made and approved.

When reviewing CUE applications, the Agency has rejected increases in requested amounts related to increase in production area, unless that area existed before 2001/2002 and utilized MeBr for pest control under limiting critical conditions, but was simply not reflected in a previous application.

As set out in the U.S. regulations, an approved critical user is an entity who meets the following requirements:

> (1) for the applicable control period, applied to EPA for a critical use exemption or is a member of a consortium that applied to EPA for a critical use exemption for a use and location of use that was included in the U.S. nomination, authorized by a Decision of the Parties to the Montreal Protocol, and then finally determined by EPA in a notice and comment rulemaking to be an approved critical use, and
>
> (2) has an area in the applicable location of use that requires methyl bromide fumigation because the entity reasonably expects that the area will be subject to a limiting critical condition (LCC) during the applicable control period, if an LCC is given in Appendix L.

A "limiting critical condition" is the basis on which the critical need for MeBr is authorized. It is defined as "the regulatory, technical, and economic circumstances . . . that establish conditions of critical use of methyl bromide in a fumigation area." 40 CFR 82.3. The limiting critical condition placed on a use category reflects certain regulatory, technical or economic factors that

either prohibit the use of alternatives or represent the lack of a technically or economically feasible alternative for that use or circumstance.

Data submitted by the CUE applicants serve as a basis for each nomination. EPA and other government experts also seek data from multiple other sources, including but not limited to the National Agricultural Statistics Service of the U.S. Department of Agriculture, the State of California Department of Pesticide Regulation, and proprietary agricultural databases available to EPA. All of the CUE applications undergo a rigorous review by highly qualified technical experts. A detailed explanation of the nomination process, including the criteria used by expert reviewers, is available in a memo titled "2003 Nomination Process", accessible through http://www.regulations.gov, Environmental Protection Agency Docket ID OAR-2005-0122, document number 0037.

Chapter VI. Critical Use Sectors

Fourteen sectors in the United States are currently working under Critical Use Exemptions (CUEs) for MeBr. Four nursery (plants for propagation) and seven crop production sectors comprise the pre-plant CUEs. Additionally, three general areas of commodity and facility pest control comprise the post-harvest CUEs.

Pre-Plant		Post-Harvest
Nursery	Production	
Forest Nursery Seedlings Fruit, Nut and Flower Nurseries Strawberry Runner Turfgrass Sod Nursery	Cucurbit Eggplant Orchard Replant Ornamentals Pepper Strawberry Fruit Tomato	Commodities Walnuts Dried beans Dried plums Figs Raisins Dates Pistachios Dry Cured Pork Products Food Processing (Facilities)

Phytosanitary requirements are generally quite restrictive for the nursery uses. As propagative plant material, they must be essentially free of foreign matter, weeds, diseases, nematodes and other pests. Often, alternative treatments are difficult to qualify as being as effective as MeBr. In some instances, market requirements are substantially similar to quarantine requirements, and much of the produce for local use is indistinguishable from material to be shipped under QPS and cannot be segregated at time of treatment. Many of the CUE requests are intended to treat the portion of the crop that does not strictly qualify for QPS, and for which a technically and economically feasible alternative treatment does not exist.

Pre-plant production uses of MeBr that have qualified under the CUE process are generally listed because available alternatives do not control one or more pests faced by the growers of these crops. Much of the production in the southeastern United States must battle soil-borne diseases, nematodes and weeds, such as yellow and purple nutsedge. Although MeBr alternatives exist for many of the nematode and disease combinations, cost-effective control of weeds is a limiting factor for tomato, strawberry, pepper, curcurbit and eggplant production. Labor costs in the United States make hand-weeding cost prohibitive as a primary weed control technique. Hand-weeding of herbicide-treated plots is considered a last resort to avoid significant economic loss. The plasticulture system of raised-bed vegetable production developed in the 1960s and 70s has succeeded in minimizing the impact of weeds as long as effective nutsedge control is possible. Methyl bromide has provided such control. Currently available herbicides compatible with tomato production prevent the planting of a second crop into the bed due to phytotoxicity (i.e. follow-crop injury). The inability to plant a second crop dramatically impacts the economic viability of producing both tomatoes and other vegetable crops such as melons and other cucurbits in the Southeast.

In the post-harvest sector, many uses for which alternatives are labeled have successfully shifted from MeBr. These uses have been successful where the length of treatment time was not a constraint on existing facilities, and where vulnerable equipment that might be damaged by heat (e.g. electronic equipment) or phosphine (e.g. exposed electrical equipment) are not present. In instances where fumigation throughout is critical, such as during harvest, certain commodity processors remain dependent on MeBr to handle the high production levels necessary to keep pace with field-harvesting. Subsequent treatments of stored commodity at these facilities are often feasible with alternatives without substantial capital investment, but this is not the case for initial treatments when commodities are received from the field.

For high-value commodities that are exported, internationally recognized maximum residue limits (MRLs) are necessary to ensure the unrestricted flow into offshore markets. The absence of such regulatory approvals renders treated product unacceptable. Regulatory acceptance of commodities treated with MeBr, have been in place for international trade for many years. The ability to use at least one potential MeBr alternative is dependent on sufficient countries recognizing the MRL as being acceptable on imported commodities.

Over the past ten years, the United States has committed significant financial and technical resources to the goal of seeking alternatives to MeBr that are technically and economically feasible to provide pest protection for a wide variety of crops, soils, and pests, while also being acceptable in terms of human health and environmental impacts. To date, the U.S. Department of Agriculture has spent over $200 million in research and outreach related to alternatives for the crops on which MeBr is currently used. In addition, various farm consortia and universities have expended significant efforts to find alternatives. It is estimated that private research and development expenditures to identify MeBr alternatives have equaled or exceeded USG expenditures.

The U.S. pesticide registration program has established a rigorous process to ensure that pesticides registered for use in the United States do not present an unreasonable risk of health or environmental harm. Within the program, the USG has given the highest priority to rapidly reviewing MeBr alternatives, while maintaining our high domestic standard of environmental protection. The resulting research program has taken into account these inputs, as well as the extensive private sector research and trial demonstrations of alternatives to MeBr. While research has been undertaken in all sectors, federal government efforts have been based on the input of experts as well as the fact that nearly 80 percent of pre-plant MeBr soil fumigation is used in a limited number of crops. Accordingly, much of the federal government pre-plant efforts have focused on strawberries, tomatoes, ornamentals, peppers and nursery crops, (forest, ornamental, strawberry, pepper, tree, and vine), with special emphasis on tomatoes in Florida and strawberries in California as model crops.

The USDA/ARS strategy for evaluating possible alternatives is to first test the approaches in controlled experiments to determine efficacy, then testing those that are effective in field plots. The impact of the variables that affect efficacy is addressed by conducting field trials at multiple locations with different crops and against various diseases and pests. Alternatives that are effective in field plots are then tested in field scale validations, frequently by growers in their own fields. University scientists are also participants in this research. Research teams that

include ARS and university scientists, extension personnel, and grower representatives meet periodically to evaluate research results and plan future trials.

Recently registered pesticides with registrations that make them potential methyl bromide alternatives are listed in Section IV of this document. EPA is currently reviewing several additional applications for registration as MeBr alternatives, including:

- Iodomethane as a pre-plant soil fumigant for strawberries, tomatoes, peppers and ornamentals.
- Dazomet as a pre-plant soil fumigant for strawberries and tomatoes.
- Furfural for use in greenhouses for cut flowers, propagative materials, ornamentals, and other non-food/non-feed commodities; outdoors for cut flower production, production nurseries, residential and commercial landscapes, residential and commercial turf, golf courses, sod farms, and sports fields.
- Sodium Azide is pending registration on the following use sites -- ornamental nurseries, sod farms, and turf renovation on golf courses.

While these activities appear promising, it must be noted that issues related to toxicity, ground water contamination, and the release of air pollutants may pose significant problems with respect to some alternatives that may lead to use restrictions since many of the growing regions are in sensitive areas such as those in close proximity to residential areas. There are a wide range of potential restrictions at both the national and state level that can be imposed including handling requirements, personal protective equipment, buffer zones, limitations on use in certain soil types, caps on use in certain geographical areas, and other restrictions as well. Indeed, it is possible that a substance may not be registered if it is deemed to have severe human health or environmental impacts. Given the enormous range of potential outcomes for alternatives, and for that matter for MeBr and chloropicrin which are being re-registered, it is not possible to provide estimates of potential reduced need for MeBr until after the precise regulatory restrictions and market conditions are known.

Ongoing research on alternative fumigants is evaluating ways to reduce emission under various application regimes and examining whether commonly used agrochemicals, such as fertilizers and nitrification inhibitors, could be used to rapidly degrade soil fumigants.

Remaining regional-crop specific pest problems

A number of alternatives have already been registered for use, and several additional promising alternatives are under review at this time. Research efforts to find new alternatives to MeBr and move them quickly toward registration and commercialization have allowed growers and users to make great progress over the last decade in phasing out many uses of MeBr. Through all of this research, it has become increasingly clear that no one existing alternative can replace MeBr in all of its uses. There are no effective alternatives for all crops, soil types and pest pressures as evidenced by the CUE sectors listed below. Accordingly, the USG has submitted a critical use nomination to address these limited needs.

General description of CUE sectors

Rigorous review by the USG narrowed the list of requested uses based on the availability of technically and economically feasible alternatives. The thorough and comprehensive review that created the U.S. nomination entailed multiple levels of analysis with teams of biologists and economists. In addition, the recommendations of these reviews were evaluated whether or not there was a critical need for MeBr, based on the criteria agreed to by the Parties of the Montreal Protocol. The following CUE were nominated by the USG and approved by the Parties to the Protocol:

1. Pre-plant Soil Uses: Cucurbits – field; Eggplant – field; Forest nursery seedlings; Fruit, Nut and Flower Nurseries - Chrysanthemum cuttings, rose plants (nursery), fruit tree nurseries, strawberry runners; Orchard replant; Peppers – field; Strawberry fruit – field; Tomato – field; Turfgrass sod nurseries.
2. Post-harvest uses: Commodities- Dried fruit, beans and nuts; Food processing facilities - mills and processors; Smokehouse ham;

For each sector, there is a brief discussion of the research efforts to develop alternatives that, if successful, will allow the use of MeBr to be reduced over time. The section also lists what actions are underway to minimize the MeBr emissions.

Pre-Plant Soil Uses

Cucurbits: (squash, melons, and cucumber)

Key Pests are soil borne fungi *Phytophthora capsici* and *Fusarium oxysporum*, and nutsedge. The only currently available MeBr alternative that is technically feasible for the control of the first two key target pests is 1,3-D + chloropicrin. Regulatory restrictions due to concerns over human exposure and ground water contamination, along with the lower yields, result in economic infeasibility of this formulation as a practical MeBr alternative under certain circumstances. Key among these factors are a delay in planting up to 14 days relative to MeBr, due to a combination of label restrictions, low soil temperatures, as well as a mandatory 30 m buffer for treated fields with 1,3-D + chloropicrin near inhabited structures. Metam-sodium offers some control of nutsedges and nematodes; however, in areas where nutsedge infestations are moderate to severe and fungal pathogens are present, metam-sodium results in an estimated 44 % yield loss relative to MeBr. Yield losses and regulatory restrictions render these promising MeBr alternatives technologically and economically infeasible.

Future Plans for reducing Methyl Bromide use in Cucurbits:
1,3-D + chloropicrin, metam-sodium, furfural, propylene oxide, and sodium azide will continue to be the subjects of field studies of utilization and efficacy enhancement where *Phytophthora* and *Fusarium* fungi are the target pests. It should be kept in mind that furfural, propylene oxide, and sodium azide are currently unregistered for use on cucurbits, and there are presently no commercial entities pursuing registration in the U.S. The regulatory restrictions on 1,3-D will also remain as negative influences on the economics of this MeBr alternative.

The timeline for developing the above-mentioned MeBr alternatives in Michigan (by Michigan State University) is as follows:
2003 – 2005: Test for efficacy (particularly against the more prevalent *Phytophthora* fungi)
2005 – 2007: Establish on-farm demonstration plots for effective MeBr alternatives
2008 – 2010: Work with growers to implement widespread commercial use of alternatives demonstrated to be effective.

Research is also under way to evaluate the feasibility and optimize the use of a 50% MeBr: 50% chloropicrin formulation to replace the currently used 67:33 formulation. In addition, field research is being conducted to optimize a combination of crop rotation, raised crop beds, black plastic and foliar fungicides. Use of virtually impermeable film (VIF) will also be investigated as a replacement for the currently used low density polyethylene (LDPE). All research is to be conducted by Michigan State University staff in collaboration with commercial cucurbit growers, and if demonstrated effective, these films could potentially reduce the future need for MeBr in this sector.

In the Southeastern U.S., research has been conducted on nutsedge control with halosulfuron, 1,3-D + chloropicrin, and metam-sodium. Future research will focus on halosulfuron and crop rotation for control of nutsedges. Approximately 3 to 5 years are expected as a timeframe for developing effective MeBr alternatives for nutsedge control in cucurbits. Research will be conducted in cooperation with commercial cucurbit growers, by faculty and extension staff at

various land-grant universities in the states encompassed by this region. Also, it is reasonable to expect that the results from Michigan research on fungicidal alternatives to MeBr will be used to develop options for fungal pests of southeastern U.S. cucurbits.

Future plans to minimize MeBr use also include:

(1) Using research and on-farm evaluations to optimize a combination of nutsedge control in fallow fields, crop rotation, and use of post-emergent herbicide in crops. Herbicides will include halosulfuron, sulfentrazone, and glyphosate.

(2) Optimize the combined use of plastic (e.g. LDPE) tarps and drip irrigation equipment for applying at-plant herbicides.

Eggplant

Methyl bromide is the only fumigant that consistently provides reliable control of target weeds, nematodes, and pathogens. The best alternatives (e.g. 1,3-D + chloropicrin, metam sodium) are not as effective in controlling nutsedge and have a long waiting period for planting (28 days) that would disrupt planting schedules and cause growers to miss key market windows. Regulatory restrictions (30.4 m buffer for treated fields near inhabited structures) due to concerns over human exposure and ground water contamination, along with technical limitations, result in potential economic infeasibility of 1,3-D alone or in combination as a practical MeBr alternative.

Future Plans for reducing Methyl Bromide use in Eggplant:
Iodomethane is under consideration as a potential MeBr replacement; it is unknown when it will be registered at the federal or State level, or what types of regulatory restrictions may be associated with its use. Given the considerable uncertainty associated with the timing and conditions of its registration, and the concurrent regulatory consideration of MeBr, it isn't possible to determine the extent of applicability of iodomethane to this crop, or the timing of phase in. The economic feasibility of this product is also impossible to ascertain at this time because there is no market price for the material in the United States. Nevertheless, registration of this product may provide an important additional pest control tool to farmers that could result in reducing the amount of critical use MeBr needed for this sector.

In addition, the following new long-term studies have been initiated at the Coastal Plain Experiment Station in Tifton, Georgia, with funding provided by USDA-CSREES, Methyl Bromide Transitions Grant:

- Evaluation of the effects of soil conditions, particularly soil temperature and moisture, on nutsedge species efficacy from several fumigants.
- Investigation of the impact of multiple-season adoption of MeBr alternatives in terms of pest species composition, including weeds, diseases, and nematodes.
- Integration of multiple tactics as alternatives to MeBr for management of weeds, diseases, and nematodes in pepper and eggplant.
- Evaluation of vegetable crop response to herbicides applied under plastic prior to crop transplants and characterize herbicide fate when applied in a plasticulture system between summer and fall crops.

Forest Seedlings

Nurseries in the U. S. are located in eight climate zones, mostly with light or medium soils. The majority of seedlings are species of conifers, and 30-40 species of hardwoods, such as oaks, hickory, poplars, and ash. Forest nurseries throughout the U. S. must contend with a variety of pests. Effective fumigation is primarily relied on to manage fungal pathogens and especially, yellow and purple nutsedges. Economic issues, such as increased application costs, have an impact on overall feasibility of alternatives (metam-sodium and chloropicrin) for the forest seedlings sector.

Future Plans for reducing Methyl Bromide use in Forest Seedlings:
Combinations of chemicals, such as chloropicrin, metam-sodium, or 1,3-D appear to be effective for some nurseries in reducing pest infestations, including some weed problems. Combinations of these compounds and application techniques (such as deep injection) to achieve the same pest control efficiencies as MeBr are being studied. So far, none have proven cost effective and have generally resulted in an increased input of other pest control products. Physical limitations (e.g. low vapor pressure of metam-sodium) lead to the lack of consistency of these products. Tests are being conducted with iodomethane, which has potential as a MeBr replacement, although it is unknown when registration might occur, and what the associated regulatory conditions of that registration at both the federal and state levels might be.

The use of virtually impermeable film (VIF) may offer a means of reducing MeBr use rates while maintaining efficacy and production goals. Work is being conducted to determine if this type of film is feasible in the U.S. from a technical standpoint and to determine if it is economically feasible; however, California does not permit the use of VIF, so it will not be possible to use it there. There is also interest in examining the effects of certain fertilizer salts (e.g. ammonium thiosulfate) which may act as barriers to volatile compounds (e.g. 1,3-D and MeBr) when applied to the soil surface, thus reducing emissions and improving efficacy. The reduction of MeBr from 98:2 to 65:35 or even 50:50, the reduction in use rate, increased periods of cover crop growth, use of glyphosate, and an increased use of mechanical cultivation may be effective in reducing weed populations, and the overall use of MeBr; however, such treatments need to be confirmed under commercial growing conditions. Experiments have indicated that some soil amendments can reduce possible adverse growth effects of some MeBr alternatives (e.g. dazomet). Work in Wisconsin suggested that white pine seedlings subjected to dazomet, but supplied with various nutrients, could reduce chlorosis sometimes observed in dazomet treated beds. Large scale trials will be necessary to confirm this effect. For disease control, studies comparing cultivation practices, such as conventional till versus no-till and organic amendments indicate that effects vary according to the species grown, thus each nursery may have to consider alternatives with species and local environmental conditions in mind, unlike the more consistent effects of MeBr fumigation.

Fruit, Nut and Flower Nurseries

Under California regulatory laws, nursery crops must be "free of especially injurious pests and disease symptoms" in order to qualify for a California Department of Food and Agriculture (CDFA) Nursery Stock Certificate for Interstate and Intrastate Shipments. There are no effective alternatives that can ensure certification.

Future Plans for reducing Methyl Bromide use in Fruit, Nut and Flower Nurseries:
Raspberry nurseries have spent $100,000 on research, including $20,000 on screening resistance for *Phytophthora* and *Verticillium*, and over $60,000 over the last decade studying various alternatives in the Watsonville, California area. Studies are also ongoing to discover how application methods can improve efficacy of chemical alternatives such as 1,3-D and metam-sodium, and mixes of chemicals. Moisture constraints, both too much and too little, can reduce efficacy of effective chemicals such as 1,3-D, especially when soil textures are not optimal for their physical chemistry. Iodomethane is a potential replacement for MeBr, but is not registered in the U.S. The use of virtually impermeable film (VIF) may offer a means of reducing fumigant use rates while maintaining efficacy and production goals, although VIF use is currently prohibited in California. There is also interest in examining the effects of certain fertilizer salts (e.g. ammonium thiosulfate) which may act as barriers to volatile compounds (e.g. 1,3-D and MeBr) when applied to the soil surface, thus reducing emissions and improving efficacy.

Between 1999 and 2000, the California fruit, vine, and nut industries have spent $378,467 on numerous research projects. From 2002-2003, researchers were granted $262,002 by this industry to study alternatives. In addition, an equal amount of funding has been granted to these industries by government and universities.

Research on MeBr alternatives has been conducted by the nursery industry since at least 1990, initially to find alternatives to 1,3-D, whose registration had been cancelled in California. Upon reinstatement of the 1,3-D registration in 1994, studies began to examine 1,3-D formulations that could provide acceptable nematode control under conditions (especially critical moisture conditions) common to commercial nursery sites that would meet certification requirements and reduce or replace the use of MeBr. Successful treatment with 1,3-D depends on enough surface moisture to retain effective fumigant concentration, but with a maximum of 12% soil moisture throughout the rest of the soil profile to facilitate optimal fumigant distribution. Studies with new emulsifiable formulations of 1,3-D and chloropicrin, such as Inline, may improve efficacy by improving fumigant distribution beyond the limitations currently associated with shank injection techniques. However, township caps, buffer zones, and limitations due to physical characteristics of soils are still important issues to successful nursery production. The Nursery Rose industry is developing technologies to improve efficacy of alternatives such as deep injection methods, soil moisture management by improving drip technologies, experience with virtually impermeable films (VIF) to increase efficacy and decrease emissions. Between 2001 and 2003, $60,000 was devoted to nursery rose alternatives research at USDA and on-farm research. A rose nursery trial conducted for two years resulted in rootknot nematode control comparable to MeBr with the use of tarped Telone C35. However, soil moisture and township caps will limit use of 1,3-D, and the cost of tarping can significantly increase prices of nursery stock.

Orchard Replant

The Orchard Replant sector represents stone fruit, almond, and walnut orchards, and table grape and raisin vineyards in California. The key pest, "orchard replant problem" (or syndrome), is characterized by poor tree growth during the early years of establishment (rejection component) and in some cases a slow and detrimental decline in root health and plant growth caused primarily by pathogenic nematodes and fungi. A pre-plant fumigation occurs only once in the life of the orchard, and therefore, the most cost-effective but deep penetrating treatment is sought by growers. The primary alternative, 1,3-D, has regulatory restrictions on its use and application rate, including township caps in California, and reduced rates that are considered ineffective for some severe replant situations.

Future Plans for reducing Methyl Bromide use in Orchard Replant:
The development of technologies to improve efficacy of alternatives, such as deep injection methods, soil moisture management by improving drip technologies, use of fallow, crop rotation, tolerant rootstocks, and improved experience with chemical/non-chemical combinations, is underway. Even where MeBr is considered critical, an improvement in efficient delivery techniques will result in reduction of MeBr use requirements. Considering that this sector uses MeBr only once in the life of the orchard, use of alternatives to replace MeBr will have to be considered in light of the long-term impact on tree and vine health, as well as fruit and nut production. There are several approaches that can help address MeBr alternatives for almonds, as well as walnuts, grapes, and stone fruit; use of herbicides to kill remnant roots, use of fallow and crop rotations, use of "virgin" soil as an amendment to possibly reduce replant problem, resistant rootstocks when available, irrigation regimes to improve consistency of metam-sodium, etc.

Ornamentals

Florida and California field grown ornamentals include bulbs, cut flowers, and cut foliage. It is a labor intensive industry characterized by high costs of production (land, labor, energy and other inputs), urban encroachment, intense cropping systems, rapidly changing market demands and high risk. It is plagued by a pest spectrum in the soil that includes nematodes, soil-borne pathogens and weeds that must be controlled without delaying production or harming the crops.

Weeds, especially nutsedge, tend to be particularly difficult to control and are a limiting factor in replacing MeBr. Once weeds emerge, contact herbicides cannot be used without damaging the crop and hand weeding is cost prohibitive on a large scale. Soil persistent pre-emergent herbicides cannot be used without risk to the current crop or subsequent plantings. Comprehensive phytotoxicity studies can not be conducted due to the large number of crops, numerous varieties within crops, and the regular introduction of new varieties through aggressive breeding programs.

MeBr has been the industry standard for soil fumigants because it works well across the entire pest spectrum, it works consistently and is environmentally safe on all soil types, is applied safely by expert applicators, is not a threat to human health and safety as currently applied, and leaves no residue that can interfere with the intense multi-cropping and breeding practices of the field grown ornamentals industry. The alternatives currently identified do not meet these criteria, even if they were available to and economical for ornamentals growers. MeBr use has declined and emissions reduced through formulation changes, tarping after application and use of alternative control measures. Although MeBr use has been reduced, it cannot be eliminated with the existing alternatives.

Chemical alternatives include 1,3-D, chloropicrin, metam sodium and their combinations. None of these alternatives provide sufficient control over the entire pest spectrum when used either alone or in combination. All have use restrictions imposed by local, state and federal agencies due to environmental risks and potential human exposure. These chemicals are also undergoing re-registration review by U.S. EPA; registrations may be lost or additional restrictions may be imposed, further limiting their usefulness to growers. Non-chemical alternatives do not provide the level or consistency of control, are too expensive, or are not compatible with current production practices. As discussed previously, weed control is also a limiting factor.

Another major factor affecting the search for MeBr alternatives is the need for flexibility in the types of crops produced. Growers must be able to respond to rapidly changing market demands. Growers must respond to peak demands, such as holidays, as well as to changing consumer preferences. They cannot afford planting or harvest delays, or production uncertainties due to unpredictable pest control.

Future Plans for reducing Methyl Bromide use in Ornamentals:
Research efforts are difficult because this is a relatively small industry, commercial acreage available for testing is limited, and the crops and cropping systems are complicated, requiring large testing programs to be representative of the industry. Regardless, the field grown ornamental industry has supported public and private research and has performed in-house

testing. Research has included registered pesticides, pesticides in various stages of development (including biologicals), and non-pesticidal treatments.

The research strategy of the field grown cut flower industry is to continue to investigate ways to use existing chemicals and non-chemical methods, as first priority. This strategy includes looking at different application techniques, product combinations and multi-year programs using existing chemicals; investigating various barrier films to use for emissions reduction, solarization and optimizing pesticide efficacy; and, testing biological control agents and other non-chemical alternatives in integrated programs when feasible. However, the industry has already devoted extensive, and expensive, effort and resources to these lines of investigation and the existing alternatives do not, singly or in combination, meet the industry's needs.

The next level of investigation includes testing registered products that are seeking label expansion into field grown ornamentals or non-registered products that fit into and are being developed for this market. The best example of the latter is iodomethane. However, these alternatives remain unproven at this time, are unregistered, and cannot be viewed at present as economically or technically feasible until research and commercial trials confirm their viability.

Field grown ornamental growers will continue to look for efficacious and economical means to produce their crops and are committed to continuing to support efforts to find MeBr alternatives. Existing chemical alternatives pose greater risks than MeBr – risks of crop failure, environmental risks and human health risks. Continued reduction in MeBr use can not progress much further until viable alternatives are available.

Peppers

Key pests are soil fungi *Phytophthora capsic*i and nutsedge. A viable alternative for susceptible fungi is the combination of 1,3-D + chloropicrin; however, regulatory restrictions (mandatory 30 meter buffer) due to concerns over human exposure and ground water contamination, planting delays of up to 28 days, along with technical limitations, result in potential economic infeasibility of this formulation as a practical MeBr alternative. Also, 1,3-D, cannot be used when soils are very wet. The alternative for nutsedge control, metam-sodium, has resulted in yield losses of up to 44% compared to MeBr where weed infestations are moderate to severe.

Future Plans for reducing Methyl Bromide use in Peppers:
Although alternatives for methyl bromide in the circumstances of the U.S. nomination remain technically and economically infeasible, research into MeBr alternatives is beginning to show some promising results and USG scientists now anticipate that transition away from MeBr will be possible in some cases over the next five to ten years. Some conditions in each of the growing areas limit the extent to which, with alternatives available in the foreseeable future, the transition can be completed. The future plan described for each region below are estimated based on the current regulatory status of methyl bromide and other alternatives. Should the regulatory status of these chemicals change as a part of the reregistration process, it could impact some of these estimates.

In Michigan, due to the cold soil temperatures and the very short growing season, there does not, at present, appear to be any combination of alternatives that can replace MeBr and still allow an economically viable crop production.

In California the major impediment to adoption of the preferred alternative to MeBr (combinations of 1,3-dichloropropene and chloropicrin) is the regulatory cap on the amount of 1,3-D used in each township. Experiments with lower rates and less permeable tarps (currently not legal in California) and better understanding of the conditions of metam sodium use should enable approximately 75% of pepper production to replace MeBr use over the next five years.

In Florida the major impediment to the adoption of the preferred alternative to MeBr (combinations of 1,3-dichloropropene and chloropicrin, sometimes followed by metam sodium) is the presence of heavy concentrations of nutsedge (nutgrass). An additional impediment is the presence of karst topography, which comprises approximately 40% of Florida agricultural land. This limits the use of 1,3-D. In Dade county the use of 1,3-D is not allowed by regulation. Experiments with metalized films in conjunction with the chemical treatments also showed promise although work in this area is still preliminary. Continued work in these areas is anticipated to allow up to 75% of Florida pepper production to replace MeBr over a period of ten years.

In Georgia the major impediment to the adoption of the preferred alternative to MeBr (combinations of 1,3-dichloropropene and chloropicrin, sometimes followed by metam sodium) is the presence of heavy concentrations of nutsedge (nutgrass). An additional impediment is the presence of karst topography, which comprises approximately 8% of Georgia agricultural land. This limits the use of 1,3-D. Experiments with metalized films in conjunction with the chemical

treatments also showed promise although work in this area is still preliminary. It is anticipated that continued work in these areas should allow up to 80% of Georgia pepper production to replace MeBr over a period of seven years.

In the southeastern U.S., comprising the States of Alabama, Arkansas, Louisiana, North Carolina, South Carolina, Tennessee, and Virginia, the major impediments to the adoption of the preferred alternative to MeBr (combinations of 1,3-dichloropropene and chloropicrin, sometimes followed by metam sodium) is the presence of heavy concentrations of nutsedge (nutgrass). Other weeds, particularly nightshade, are also present in abundance. There is scattered karst topography throughout the region that limits the use of mixtures containing 1,3-D. Experiments with metalized films in conjunction with the chemical treatments also showed promise although work in this area is still preliminary. Continued work in these areas is anticipated to allow up to 85% of pepper production in the southeastern United States to replace MeBr over a period of seven years.

New data on potential MeBr alternatives for use on peppers, submitted by the Georgia and Southeast U.S. Peppers Consortium, show that 1,3-D + chloropicrin, followed by more chloropicrin, was more effective than MeBr against yellow nutsedge, but less effective against purple nutsedge. Although this treatment performed as well as MeBr in terms of spring crop yield, its fall yield performance was inferior to that of MeBr. In a second treatment,1,3-D by itself, followed by chloropicrin, was significantly less effective than MeBr for the control of both purple and yellow nutsedge, but as effective as MeBr for the control of soil nematodes. In terms of spring and fall pepper yield, however, this treatment performed as well as MeBr. In a third treatment,1,3-D + chloropicrin, followed by metam sodium, was as effective as MeBr against yellow nutsedge, 36% less effective than MeBr against purple nutsedge, and as effective as MeBr for the control of soil nematodes. This treatment also performed as well as MeBr in terms of both spring and fall pepper yield. Although these combinations are showing promise, they will require further testing and validation under commercial conditions.

Iodomethane is under consideration as a potential MeBr replacement; it is unknown when it will be registered at the federal or State level, or what types of regulatory restrictions may be associated with its use. Given the considerable uncertainty associated with the timing and conditions of its registration, and the concurrent regulatory consideration of MeBr, it isn't possible to determine the extent of applicability of iodomethane to this crop, or the timing of phase-in. The economic feasibility of this product is also impossible to ascertain at this time because there is no market price for the material in the United States. Nevertheless, registration of this product may provide an important additional pest control tool to farmers that could result in reducing the amount of critical use MeBr needed for this sector.

Strawberries

In California, regulatory limits on the amount of 1,3-D that can be used in each township results in the continuing need for MeBr. In Florida and other eastern States, nutsedge is a primary pest on about 40 percent of the crop area, and the alternative can not be used on land that has karst topography. Where there is moderate to severe pest pressure, the suggested alternatives for strawberry fruit production fail to provide the necessary degree of pest control, or their use is not easily adoptable due to state-imposed restrictions. Applying alternatives is further complicated when plant-back restrictions prevent farmers from meeting marketing windows (e.g. winter or early spring) when strawberry sale prices are as much as 100% higher than during the rest of the year.

Future Plans for reducing Methyl Bromide use in Strawberry:
Positive results have been observed for replacing MeBr use with options such as 1,3- D + chloropicrin, metam-sodium, VIF tarps, etc. Growers will achieve further reductions in MeBr use where nutsedge is not a primary pest (representing about 60% of the industry) by changing the formulation to 57:43; this change can result in a 9% reduction in MeBr use. It may be feasible to use 50:50 mixtures with chloropicrin under plastic mulch beds to achieve further reductions, but this has not yet been demonstrated under local conditions. Increasing the percentage of Pic can occur with the fewest obstacles to implementation and can potentially reduce MeBr use up to 15% by 2007.

It is more difficult to accomplish comparable reductions by formulation changes in nutsedge infested regions, as experience has shown that MeBr dosages below 30.2 g/m^2 do not provide satisfactory nutsedge control. These growers will likely implement alternative methods, such as VIF or high barrier films that could reduce MeBr by one third. Ongoing research will help define the best approach. If the use of VIF or high barrier tarps proves effective, there is potential to significantly reduce MeBr use. The net effect would be a 28.4% reduction by 2007.

Strawberry Nursery

Methyl bromide is needed for strawberry nursery production to produce plants free of all damaging diseases and nematodes to meet state and foreign certification standards, as well as prospective buyer expectations. In addition to these certification-related pest control concerns, weed control is also essential to insure maximum runner production and prevent the spread of noxious weeds. The available alternatives have thus far not been found to provide acceptable levels of control of the key pests to depths of three feet.

Future Plans for reducing Methyl Bromide use in Strawberry Nursery Production:
Results of ongoing research suggest that there are treatments for strawberry nurseries that may have the potential to replace MeBr in the future. Iodomethane plus chloropicrin, chloropicrin followed by dazomet, and Telone C35 (1,3-D + chloropicrin) followed by dazomet are being investigated as potential MeBr replacements in strawberry nurseries. The industry supports research to identify the most effective methods to treat soil. After possibly five years of research trials, scale-up trials on a commercial level will be done to confirm the most effective treatments found in research trials. Combinations of several chemical and non-chemical controls are likely to be the most effective alternative to MeBr, but their ability to provide the same level of consistent control must be tested and demonstrated before MeBr can be replaced.

Tomatoes

The key pest pressure is moderate to high nutsedge in the Southeastern U.S. Regulatory constraints due to the presence of karst geology and delay in planting and harvesting (the plant-back interval for 1,3-D + chloropicrin is two weeks longer than MeBr + chloropicrin) limit the use of alternatives. There are additional delays in areas with cold climates where the soil temperatures must be higher to fumigate with alternatives. Such delays result in users missing key market windows, and adversely affect revenues through lower prices.

Future Plans for reducing Methyl Bromide use in Tomatoes:
Although alternatives for MeBr in the circumstances of the U.S. nomination remain technically and economically infeasible, research into MeBr alternatives is beginning to show some promising results and USG scientists now anticipate that transition away from MeBr will be possible in many cases over the next five to ten years. Some conditions in each of the growing areas limit the extent to which, with alternatives available in the foreseeable future, the transition can be completed.

In Michigan, due to the cold soil temperatures and the very short growing season, there does not, at present, appear to be any combination of alternatives that can replace MeBr and still allow an economically viable crop production.

In California, the major impediment to adoption of the preferred alternative to MeBr (metam sodium) is the hilly terrain in which the tomatoes are grown. (When tomatoes are grown in flat terrain, 1,3-D or 1,3-D and chloropicrin combinations can be used as long as the regulatory cap on the amount of 1,3-D used in a township is not exceeded. These areas are not part of the U.S. nomination.) Until the problem of uneven distribution of the pest control agent in hilly terrain is solved, the USG does not foresee adoption of 1,3-D or 1,3-D + chloropicrin combinations as alternatives.

In the southeastern U.S., comprising the States of Alabama, Arkansas, Florida, Georgia, Louisiana, North Carolina, South Carolina, Tennessee, and Virginia, the major impediments to the adoption of the preferred alternative to MeBr (combinations of 1,3-dichloropropene and chloropicrin, sometimes followed by metam sodium) is the presence of heavy concentrations of nutsedge (nutgrass). Other weeds, particularly nightshade, are also present in abundance. There is scattered karst topography throughout the region, ranging from approximately 40% of Florida agricultural land to 8% of Georgia agricultural land, to lesser amounts in the other States. The presence of karst topography limits the use of mixtures containing 1,3-D. Experiments with metalized films in conjunction with the chemical treatments have also showed promise although work in this area is still preliminary. Continued work in these areas is anticipated to allow up to 80% of tomato production in the southeastern United States to replace MeBr over a period of eight years.

Turfgrass Sod Nursery

Methyl bromide is the only treatment that consistently provides effective control of off-type perennial grasses, as well as nutsedge and other weeds, nematodes, and insect pests. Sod certification programs operate on a state or regional level, some of which specifically require MeBr fumigation as a condition for certification. Alternatives, such as dazomet and metam-sodium, are unreliable and do not provide the degree of consistent pest control needed by the industry to meet market demands.

Future Plans for reducing Methyl Bromide use in Turf:
Although alternatives for MeBr in the circumstances of the U.S. nomination remain technically and economically infeasible, research into MeBr alternatives is beginning to show some promising results and USG scientists now anticipate that transition away from MeBr will be possible in many cases over the next five to ten years. Some conditions in each of the growing areas limit the extent to which, with alternatives available in the foreseeable future, the transition can be completed.

Turf grass is grown primarily in California, Florida, Georgia, Alabama and Texas. The major impediment to the adoption of the preferred alternative to MeBr (dazomet and metam sodium) is the presence of high pest pressure that render the alternatives ineffective against the pests affecting this crop. Although alternative treatments can be foreseen as solutions to approximately 75% of MeBr use over the next eight to ten years, with currently available alternatives, it is not expected that MeBr use can be completely replaced in this sector. The replacement of MeBr will require the development of application technologies to better deliver these alternatives to soils containing target pests. Alternatives will likely require more frequent applications thereby increasing costs and environmental pesticide burden.

Metam-sodium and dazomet already are used in the sod turfgrass production industry. It has not been determined how the 1% of total sod farm hectares that use MeBr can further reduce its use. Studies of high density polyethylene will be conducted to evaluate its efficacy in this sector.

Post-Harvest Uses

Commodities

Methyl bromide is needed primarily to treat stored agricultural commodities in a very short period, during the peak production season, shortly after harvest before they can be stored and/or shipped. Methyl Bromide fumigation for commodities occurs to ensure pest-free food and meet the strict requirements of the Food Sanitation Regulations. Methyl bromide is typically utilized in processed food and feed facilities as a space fumigant for treating the facility one to three times per year. As the need arises, MeBr is also used for trailer fumigations of product or packaging material. Phosphine, alone or combined with carbon dioxide (Eco2fume®), is the principal chemical alternative currently available for use. Although sulfuryl fluoride has received a federal registration for many stored commodities, it is not registered in California where these uses occur. Furthermore, as many of these commodities are exported, the lack of internationally recognized food tolerances (i.e. maximum residue limits or MRLs) will make the use of sulfuryl fluoride impractical until such tolerances are granted. These sectors are already using phosphine alone or in combination to the extent that their processing systems and marketing needs allow it due to the increased time of treatment over MeBr. Complete replacement of MeBr by phosphine fumigation is impracticable since it takes longer than MeBr and is not feasible when rapid fumigations are needed such as during harvest. Also harvest of commodities occurs in autumn, when temperatures are falling, making temperature-dependent phosphine fumigation less practicable. Any additional shifting from MeBr to the slower phosphine fumigation would result in disruption of commodity processing during peak production times, lost market windows, and substantial economic losses. Adoption of not in kind alternatives, such as controlled atmospheres, cold, and carbon dioxide under pressure would require major investments for appropriate treatment units and /or retrofitting of existing warehouses.

Future Plans for reducing Methyl Bromide use in Commodities:

For dried beans, walnuts, pistachios, dried fruit, and dates, alternatives are phosphine, PPO, and sulfuryl fluoride. It is believed that 100% of nuts and dried fruit will be able to convert to sulfuryl fluoride when receiving countries have established tolerances for this product on these food commodities. Although these tolerances (MRLs) are under consideration before CODEX, it is not possible to determine when the CODEX and individual country approvals may occur. The transition period could be as long as 10 years, to allow for the construction of fumigation facilities able to effectively use sulfuryl fluoride, phosphine or PPO. Also, phosphine changes the flavor of fresh dates and is not considered an alternative.

Dry Cured Pork

Producers of dry cured pork products (including smoked hams) experience pest pressure from insects. Alternatives include phosphine and heat. Heat is not viable as an alternative because of its effect on the final product (rancidity) and its ability to alter the character of the final product, producing, for example, a cooked pork product rather than a dry cured pork product with the attendant flavor differences. Phosphine is corrosive on certain metals and can not be used in mechanical and electrical areas of the facilities. Until recently, there were no registered alternatives in the United States for ham; however, in July of 2005, sulfuryl fluoride received a registration granting a food tolerance for this sector. A research effort is underway to ascertain its efficacy for controlling the target pests.

Future Plans for reducing Methyl Bromide use in Dry Cured Pork:

Due to the challenges of penetrating the tissue, most available fumigants are not technically feasible. Experts are exploring potential candidates such as sulfuryl fluoride, but efficacy data are lacking under the conditions experienced in the facilities used to cure these hams. Small-scale trials cannot be conducted until a suitable compound has been identified through laboratory efficacy experiments.

Facilities

There are many food processing facilities in the United States for which the USG is not requesting MeBr use because they have been able to successfully implement alternatives. However, other facilities cannot adopt alternatives at this time because of structural configurations that make the alternatives economically infeasible. Some facilities are using both phosphine and heat treatments to disinfest at least portions of their plants. Facilities have been able to reduce the number of MeBr fumigations from an average of six times a year to an average of two times per year. Also, MeBr now is typically applied at 25-30 % of the approved label rate.

The U.S. CUE nomination in this sector only includes a request for MeBr use where use of alternatives is limited by technical or economic constraints. Phosphine, both alone and in combination with carbon dioxide, is often used to treat incoming grain and some finished products. Unfortunately, phosphine is corrosive to copper, silver, gold and their alloys. These metals are critical components of both the computers that run the machines as well as electrical components in some of the machines in the plants. Additionally, phosphine requires more time to kill insect pests than MeBr, so plants will need to be shut down longer to achieve mortality, with associated economic losses from this downtime. There are also reports of stored product pests becoming resistant to phosphine.

There are several limitations associated with the use of heat in this industry. Not all areas of a plant can be efficiently fumigated with heat. Some food substances, for instance cheeses, will go rancid with heat treatments. Not all finished food products can be heated for the length of time heat is required for efficient kill of pests. Achieving uniform distribution of the heat throughout the facility can be a significant obstacle, and reports of structural damage due to excess heat in facilities have been received. Incidents have been reported where heat triggered fire suppression water sprinkler systems. High heat can damage processing equipment not engineered for such temperatures and manufacturers may not warrant their equipment after exposure to high heat. Few facilities have the heating capacity to raise the temperature to 60-65°C (140-150°F) to achieve insecticidal control. Installing permanent heating capacity or bringing in temporary heaters is usually cost prohibitive.

Sulfuryl fluoride (SF) received a new label in July, 2005, that clarified its use on certain raw agricultural commodities and processed foods. The label does not allow for direct fumigation of many processed foods such as pasta, breakfast cereals, and bakery mixes; or pet foods. To prevent excessive residues, the sulfuryl fluoride label requires that the amount of flour present during fumigation be minimized. This presents a technical and logistical hurdle that impacts the economics of a fumigation.

Future Plans for reducing Methyl Bromide use in Facilities:

Although alternatives for MeBr in the circumstances of the U.S. nomination remain technically and economically infeasible, research into MeBr alternatives is beginning to show some promising results and USG scientists now anticipate that transition away from MeBr will be possible in approximately half of the flour mills and rice mills that currently use MeBr over the next four years. There is a newly registered alternative, sulfuryl fluoride, which shows promise

although current information indicates that this alternative is significantly more expensive than MeBr when used in sufficient concentration to kill all insect stages including the egg stage.

Wider use of this alternative in other food producing facilities is limited by the need to obtain tolerances for all foodstuffs present in the facility being fumigated if the product is not to be removed prior to fumigation or discarded thereafter.

Older alternatives, such as phosphine and heat are not expected to completely replace MeBr although they are important in reducing the frequency of MeBr fumigations.

Until recently, about 100 rice and flour mills in California and New York were unable to use sulfuryl fluoride due to the lack of a state registration for this product. California has now registered sulfuryl fluoride for use in rice and flour mills, and it is expected that approximately three-quarters of these mills will eventually be able to convert, over a 4 year period, to sulfuryl fluoride.

The rice milling industry has spent over U.S.$500,000 on research to develop alternatives since 1992, and plans to use additional pesticides, such as carbonyl sulfide, carbon dioxide, phosphine, magnesium phosphide (magtoxin®), and dichlorvos (vapona®) over the next few years. Non-chemical methods used by this sub-sector to reduce MeBr use, include heat and cold treatments, and many individual companies are involved in further research and testing of alternatives. Industry experts have been trying to determine how best to incorporate sulfuryl fluoride into their IPM programs since its recent registration.

The bakery sector is implementing heat as an alternative at those facilities where heat is technically feasible. Currently, heat is being implemented at several facilities nationwide, but further trials are needed to determine the effects of heat on a long-term basis. However, older facilities with hardwood floors and plant electrical wiring systems are unsuitable for heat treatments as damage may occur. Other methods being used to reduce reliance on MeBr are: pest exclusion, cleaning, early detection, improved design of equipment, trapping, and other integrated pest management (IPM) approaches. Phosphine continues to be tested, and sulfuryl fluoride just received a federal registration for this use.

The flour milling industry is committed to IPM techniques including non-chemical means in order to minimize reliance on any one tool. Many plants have reduced the amount of annual fumigations from 4-5 per year to 2-3 per year. Some of these facilities combine MeBr with carbon dioxide. Further, these applicants have authored a manual on IPM practices that is widely utilized throughout the industry and sponsor an industry conference on IPM. The industry continues to test high heat, phosphine, alone and in combination; and the combination of heat, phosphine, and carbon dioxide. In addition, industry experts have been trying to determine how best to incorporate sulfuryl fluoride into their IPM programs since its recent registration.

The Pet Food Institute has invested hundreds of thousands of dollars in research on a variety of alternatives to MeBr, including heat treatments. Sulfuryl fluoride was tested in an inactive pet food facility last year as well. They have made improvements in worker training, pest

monitoring, and sanitation to greatly reduce the necessity for fumigations with MeBr, or any other fumigant.

TABLES

Table 1. 2006 Critical Uses and Critical Limiting Conditions

EPA determined that the following uses with the limiting critical conditions specified below qualify to obtain and use critical use MeBr in 2006. However, as discussed previously, some of the circumstances for some of the critical use categories may have changed due to recent registrations of an alternative and therefore EPA has proposed a decrease in the total critical use exemption level for 2006 relative to what has been approved by the MOP.

Approved Critical Uses	**Approved Critical User and Location of Use**	**Limiting Critical Conditions**
PRE-PLANT USES		
Cucurbits	(a) Michigan growers	with a reasonable expectation that moderate to severe soilborne fungal disease infestation, or moderate to severe disease infestation could occur without methyl bromide fumigation; or with a need for methyl bromide for research purposes
	(b) Southeastern U.S. except Georgia limited to growing locations in Alabama, Arkansas, Kentucky, Louisiana, North Carolina, South Carolina, Tennessee, and Virginia	with a reasonable expectation that one or more of the following limiting critical conditions either already exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or to a lesser extent: fungal disease infestation and root knot nematodes; or with a need for methyl bromide for research purposes
	(c) Georgia growers	with a reasonable expectation that one or more of the following limiting critical conditions either already exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, moderate to severe fungal disease infestation, or to a lesser extent: root knot nematodes; or with a need for methyl bromide for research purposes
Eggplant	(a) Florida growers	with a reasonable expectation that one or more of the following limiting critical conditions either already exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe nematodes, or moderate to severe disease infestation, or restrictions on alternatives due to karst geology; or with a need for methyl bromide for research purposes
	(b) Georgia growers	with a reasonable expectation that one or more of the following limiting critical conditions either already exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe nematodes, or moderate to severe pythium root and

Approved Critical Uses	Approved Critical User and Location of Use	Limiting Critical Conditions
		collar rots, or moderate to severe southern blight infestation, and to a lesser extent: crown and root rot ; or with a need for methyl bromide for research purposes
	(c) Michigan growers	with a reasonable expectation that moderate to severe soilborne fungal disease infestation could occur without methyl bromide fumigation; or with a need for methyl bromide for research purposes
Forest Nursery Seedlings	(a) growers in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia	with a reasonable expectation that one or more of the following limiting critical conditions already either exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe disease infestation
	(b) International Paper and its subsidiaries limited to growing locations in Arkansas, Alabama, Georgia, South Carolina and Texas	with a reasonable expectation that one or more of the following limiting critical conditions already either exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe disease infestation
	(c) Public (government owned) seedling nurseries in the states of Idaho, Illinois, Indiana, Kansas, Kentucky, Maryland, Missouri, Nebraska, New Jersey, Ohio, Oregon, Pennsylvania, Utah, Washington, West Virginia and Wisconsin	with a reasonable expectation that one or more of the following limiting critical conditions either already exist or could occur without methyl bromide fumigation: moderate to severe weed infestation including purple and yellow nutsedge infestation, or moderate to severe Canada thistle infestation, or moderate to severe nematodes, and to a lesser extent: fungal disease infestation
	(d) Weyerhaeuser Company and its subsidiaries limited to growing locations in Alabama, Arkansas, North Carolina and South Carolina	with a reasonable expectation that one or more of the following limiting critical conditions already either exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, moderate to severe disease infestation, and to a lesser extent: nematodes and worms
	(e) Weyerhaeuser Company and its subsidiaries limited to growing in Washington and Oregon	with a reasonable expectation that one or more of the following limiting critical conditions already either exist of could occur without methyl bromide fumigation: moderate to severe yellow nutsedge infestation, or moderate to severe fungal disease infestation
	(f) Michigan growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exist or could occur without methyl bromide fumigation: moderate to severe disease infestation, moderate to severe Canada thistle infestation, moderate to severe nutsedge infestation, and to a lesser extent: nematodes
	(g) Michigan herbaceous perennials	with a reasonable expectation that one or more of the following limiting critical conditions already

Approved Critical Uses	Approved Critical User and Location of Use	Limiting Critical Conditions
	growers	exist or could occur without methyl bromide fumigation: moderate to severe nematodes, moderate to severe fungal disease infestation, and to a lesser extent: yellow nutsedge and other weeds infestation
Orchard Nursery Seedlings	(a) Members of the Western Raspberry Nursery Consortium limited to growing locations in California and Washington (Driscoll's raspberries and their contract growers in California and Washington)	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe nematode infestation, medium to heavy clay soils, or a prohibition of on the use of 1,3-dichloropropene products due to reaching local township limits on the use of this alternative; or with a need for methyl bromide for research purposes
	(b) Members of the California Association of Nurserymen-Deciduous Fruit and Nut Tree Growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe nematodes, medium to heavy clay soils, or a prohibition of on the use of 1,3-dichloropropene products due to reaching local township limits on the use of this alternative; or with a need for methyl bromide for research purposes
	(c) California rose nurseries	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe nematodes, or user may be prohibited from using 1,3-dichloropropene products because local township limits for this alternative have been reached; or with a need for methyl bromide for research purposes
Strawberry Nurseries	(a) California growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe disease infestation, or moderate to severe yellow or purple nutsedge infestation, or moderate to severe nematodes; or with a need for methyl bromide for research purposes
	(b) North Carolina, Tennessee and Maryland growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe black root rot, or moderate to severe root-knot nematodes, or moderate to severe yellow and purple nutsedge infestation, and to a lesser extent: crown rot; or with a need for methyl bromide for research purposes
Orchard Replant	(a) California stone fruit growers	with a reasonable expectation that one or more of

Approved Critical Uses	Approved Critical User and Location of Use	Limiting Critical Conditions
		the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe nematodes, or moderate to severe fungal disease infestation, or replanted (non-virgin) orchard soils to prevent orchard replant disease, or medium to heavy soils, or a prohibition on the use of 1,3-dichloropropene products because local township limits for this alternative have been reached; or with a need for methyl bromide for research purposes
Ornamentals	(a) California growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe disease infestation, or moderate to severe nematodes, or a prohibition on the use of 1,3-dichloropropene products because local township limits for this alternative have been reached; or with a need for methyl bromide for research purposes
	(b) Florida growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe weed infestation, or moderate to severe disease infestation, or moderate to severe nematodes, or karst topography; or with a need for methyl bromide for research purposes
Peppers	(a) California growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe disease infestation, or moderate to severe nematodes, or a prohibition on the use of 1,3-dichloropropene products because local township limits for this alternative have been reached; or with a need for methyl bromide for research purposes
	(b) Alabama, Arkansas, Kentucky, Louisiana, North Carolina, South Carolina, Tennessee and Virginia growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe nematodes, or moderate to severe pythium root, collar, crown and root rots, or the presence of an occupied structure within 100 feet of a grower's field the size of 100 acres or less; or with a need for methyl bromide for research purposes
	(c) Florida growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe yellow or

Approved Critical Uses	Approved Critical User and Location of Use	Limiting Critical Conditions
		purple nutsedge infestation, or moderate to severe disease infestation, or moderate to severe nematodes, or karst topography; or with a need for methyl bromide for research purposes
	(d) Georgia growers	with a reasonable expectation that one or more of the following limiting critical conditions either already exist or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe nematodes, or moderate to severe pythium root and collar rots, or moderate to severe southern blight infestation, and to a lesser extent: crown and root rot ; or with a need for methyl bromide for research purposes
	(e) Michigan growers	with a reasonable expectation that moderate to severe fungal disease infestation would occur without methyl bromide fumigation; or with a need for methyl bromide for research purposes
Strawberry Fruit	(a) California growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe black root rot or crown rot, or moderate to severe yellow or purple nutsedge infestation, or moderate to severe nematodes, or a prohibition of the use of 1,3-dichloropropene products because local township limits for this alternative have been reached, time to transition to an alternative; or with a need for methyl bromide for research purposes
	(b) Florida growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge, or moderate to severe nematodes, or moderate to severe disease infestation, or karst topography and to a lesser extent: carolina geranium or cut-leaf evening primrose infestation; or with a need for methyl bromide for research purposes
	(c) Alabama, Arkansas, Georgia, Illinois, Kentucky, Louisiana, Maryland, New Jersey, North Carolina, Ohio, South Carolina, Tennessee and Virginia growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge, or moderate to severe nematodes, or moderate to severe black root and crown rot, or the presence of an occupied structure within 100 feet of a grower's field the size of 100 acres or less; or with a need for methyl bromide for research purposes
Tomatoes	(a) Michigan growers	with a reasonable expectation that one or more of the following limiting critical conditions already

Approved Critical Uses	Approved Critical User and Location of Use	Limiting Critical Conditions
		either exists or could occur without methyl bromide fumigation: moderate to severe disease infestation, or moderate to severe fungal pathogens infestation; or with a need for methyl bromide for research purposes
	(b) Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, North Carolina, South Carolina, and Tennessee growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe yellow or purple nutsedge infestation, or moderate to severe disease infestation, or moderate to severe nematodes, or the presence of an occupied structure within 100 feet of a grower's field the size of 100 acres or less, or karst topography; or with a need for methyl bromide for research purposes
	(c) California growers	with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe disease infestation, or moderate to severe nematodes; or with a need for methyl bromide for research purposes
Turfgrass	(a) U.S. turfgrass sod nursery producers who are members of Turfgrass Producers International (TPI)	for the production of industry certified pure sod; with a reasonable expectation that one or more of the following limiting critical conditions already either exists or could occur without methyl bromide fumigation: moderate to severe bermudagrass, nutsedge and off-type perennial grass infestation, or moderate to severe, or moderate to severe white grub infestation; or with a need for methyl bromide for research purposes
POST-HARVEST USES		
Food Processing	(a) Rice millers in all locations in the U.S. who are members of the USA Rice Millers Association.	with a reasonable expectation that one or more of the following limiting critical conditions exists: moderate to severe infestation of beetles, weevils or moths, or older structures that can not be properly sealed to use an alternative to methyl bromide, or the presence of sensitive electronic equipment subject to corrosivity, time to transition to an alternative
	(b) Pet food manufacturing facilities in the U.S. who are active members of the Pet Food Institute. (For today's rule, "pet food" refers to domestic dog and cat food).	with a reasonable expectation that one or more of the following limiting critical conditions exists: moderate to severe infestation or beetles, moths, or cockroaches, or older structures that can not be properly sealed to use an alternative to methyl bromide, or the presence of sensitive electronic equipment subject to corrosivity, time to transition to an alternative

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	(c) Bakeries in the U.S.	with a reasonable expectation that one or more of the following limiting critical conditions exists: design problems or the presence of sensitive electronic equipment subject to corrosivity, time to transition to an alternative
	(d) Members of the North American Millers' Association in the U.S.	with a reasonable expectation that one or more of the following limiting critical conditions already exists or could occur without methyl bromide fumigation: moderate to severe beetle infestation, or older structures that can not be properly sealed to use an alternative to methyl bromide, or the presence of sensitive electronic equipment subject to corrosivity, time to transition to an alternative
	(e) Members of the National Pest Management Association associated with dry commodity structure fumigation (cocoa) and dry commodity fumigation (processed food, herbs, spices, and dried milk)	with a reasonable expectation that one or more of the following limiting critical conditions already exists or could occur without methyl bromide fumigation: moderate to severe beetle or moth infestation, or older structures that can not be properly sealed to use an alternative to methyl bromide, or the presence of sensitive electronic equipment subject to corrosivity, time to transition to an alternative
Commodity Storage	(a) California entities storing walnuts, beans, dried plums, figs, raisins, dates and pistachios in California	with a reasonable expectation that one or more of the following limiting critical conditions exists: rapid fumigation is required to meet a critical market window, such as during the holiday season, rapid fumigation is required when a buyer provides short (2 days or less) notification for a purchase, or there is a short period after harvest in which to fumigate and there is limited silo availability for using alternatives; or with a need for methyl bromide for research purposes
Dry Cured Pork Products	(a) Members of the National Country Ham Association	with a reasonable expectation that one or more of the following limiting critical conditions already exists or could occur without methyl bromide fumigation: moderate to severe red legged ham beetle, cheese/ham skipper, dermested beetle or ham mite infestation
	(b) Members of the American Association of Meat Processors	with a reasonable expectation that one or more of the following limiting critical conditions already exists or could occur without methyl bromide fumigation: moderate to severe red legged ham beetle, cheese/ham skipper, dermested beetle or ham mite infestation
	(c) Nahunta Pork Center (North Carolina)	with a reasonable expectation that one or more of the following limiting critical conditions already exists or could occur without methyl bromide fumigation: moderate to severe red legged ham beetle, cheese/ham skipper, dermested beetle or ham mite infestation

Table 2. Principal Pre-plant MeBr Alternatives and their Strengths and General Limitations / Impediments to Adoption

MeBr Alternative	Strength	General Limitations / Impediments to Adoption
Chloropicrin (PIC)	Good fungicide	Weak on nematodes Ineffective on weeds
Metam sodium / potassium	Good nematicide	Marginal fungicide and herbicide Strong odor / large buffers Antagonistic to PIC
Iodomethane	Similar handling and application properties to MeBr plus PIC	Not registered Cost is unknown Must be applied with PIC Longer/irregular aeration period required after treatment
1,3-dichloropropene (1,3-D)	Good nematicide with some disease control	Subject to regulatory constraints on karst topography Subject to regulatory constraints in California (Township caps)
1,3-D plus PIC	Good nematicide and fungicide	Ineffective alone on weeds, requires a compatible herbicide treatment
Metam sodium / potassium followed by PIC	Good nematicide and fungicide	Marginally effective on weeds Requires separate applications to avoid antagonism
Steam treatment	Effective against diseases, nematodes and weeds	Cost prohibitive except on raised beds or potted media in protected culture
Solarization	Effective against pests near the surface	Highly variable results wherever rainfall occurs during treatment (well-suited only for desert climates) Ineffective against pests at depths beyond a few centimeters Long treatment times prevent planting of second crops (well-suited to hot/dry locations where only one crop is grown per season)

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