Australian Government
Department of Agriculture, Water and the Environment

Quarantine and Pre-shipment uses of methyl bromide, 2017-2020

Report to the Australian Government, Department of Agriculture, Water and Environment

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Cataloguing data

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Contents

Tables

Summary

This survey was undertaken to identify quarantine and pre-shipment (QPS) uses of methyl bromide in Australia over the period 2017 – 2020 inclusive. Using data obtained from a user survey and the Department of Agriculture, Water and the Environment (DAWE), annual methyl bromide imported into Australia during this period ranged from approximately 750 to 960 tonnes per annum. Not all methyl bromide imported in a given year is used for fumigation activities within that year. However, the volumes over the four year period represent an increase in methyl bromide import into Australia of 20% compared to the previous four year period.

The major contributing factors to this increased use of methyl bromide in QPS applications appears to be driven by the need for quarantine fumigations to control Brown marmorated stink bug, a pest that has become prevalent since the previous survey, and the significant increase in fumigation of logs for export as a requirement of importing countries.

Existing and near market chemical fumigation alternatives to methyl bromide include sulfuryl fluoride, phosphine, ethyl formate and ethanedinitrile. Of these sulfuryl fluoride and ethanedinitrile have the potential to replace more than 500 tonnes (2019 and 2020 usage) of methyl bromide estimated for pre-shipment fumigation of timber logs. The manufacturers are engaged in the process of obtaining appropriate approvals for QPS use.

Recapture technologies currently exist that include capturing methyl bromide onto active carbon and carbons sorption plus scrubbing systems. Use of recapture technologies involve higher capital expenditure and operating costs, and while these appear to be used in other countries, are not prevalent in Australia. The lack of uniformity of destruction/recapture legislation across jurisdictions is a possible reason for this, resulting in a lack of incentive to adopt such technologies where adoption is not required by competitors. Since the last survey undertaken in 2017 where no methyl bromide destruction technologies were available, one process by Australian company EIM Technologies Pty Ltd has been approved by the Montreal Protocol. This technology is based on destruction of methyl bromide by thermal decay in a single pass destruction step, followed by conversion of the by-products through a water-based scrubbing system.

The impediments to uptake of methyl bromide alternatives and adoption of recapture technology that were identified in the previous survey continue to be cited as current impediments and include the requirements for proof of efficacy and approval of alternatives for quarantine purposes by regulatory authorities in Australia, and concomitant acceptance by trading partners; in addition to cost, operational and logistical inconvenience, commercial competitive pressure and lack of regulatory or financial incentives to install recapture systems or change to methyl bromide alternatives.

Manufacturers are continuing to engage in providing efficacy data of a number of alternative fumigants (sulfuryl fluoride, ethyl formate and ethanedinitrile).

Introduction

Methyl bromide is a fumigant that has been in commercial use for more than 60 years to control pests including various soil borne fungi, bacteria, insects, mites, nematodes and rodents as well as many weeds and seeds. It was also used extensively to disinfest food-processing buildings and stored durable commodities such as grain (including rice, wheat, maize and others), dried fruit and other dried foodstuffs and beans. Methyl bromide is also a well-established treatment for quarantine and pre-shipment (QPS) control of a diverse range of pests and diseases on many commodities in trade; including timber, wooden packaging and various perishables such as fruits, vegetables and cut flowers. Prior to the phase out of methyl bromide for non-quarantine and pre-shipment (non-QPS) uses, the United Nations Environment Programme (UNEP) estimated 71500 metric tonnes of methyl bromide was used world wide (UNEP, 1999). This use included non-QPS methyl bromide use (80 percent of which was largely from soil fumigation) and QPS use (20 percent: largely grain and wood products fumigation at pre-shipment). Since the introduction of the Montreal Protocol restrictions on the consumption of methyl bromide for non-QPS use, the global use of methyl bromide for fumigation purposes has reduced to about 10,000 tonnes a year.

The purpose of this report is to provide the Department of Agriculture, Water and the Environment (DAWE) with information on the use of methyl bromide for Quarantine and Pre-Shipment (QPS) fumigations in Australia for the years 2017, 2018, 2019 and 2020. In addition, the report includes information on the adoption of alternatives or reduction measures (methyl bromide recapture or destruction technologies) for such uses. The report is an update to the previous analysis which similar information for the years 2013-2016 and will assist DAWE in its policy and decision making in relation to QPS use and management in Australia .

In order to inform the analysis, data on QPS use of methyl bromide in Australia for the subject years were obtained applying the following methodology as a framework:

A. Identification of QPS methyl bromide fumigators or users of fumigation services in Australia. This was done by updating the previous contact list through researching:

1. relevant State and Territory databases;

2. internet resources, such as business listings, members of relevant associations;

3. the register of participants in the Australian Wood Packaging Certification Scheme (AWPCS);

4. the listing of fumigation service providers having a compliance agreement for quarantine treatments of imports according to the methyl bromide fumigation standard;

5. importers of methyl bromide for QPS use in Australia;

6. suppliers of methyl bromide for QPS use in Australia; and

7. exporters using methyl bromide on products prior to export, such as on grain, wood, timber, cotton seed and pulses.

B. A survey was prepared for use by fumigators or users of fumigation services. The survey sought information on the following parameters:

1. the amount of methyl bromide used to comply with pre-shipment requirements of destination countries of exports, broken down by commodity, pest treated, year, state of use and destination;

2. the amount of methyl bromide used on imports to comply with Australian quarantine requirements, broken down by commodity, pest treated, year and state of use; and

3. use of methyl bromide on intra-state trade, broken down by commodity, pest treated, year, and state of use.

C. Consultation of other datasets to obtain information on methyl bromide use on QPS applications, such as import and export records, methyl bromide sales and use reports and the AIMS database and validate information provided through the survey.

Apart from methyl bromide use data, information on alternatives to methyl bromide was obtained through further surveying of industry to include:

• Identification of existing and near market alternatives to methyl bromide in QPS uses;

• Impediments to uptake in Australia of existing and near market alternatives to methyl bromide for QPS applications which are available internationally and domestically;

• Information on alternatives that have been deregistered in Australia during the period of the study.

An assessment of existing or new methyl bromide recapture or destruction technologies that are available internationally and in Australia, and the barriers which may prevent the adoption of those technologies in Australia in QPS applications was undertaken. This included an estimate the amount of methyl bromide available for recapture and the amount recaptured.

1 Methodology

Several lines of quantitative information were gathered and analysed for the project. These included surveying methyl bromide importers, users and fumigation service providers seeking information on their annual usage of methyl bromide including commodities treated and purpose of treatment (quarantine, pre-shipment or domestic quarantine); accessing data from the DAWE import database on quarantine uses (AIMS); and accessing data from the DAWE export database on pre-shipment methyl bromide fumigations (EXDOC; PEMS). In addition, the annual quantity of methyl bromide importation by importers was provided through Full Import Declaration (FID) records.

1.1 Industry survey

Companies identified as methyl bromide service providers for receiving the survey were obtained from several sources. The list from the last survey undertaken in 2017 was considered a suitable starting point and was checked for currency. There had been several changes between the 2013-2016 survey period and the one undertaken for this analysis with some companies no longer operating, and acquisitions of businesses by existing service providers.

In addition, importers of methyl bromide based on companies listed as registrants with the Australian Pesticides and Veterinary Medicines Authority (APVMA) and those with import licences under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* were included. The list was cross-referenced with fumigation providers in the DAWE Australian Wood Packaging Certification Scheme (AWPCS) Register available at the time of writing. Finally, sites operating under an approved arrangement – Class 12.1: Methyl Bromide Fumigation were cross-referenced with the list.

The final list consisted of 134 companies. Some of these were contacted based on responses from the survey where respondents identified service providers who were not initially captured. This list of 134 companies is similar in number to the 121 companies in the survey from Cox (2017). The number of recipients was larger (153) as there were several branches or contacts identified for some companies.

Recipients were given several options to respond as follows:

1. If recipients did not use methyl bromide fumigation, they were invited to simply reply to the email with their contact details (name, telephone, company), and would be removed from the list.
2. If recipients used methyl bromide but did so through a third party, they were invited to reply to the email with your contact details, and those of the fumigator.
3. If recipients did perform methyl bromide fumigation, they were requested to provide volumes of use data for the years 2017-2020. In particular, the information requested was for volumes of use for different commodities and whether these were done for export, import or domestic use. There were three options for the provision of this information:
    a. Request a call-back to provide the information over the telephone;

b. For those recipients with the necessary data already compiled as part of the records required to keep under the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995, the data file could be sent by return email; or
c. A survey form was available online. This was available in Microsoft Forms. For recipients choosing to provide information by Microsoft forms, additional questions were asked seeking user information on use of alternatives to methyl bromide and use of recapture/destruction technologies. A copy of the Microsoft Forms survey is provided at Appendix A.

1.2 AIMS dataset

The AIMS database is a restricted access database of imported consignments that require biosecurity intervention prior to being released from Biosecurity Control. It includes biosecurity directions issued by DAWE for quarantine fumigations applied to imported goods. A listing of over 190,000 fumigation directions covering the survey period was provided by DAWE for analysis. The relevant data provided in the extracted records included date of fumigation, dosage rate and exposure time. The records were essentially all listed as treatment at 21^{o}C. Unfortunately, in the data set provided, there was no information on commodity treated, so some assumptions were made to determine the commodity based on treatment rates and fumigation times.

Because the dosage rates are often specific to particular situations, the reasons for the fumigations can usually be inferred (for example, fumigation against risk of importation of Giant African Snail (*Lissachitina fulica*) at 128 g/m^3 for 24 hours, fumigation of some perishables at 24 g/m^3 for 2 hours against risk of susceptible quarantine pests, standard fumigation of a wide range of commodities, at 48 g/m^3 for 24 hours for various quarantine pests, including pests of wood). Further, treatment for a wide range of commodities for the hitchhiker pest, Brown marmorated stink bug, were readily identified based on the treatment rate.

It was not possible to provide a summary of quarantine fumigations of imports based on the categories in the format used in previous surveys as there was simply insufficient information to identify commodities down to the level of specificity previously identified. However, where treatments were clearly not related to control of a specific pest, broad commodity groups could be surmised.

1.3 EXDOC/PEMS dataset

Export records where methyl bromide fumigation was undertaken were obtained from DAWE. Prior to 2020, these records were maintained in the Export Documentation (EXDOC) database, and for 2020, they were maintained in the Plant Export Management System (PEMS).

The information provided by DAWE for this project included a description of the goods treated, destination country and shipment method. The methyl bromide treatment rate and duration for the individual commodities was recorded and included different doses applied for different temperature conditions.

Information drawn from EXDOC/PEMS was used to estimate methyl bromide use based on importing country requirements for the major destination countries over the survey period.

1.4 Methyl bromide import/sales volumes

There are only a limited number of companies with methyl bromide products registered for QPS use in Australia. The annual volumes of methyl bromide imported by these companies are reported to DAWE, and these figures were provided. In addition, official figures for methyl bromide imports for QPS purposes in Australia are reported to the Ozone Secretariat in accordance with Article 7 of the Montreal Protocol by DAWE. These additional sets of figures were used as benchmark quantities for annual methyl bromide use in Australia to compare to use data collected through the survey and from the AIMS and EXDOC/PEMS data.

2 Results

2.1 Import volumes of methyl bromide

Import data for methyl bromide was obtained from DAWE and consisted of both Tariff and Full Import Declaration (FID) data. Seven companies were identified as importing >10 tonnes per annum in at least 1 year, with a further two companies importing <10 tonnes in some years. In addition, the quarantine and pre-shipment import volumes for Australia are reported in the UNEP country profile although it should be noted that those figures extract exported methyl bromide. There were differences in the overall import volumes from the three different data sources as shown in Table 1.

Table 1: Methyl Bromide – Tonnes imported into Australia (2017-2020)

Source of data	TOTAL METHYL BROMIDE IMPORTED (tonnes)			
	2017	2018	2019	2020
Full Import Declaration Data	962	799	901	753
Tariffs Data	962	795	666	503
UNEP country profile [1]	898	682	794	695

1) Figures do not include exported methyl bromide.

The FID data set will be used for further analyses.

2.2 Survey responses

There were 50 responses received from 45 companies with multiple branches of companies responding in some cases. In terms of company numbers, this equates to a 34% response rate and compares similarly to the previous survey response rate of 35% (Cox, 2017). Attempts were made to increase response rate through telephone calls and email follow up. Interestingly, the total number of responding companies was almost the same (43-45) for both survey periods.

Fumigators that treated single commodities were readily able to provide this information. In these cases, the major commodities identified for individual treatments were pulses and grains with smaller quantities identified as being used on fresh produce and flowers.

Unfortunately, for fumigators that undertook large numbers of fumigations on a regular basis and across a wide range of commodities, commodity information was unable to be provided. A recurring theme for not being able to do this related to the manual record keeping with no companies appearing to maintain or record usage electronically except for their overall methyl bromide use. As an example, a fumigator that treats 100 containers per month would have almost 5000 individual records over the survey period, and while these individual records are expected to include the necessary details on commodity treated, volume of container/chamber treated, and the dose of methyl bromide, the amount of work involved in compiling this information for the current survey was prohibitive. Covid-19 was also cited as a reason for not being able to provide information with hard copy records located in offices that were shut down

during the response period. A further frustration expressed by several respondents was that this information is continuously supplied to DAWE and there is no distinguishing between different sections in DAWE where data sharing may not be possible due to current privacy requirements. DAWE is considering options to address possible data sharing.

As a result of these shortcomings, the data obtained through the survey are considered to be of low reliability in terms of meeting DAWEs objective in determining the main uses/commodities treated for methyl bromide over the survey period.

A summary of the survey responses is provided in Table 2. Between 334 tonnes and 457 tonnes of the annual methyl bromide use were accounted for in the survey responses. These in turn account for between 46-54% of the methyl bromide import volumes, or between 48-63% of volumes imported for QPS fumigations reported to the Ozone Secretariat (see Section 2.1).

There was insufficient information to determine any reliable values used for domestic (interstate) fumigations. However, based on previous surveys and the limited information received from the survey, it is expected to account for <1% of overall methyl bromide use. Three respondents identified domestic treatments, however, the major quantity identified was a total use volume per annum which was split between import, export and domestic so no further determination was possible.

Several larger users only provided a total volume per annum with no split in the amount used between import and export. Where this occurred, an assumption that 10-15% was used for quarantine fumigations was applied based on discussions and other data received from other fumigators treating mixed commodities. A rate of 12.5% was applied to total use figures in these cases to estimate quarantine volumes.

Table 2: 2017-2020, Industry survey results on Quarantine and Preshipment uses

Broad use	**2017**	**2018**	**2019**	**2020**
Export (Pre-shipment)	86.4%	83.3%	82.6%	83.8%
Import (Quarantine)	13.6%	16.7%	17.4%	16.2%
TOTAL tonnes from survey	457	431	414	334
% survey compared to import volumes (Table 1)	46	54	49	46
% survey compared to QPS imports as reported to Ozone Secretariat	51	63	52	48

Where commodities were identified, an analysis of their contribution to total methyl bromide use could be undertaken. This was only possible for export use of methyl bromide and results in

terms of percentage of identified use showed three commodity groups being the major users as shown in Table 3. In interpreting this information, it is noted that sometime QPS fumigations are undertaken on products for which there is no target pest identified. For example, baled hay and logs are generally fumigated to ensure it is free of insects and benefit from reduced sampling for phytosanitary inspection. Similarly, obtaining the accurate amount of methyl bromide used to treat wood packaging to ISPM 15 standard is challenging. While this was identified in the previous survey as a major target for fumigation, it is not commodity specific.

Table 3: 2017-2020, Industry survey results by commodity, Export use (%)

Commodity	2017	2018	2019	2020
Almonds	0.6	0.5	0.6	0.7
Fresh produce	0.7	0.6	0.7	1.0
Grain	13.0	18.8	10.2	10.1
Logs	78.2	76.3	84.2	81.7
Pulses	3.1	1.4	1.4	2.9
Pulses, Grains	1.0	0.1	0.2	1.2
Mixed	3.5	2.3	2.8	2.5

These results need to be treated with caution because only 50-55% of the use volumes of methyl bromide reported through the survey actually identified individual commodities that were being treated. However, the results broadly correspond to those identified from export records (see Section 2.4.2). The results for grains and pulses as individual commodity groups are essentially reversed with the major contribution being fumigation to pulses rather than grains from export records. In terms of combined application to pulses and grains, however, the results from Table 3 indicates 11% to 17% use on grains and pulses, while the information in Section 2.4.2 (Table 8) has a range of 12% to 20% for these combined commodities.

2.3 Quarantine usage of methyl bromide

In the last report of this nature (Cox, 2017), in the order of 170,000 AIMS directions for quarantine treatment were available, and from these, identifiable uses of >1 tonne per annum methyl bromide were determined. These categories of import included:

- Equipment, parts and containers, other than for snail/insect treatments;

- Flowers, bulbs and plants;
- Fresh fruits and vegetables;
- Steel and scrap; and
- Wood and timber.

The common reason for treatment of imported equipment, steel and scrap other than for snail or insect control was considered to be for the presence of wood as packaging.

Despite the statement that the above categories represent identifiable uses exceeding 1 tonne per annum, by far the greatest contribution of methyl bromide use over the 2013-2016 survey period from AIMS data and survey returns was unable to be categorised (average 34% of quarantine use).

As noted in Section 1.2, the import information provided from AIMS for this project was not suitable to identify specific categories of import and assumptions have been required based on the treatment rate/volume.

From the survey responses, only one company provided the full range of fumigation records. That company undertook several hundred fumigations per annum with a range of quarantine and pre-treatment fumigations. The treatment rates and volumes of treated containers/chambers was assessed for the 2020 data to obtain an indication of volumes treated per records as it is considered too unreliable to simply adopt an assumption that all AIMS records relate to a 20-foot container (33.2 m^3 volume). The analysis of import records indicates an equivalent of 2.9 twenty-foot equivalent units (TEU) per fumigation.

The estimated quantity of methyl bromide for quarantine use was calculated from the AIMS data as follows:

1. The number of records for a specific treatment was determined. For example, treatment for BMSB is undertaken at 24 g/m^3 for 24 hours. In 2019 there were 14166 fumigation records for this treatment.
2. The total container/chamber volume treated was determined based on the TEU value per fumigation. A single 20-foot container has a volume of 33.2 m^3. There were an estimated 2.9 equivalent 20-foot containers treated per fumigation record, so this equates to 33.2 X 2.9 = 96.3 m^3 treated per fumigation. At 14166 fumigation records, a total of 1363900 m^3 was treated for BMSB in 2019.
3. The mass of methyl bromide for each treatment was determined as rate X volume. For the BMSB fumigations in 2019, this equates to (24 (g)/1000000 (g/tonne)) X 1363900 = 32.7 tonnes methyl bromide.

Table 4 lists the range of treatments and the number of AIMS records by reporting year. Then, based on the number of records and treatments, using the estimation approach, Table 5 reports the estimated quarantine methyl bromide use compared to broad commodity groups. The commodity groups were surmised based on methyl bromide treatments.

Table 4: 2017-2020, AIMS data, number of records by methyl bromide treatment. Shaded treatments considered in further analyses

Methyl bromide treatment:	2017	2018	2019	2020
16 g/m^3 for 12 hrs 15^{o}C or above	703	29540	25673	209
Methyl Bromide BMSB	0	0	14166	34505
48 g/m^3 for 24 hrs 21^{o}C or above	7786	7243	5371	4352
32 g/m^3 for 2 hrs 21^{o}C or above	7933	6856	5645	2467
32 g/m^3 for 24hrs 21^{o}C or above	569	1722	346	555
32 g/m^3 for 3 hrs 21^{o}C or above	376	400	327	287
80 g/m^3 for 48 hrs 21^{o}C or above	149	148	190	433
80 g/m^3 for 72 hrs 21^{o}C or above	193	197	180	209
128 g/m^3 for 24 hrs 21^{o}C or above	170	167	199	205
40 g/m^3 for 3 hrs 21^{o}C or above	127	118	143	151
32 g/m^3 for 6 hrs 21^{o}C or above	30	30	43	37
32 g/m^3 for 2.5 hrs 21^{o}C or above	52	50	21	14
48 g/m^3 for 3 hrs 21^{o}C or above	24	42	34	35
80 g/m^3 for 24 hrs 21^{o}C or above	7	25	27	28
40 g/m^3 for 2 hrs 21^{o}C or above	9	3	4	5
48 g/m^3 for 2 hrs 21^{o}C or above	11	2	5	3
48 g/m^3 12 hrs min 15^{o}C	1	5	10	1

Methyl bromide treatment:	2017	2018	2019	2020
48 g/m^3 for 2.5 hrs 21^{o}C or above	3	4	1	1
64 g/m^3 for 2 hrs 21^{o}C or above	0	0	1	7
32 g/m^3 for 3.5 hrs 21^{o}C or abov	0	1	0	1
32 g/m^3 for 4 hrs 21^{o}C or above	0	1	0	1
64 g/m^3 for 4 hrs 21^{o}C or above	0	1	0	0
56 g/m^3 for 12 hrs 10^{o}C or above	0	0	0	0

Table 5: Estimated quarantine methyl bromide use for commodities and pests, 2017-2020, AIMS data.

Treatment	Possible commodities or target pests	Estimated metric tonnes[1]			
		2017	2018	2019	2020
24 g/m^3 for 12 hrs 10^{O}C	Brown marmorated stink bug treatments. Mixed commodities (see Section 2.3.1).	0	0	33	80
16 g/m^3 for 12 hrs 15^{O}C		1.1	46	40	0
48 g/m^3 for 24 hrs 21^{O}C	Timber products including timber or bamboo packaging/dunnage.	42	39	29	23
80 g/m^3 for 24 hrs 21^{O}C		0.1	0.2	0.2	0.2
32 g/m^3 for 2 hrs 21^{O}C		24	21	17	7.6

32 g/m^3 for 3 hrs 21^{O}C	Fresh produce/perishables (cut flowers, fresh fruit, vegetables, nursery stock)	1.2	1.2	1.0	0.9
40 g/m^3 for 3 hrs 21^{O}C		0.5	0.5	0.6	0.60.2
32 g/m^3 for 2.5 hrs 21^{O}C		0.2	0.2	0.1	0.0
48 g/m^3 for 3 hrs 21^{O}C		0.1	0.2	0.2	0.2
32 g/m^3 for 6 hrs 21^{O}C		0.1	0.1	0.1	0.1
80 g/m^3 for 48 hrs 21^{O}C	Khapra beetle[2]	1.3	1.3	1.6	3.7
80 g/m^3 for 72 hrs 21^{O}C	Pulses	1.6	1.7	1.5	1.8
128 g/m^3 for 24 hrs 21^{O}C	Giant African Snail	2.2	2.2	2.6	2.7
TOTAL QUARANTINE METHYL BROMIDE (Tonnes, AIMs extrapolated values)		**77**	**120**	**128**	**123**

1) Tonnes estimated on a 20-foot equivalent container being treated (33.2 m^3 with 2.9 TEU / treatment).
2) DAWE has a list of high risk plant products to protect against khapra beetle

The volumes reported in Table 5 are considered a base level because all treatments have been calculated based on the 21^{o}C rate. It is possible that treatments that occur over night would apply a higher rate of methyl bromide to compensate for lower night time temperatures.

There were four treatment rates from the AIMS data set that accounted for >90% of quarantine methyl bromide use. These were the Brown marmorated stink bug treatments (see Table 4 – two treatment rates), 48 g/m^3 for 24 hours at 21^{o}C and 32 g/m^3 for 2 hours at 21^{o}C. All the AIMS data were reported for the dose at 21^{o}C with no indication of dose adjustments for lower temperatures.

In terms of known import volumes of methyl bromide (Table 1), and QPS import volumes reported to UNEP, these values represent approximately 8-16% of methyl bromide use (8.5% to

18% based on QPS use reported to the Ozone Secretariat). This relatively consistent with the volumes provided in Cox (2017) where between 11-22% of methyl bromide fumigations were for quarantine purpose. Further, while the survey response data described in Section 2.2 are not considered reliable for QPS use estimation by different commodities, the results provided indicate possibly 10 to 15% of methyl bromide fumigations will be for quarantine purpose.

2.3.1 Brown marmorated stink bug (BMSB)

What is clear between the AIMS dataset for the 2017-2020 period compared to the previous four years is the requirement to treat for Brown marmorated stink bug. This pest was not mentioned in the Cox (2017) report. Treatments began in 2017 and over the previous four years, have been the major quarantine use of methyl bromide based on AIMS data. Where treatments are undertaken for BMSB, the actual commodity treated could be highly variable given this is a hitchhiker pest and could be imported on a large range of commodities. DAWE provides a list of target high risk goods that require mandatory treatment for BMSB risk.

The current treatment rate for BMSB fumigation is a dose of 24 g/m^3 or above, at 10°C or above, for a minimum of 12 hours (but less than 24 hours), and a minimum end point reading of 12 g/m^3; or a dose of 24 g/m^3 or above, at 10°C or above, for 24 hours or longer, and a minimum end point reading of 8 g/m^3. These treatment rates came into effect in approximately mid-2019.

Prior to this, the DAWE prescribed treatment rate was a dose of 16 g/m^3 or above, at 15°C or above, for 12 hours or longer, with a minimum end point reading of 8 g/m^3. There was minor use at this rate in 2017 (~1.4% of quarantine use). However, in 2018, this rate was used for all BSMB treatment and accounted for ~40% of quarantine fumigations. Over the last two years of this survey period (2019, 2020), methyl bromide use for BSMB fumigations has continued to increase at 56 and 65% of quarantine use, respectively.

The volumes used for imported and exported commodities are a guide only and need to be treated with caution. They are subject to certain assumptions based on the known treatment regime with respect to container sizes. Nonetheless, the broad percentages for import and export use volumes are considered a reasonable estimate.

2.4 Pre-shipment usage of methyl bromide

To inform this report, DAWE has provided the list of methyl bromide fumigations on export goods. Complete data for 2017 were not available, so the period assessed here is 2018-2020.

The information was provided for the following fields from EXDOC.

- Destination Country
- No of Containers
- Product Group - (Horticulture or Grain)
- Commodity Name
- Exports Tonnage - All export volume unit converted to tonnage.
- Treatment Code - Different types of treatment
- Treatment Days
- Treatment Info
- MB Grams - Methyl Bromide grams extracted from treatment info.

There are uncertainties in extrapolating the EXDOC results to useable methyl bromide figures. In EXDOC, container size information is not provided and secondly, not all the consignments have used containers.

2.4.1 Estimating container sizes

To assist with calculating methyl bromide use, DAWE advised that logs are mainly exported in 40 ft containers (volume 67.7 m^3), grains, pulses, etc are generally exported in 20 ft containers (volume 33.2 m^3). Hay and straw may be exported both in 20 or 40 ft containers. For hay and straw, DAWE suggested the weight of the commodity may be used to work out the size of the containers. If the weight of each container is 17 tonnes or below, it is assumed that container was a 20 ft container and when the weight of containers is 30 tonnes and above, a 40 ft container is assumed.

The assumption of container size for logs resulted in low confidence values. As an example, in 2018 there were 7619 fumigation records for logs where a number of containers was specified. The weight per container (calculated as tonnage/number of containers) ranged from <1 tonne to 47 tonnes. More than half the containers (55%) weighed less than 20 tonnes and the assumption that all logs will be imported in a 40ft container therefore appears to result in a significant overestimation of methyl bromide. This is particularly the case given the dominance of log treatment in overall use of methyl bromide. To overcome this, calculations were based on the establishment of a 20-foot equivalent container (TEU). The export of logs is dominated by softwood based on Australian forest and wood product statistics. This wood can have densities <500 kg/m^3. However, given there are also some hardwood exports, for simplicity, a standard density of 500 kg/m^3 was applied. A 20-foot container has a volume of 33.2 m^3, which would equate to 16.6 tonnes of timber if fully stocked. To account for gaps between logs in stacks, and at the top of the container as logs are unlikely to be able to be loaded to the top, a loading density of 60% was assumed. Therefore, it was assumed that 20 m^3 of the container would consist of logs, equating to 10 tonnes of timber per TEU.

Influence of assumptions: In the absence of verified information, assumptions are made and they have a significant influence on calculations. For example, if it is assumed containers have a load factor of 80%, methyl bromide use would be calculated based on 13 tonnes/container. This doesn't change the methyl bromide used per container, but it will influence the total methyl bromide calculated for log fumigation (~13% reduction). Similarly, if log exports are dominated by unseasoned timber, the wood density may be higher which again, reduces the total number of containers that would require treatment from that assumed in this report.

To calculate the total methyl bromide used in a container, the following equation is applied:

Total methyl bromide used per container = Volume (m^3) x Dose (g/m^3)/1000, kg

Total methyl bromide used for a given record is then calculated by multiplying the above figures by the number of containers.

Not all the consignments have used containers and the "Number of Containers" field = 0 in EXDOC. Therefore, in performing calculations to estimate the amount of methyl bromide, where

the number of containers was stated as "0", it was assumed this was fumigating inside ship hulls or bulk vessel consignments and an 80% loading rate for commodities (other than logs) based on reported tonnage was used. It was assumed for convenience that the density of the commodity was 1000 kg/m^3.

2.4.2 Export records and analysis

The total number of records obtained through EXDOC for 2018, 2019 and 2020 were 22700, 27476 and 21544, respectively where methyl bromide was recorded as a treatment. These records have been sorted into bulk commodity groups and analysed by tonnage of treated commodity (Table 6), quantity of methyl bromide for each commodity group (tonnes, Table 7) and the percentage of methyl bromide used for each commodity group (Table 8).

Table 6: EXPORT – Tonnes of bulk commodity groups treated

Commodity group	**2017**	**2018**	**2019**	**2020**
Timber - logs	Complete EXDOC information not available for this year.	4,742,360	5,303,225	5,385,492
Pulses		1,089,778	1,295,889	1,352,302
Grain		532,535	95,800	672,999
Fresh produce		12,410	22,831	19,646
Timber - non-logs		36,895	23,825	19,170
Nuts and seeds		21,438	14,646	17,345
Other		6,142	12,236	9,642
Meal		2,294	199	636
Plants		436	2,029	349
Hay		267	355	334
Cottonseed		47	0	0

Table 7: EXPORT – Estimated Methyl Bromide Use (metric tonnes) per commodity group

Commodity group	**2017**	**2018**	**2019**	**2020**
Timber - logs	Complete EXDOC information not available for this year.	485	549	621
Pulses		60	66	73
Grain		31	8.4	7.3
Fresh produce		1.7	2.8	2.0
Timber – non-logs		4.0	2.3	1.8
Nuts and seeds		1.0	0.74	0.85
Other		0.59	1.3	0.82
Meal		0.15	0.01	0.06
Plants		0.04	0.04	0.04
Hay		0.06	0.05	0.05
Cottonseed		0.00	0.00	0.0
TOTAL		**583**	**631**	**707**

Table 8: EXPORT – Percent (%) of Methyl Bromide Use per commodity group

Commodity group	2017	2018	2019	2020
Timber - logs	Complete EXDOC information not available for this year.	83.1	87.0	87.9
Pulses		10.3	10.5	10.3
Grain		5.3	1.33	1.0
Fresh produce		0.29	0.44	0.28
Timber - non-logs		0.68	0.37	0.25
Nuts and seeds		0.17	0.12	0.12
Other		0.10	0.21	0.12
Meal		0.03	0.0	0.01
Plants		0.01	0.01	0.01
Hay		0.01	0.01	0.01
Cottonseed		0.0	0.0	0.0

Treatment of logs represents by far the greatest use of methyl bromide over the 2018-2020 period. In terms of percent of methyl bromide used on pre-shipment treatments, over this period, use on logs ranged from 83-88% and is a significant departure from the use observed in the previous survey (Cox, 2017). In that survey, over the period of 2013-2016, methyl bromide use on "Wood and Timber" showed an increasing contribution from 24% in 2013 to 34% in 2016. This is still significantly below the use on logs estimated based on current export records. However, it is unclear how methyl bromide use volumes on logs was estimated in Cox (2017). That report states that in 2016, there were 3.6 million m^3 of softwood logs exported from Australia. This is confirmed with the Australian forest and wood product data. These logs were essentially all with bark and therefore, would have required treatment with methyl bromide. The data provided from DAWE for the 2018-2020 period indicates the average treatment rate per 20-foot equivalent container is 62 g/m^3, and assuming this to be the case for the 2016 softwood log exports, the use on softwood logs in 2016 would be estimated at ~370 tonnes. Cox (2017) reports 205 tonnes for 2016 used on wood and timber exports so it is clear assumptions used in calculations will have a significant impact on final values estimated.

Interestingly, the main pre-shipment uses of methyl bromide observed in Cox (2017) were to cereal grains including rice where 35-50% of methyl bromide for pre-shipment fumigations was used. This compares to the current assessment period where 5.3% methyl bromide was used on

grains in 2018 decreasing to 1% in 2020. DAWE provided updated EXDOC data to include fumigations to commodities other than with methyl bromide. However, only phosphine was recorded, and this was mainly on pulses. The overall use of phosphine appeared negligible compared to methyl bromide use due to importing countries mandatory methyl bromide fumigation requirements.

Further analysis has been undertaken to investigate the significant reduction in use on grains identified in the current EXDOC data compared to the previous survey. DAWE has provided a full list of export records for the 2017-2018 financial year (71000 records). From these, grains only (oats, wheat, barley) were considered. More than 90% of exports went to 14 countries. Of these, China was the dominant market at ~30% of grains, noting it does not require mandatory fumigation for cereal grains. MiCOR was checked for treatment requirements of grains (specifically wheat) to these countries. While there was a general requirement that consignments are to be free from pests, soil, weed seeds and extraneous material, a specific treatment with methyl bromide was not stated for any of the top 14 countries. Exports of wheat to India were significantly lower from the second half of 2017 than in previous years. India is a country that does require methyl bromide treatment. Information received from Austrade report almost 1.8 million tonnes of wheat was exported to India in 2017. This agrees with additional information provided by DAWE for total wheat exports to India. This compared to 30800, 1964 and 50 tonnes in 2018, 2019 and 2020, respectively, although in 2020, 21800 tonnes of oats were also exported to India. Mandatory methyl bromide fumigation is required for grains pulses exports to India, Pakistan, Malaysia. Most of the markets do not require mandatory fumigation and for some such as Bangladesh and African countries, fumigation may be undertaken by any fumigant including phosphine, methyl bromide or sulfuryl fluoride.

Wheat (and other grains) is required by India to be treated with methyl bromide (base treatment of 32 g/m^3 for 24 hours at 21^{o}C). Shipping Australia Limited reports an industry standard for packing of grains in containers. The average bulk density of wheat is reported as 75 kg/hectolitre and it is calculated that 24.75 tonnes of wheat would be packed into a standard 20-foot container. Therefore, for the wheat export to India in 2017, an estimated 72500 TEU containers would be treated at 32 g/m^3 resulting in approximately 77 tonnes methyl bromide (33.2 m^3 per TEU).

Interestingly with the wheat export data, the bulk of the wheat was exported in the first half of 2017, which would follow the harvest period that occurs later in the year. Of the 1.8 million tonnes, approximately 98% was exported in the first half of 2017 and only approximately 34000 tonnes in the second half of that year. For the 2018 data available for the first half of the year, wheat exports to India were very significantly reduced and only accounted for approximately 31000 tonnes. This volume of wheat would be treated in 1250 TEU containers and only account for approximately 1.3 tonnes of methyl bromide.

3 Alternatives to Methyl Bromide Available in Australia

Information on alternative chemical treatments, and one non-chemical treatment, to methyl bromide in Australia has been assessed. Other non-chemical treatments, such as steam, controlled atmosphere and irradiation, have not been assessed in this report. As part of the industry survey described in Section 1.1, respondents using Microsoft Forms were asked questions relating to their use of alternatives, and reasons why alternative options may not be used in Australia. Wider consultation was taken through direct email with Australian registrants of alternative chemistry, and some heat treatment providers. The wider consultation email was sent to 28 companies and sought information on the following issues:

- identifying existing and near market alternatives to methyl bromide in QPS uses for the categories provided;
- for existing and near market alternatives which are available internationally and domestically, listing reasons which progress or impede their uptake in Australia (i.e. technological, economical impediments);
- identifying other barriers preventing the adoption of alternatives to methyl bromide QPS applications;
- identifying alternatives being considered in particular markets or used instead of methyl bromide on occasion; and
- identifying any alternatives that have been deregistered in Australia during the period of the study.

No responses were received from heat treatment providers. Five responses were received from owners of alternative chemistry, and their responses are reported within this section.

3.1 UNEP identified methyl bromide alternatives

UNEP provides a factsheet on QPS uses of methyl bromide and their alternatives. The information from this fact sheet for heat treatment and chemical alternatives is provided in Table 9. In addition to these treatments, ethanedinitrile (EDN; Cyanogen) is noted as a feasible alternative to methyl bromide for grain and other foodstuffs. It is not recorded as a potential alternative to fumigating logs and wood products in the UNEP 2015 fact sheet. However, in the recent New Zealand EPA methyl bromide reassessment decision, EDN is noted as going through their HSNO assessment process as alternative log fumigant (New Zealand EPA, 2021). New Zealand is working with China to approve fumigation of logs with EDN as an equivalent quarantine treatment and EDN has been included in Table 9:

Table 9: Alternatives that can potentially replace or reduce methyl bromide use for QPS purposes[1]

Treatment	Commodity (highlighted cells indicate the main categories of QPS)
Sulfuryl fluoride	Whole logs
	Wood (round wood, sawn wood, wood chips)
	Grain, cereals and oil seeds for consumption
	Dried foodstuffs
	Equipment, empty shipping containers
	Hay, straw, thatch grass, dried animal fodder
	Personal effects, furniture
	Tree nuts
	Cotton and other fibre crops
	Buildings with quarantine pests

[1] This table covers chemical alternatives and heat treatment. Other non-chemical alternatives are not covered by this report.

Treatment	Commodity (highlighted cells indicate the main categories of QPS)
Phosphine	Whole logs
	Wood (round wood, sawn wood, wood chips)
	Fresh fruit and vegetables
	Grain, cereals and oil seeds for consumption
	Dried foodstuffs
	Equipment, empty shipping containers
	Hay, straw, thatch grass, dried animal fodder
	Personal effects, furniture
	Seeds
	Tree nuts
	Cotton and other fibre crops
	Cut flowers and branches
	Nursery stock
	Buildings with quarantine pests
Ethyl formate	Fresh fruit and vegetables
	Grain, cereals and oil seeds for consumption
	Tree nuts
	Cut flowers and branches
Ethylene oxide	Personal effects, furniture
	Tree nuts
Methyl iodide	Whole logs
	Wood (round wood, sawn wood, wood chips)

Treatment	**Commodity (highlighted cells indicate the main categories of QPS)**
Methyl isothiocyanate (MITC)	Nursery stock
MITC/sulfuryl fluoride mixture	Whole logs
	Wood (round wood, sawn wood, wood chips)
Carbonyl sulphide	Grain, cereals and oil seeds for consumption
Propylene oxide	Dried foodstuffs
	Tree nuts
Heat treatment	Whole logs
	Wood (round wood, sawn wood, wood chips)
	Wood packaging materials
	Grain, cereals and oil seeds for consumption
	Dried foodstuffs
	Equipment, empty shipping containers
	Hay, straw, thatch grass, dried animal fodder
	Personal effects, furniture
	Tree nuts
	Cotton and other fiber crops
	Buildings with quarantine pests
Ethanedinitrile (EDN)	Forest products (logs, timber)
	Grains
	Devitalisation of seeds
	Fungal pathogens

3.2 Current status of chemical alternatives to methyl bromide in Australia

From the industry survey, 67% of respondents answering the question relating to use of alternatives indicated they did use other products. The dominant alternatives were sulfuryl fluoride and phosphine. One respondent indicated the use of carbon dioxide which is not a fumigant but is a known controlled atmosphere treatment. The organic industry rely on its use as an alternative to chemical fumigation.

The current status of chemical alternatives to methyl bromide have been considered through determination of which chemicals are registered in Australia by the regulator, the Australian Pesticides and Veterinary Medicines Authority (APVMA), and for what uses registration is approved. This information is available from the APVMA PUBCRIS database.

3.2.1 Sulfuryl fluoride

Sulfuryl fluoride is a high global warming potential (GWP) alternative fumigant and therefore there is reluctance by some companies to progress its use. It is currently registered with the APVMA in two end-use products. The following uses are registered as of November 2021:

Table 10: Australian registered use situations for sulfuryl fluoride

Situation	Pests controlled
Dwellings, buildings, construction materials, timber, logs, furnishings, shipping containers, vehicles.	Existing infestations of rodents and insects such as borers, bed bugs, cockroaches, clothes, moths, carpet beetles and dry wood termites.
Commodity storage and non-residential structures NOT containing food commodities.	All life stages of stored product pests including Indian meal moth (*Plodia interpunctella*), Mediterranean flour moth (*Ephestia kuehniella*), Confused flour beetle (*Tribolium confusum*), rust red flour beetle (*Tribolium castaneum*), warehouse beetle (*Trogoderma variable*), saw toothed grain beetle (*Oryaephilus surinamensis*), dried fruit moth (*Ephestia cautella*) drugstore beetle (*Stegobium paniceum*), Tobacco beetle (*Lasioderma serricorne*), hide beetle (*Dermestes maculatus*), grain weevil (*Sitophilus granaries*), rice weevil (*Sitophlus oryzae)*, rusty grain weevil (*Cryptolestes ferrugineus*) and lesser grain borer (*Rhyzopertha dominica*).
Commodity storage structures containing the following food commodities only: Cereal grains, dried fruits, nuts, baled hay for animal feed, pet food.	
Seed storage facilities (not for human consumption).	

3.2.2 Phosphine

There are 34 registered phosphine products in Australia as several different fumigant formulation types (blanket, tablets, compressed gas). Products are registered for a range of situations including insect pests in produce and buildings, sealed structures and pests of cut flowers. Commodities noted for treatment include raw cereal grains (barley, maize, millets, oats, rice, rye, sorghum, triticale, wheat), other food commodities such as flour, milled cereal products, breakfast cereals, dried fruits, dried vegetable, other dried foods, peanuts, oilseeds, cocoa, coffee beans), bulk stock feeds and seeds for propagation.

In their review of grain devitalisation methods, Meibusch *et al* (2019) consider phosphine to be the only widely used alternative to methyl bromide that is cost effective, rapidly acting and does not leave resides on the stored product. However, they observe that pests with high levels of resistance toward phosphine have become common in Asia, Australia and Brazil, which is of great concern, given the paucity of alternative fumigants. Phosphine remains the single most relied-upon fumigant to control stored grain pests in Australian grain production systems, but continued misuse is resulting in poor insect control.

3.2.3 Ethyl formate

There are three products registered (which have ethyl formate as the active constituent) with the APVMA in Australia for the following use patterns.

Table 11: Australian registered use situations for ethyl formate

Situation	Pests controlled
Cereal grains, oilseeds, dried fruits, dates, tobacco, grain storage premises and equipment for animal feed.	Lesser grain borer (*Rhyzopertha dominica*), flour beetle (*Tribolium castaneum*), Psocids, storage moths (*Esphestia* spp, *Plodia* spp), saw toothed grain beetle (*Oryzaephilus* spp.), flat grain beetle (*Cryptolestes* spp.), cigarette beetle (*Lasioderma serricorne*), nitidulid beetles (*Carpophilus hemipeterus, C. maculates*).
Fresh fruit and vegetables	Various pests for lettuce, onion, sweet pepper/capsicum, rhubarb, banana, pineapple, strawberry, kiwifruit, grapes, citrus, apples, apricots, sweet corn.
Bed bugs infested commercial and household items placed in well sealed shipping container, container under gas proof sheet and fumigation chamber.	Bed bugs – adults, immature and egg stages of *Cimex* sp.

3.2.4 Ethylene oxide

Ethylene oxide is registered in 18 end use products by the APVMA. However, for use specifically as a fumigant there are only 4 products registered.

For these products, specific pests are not identified. Rather, the statement exists on product labels that the product is lethal to most forms of bacteria, viruses, moulds, insects and their eggs.

The following non-food commodities are listed as suitable for fumigation where treatment is required by AQIS for import and export:

> Plant fibre materials, polishes, leather articles, wood products (timber furniture and homeware accessories), wickerware, paper, bristles, clothes, curtain fabric, footwear, hats, umbrellas, walking sticks, ceramic products, glassware, metal materials such as machinery and parts, musical instruments, clocks, electrical components, talc, cosmetics.

3.2.5 Methyl iodide

There are no end use product registrations with methyl iodide in Australia.

3.2.6 Methyl isothiocyanate

There are no active constituent or end use product registrations with methyl isothiocyanate in Australia.

3.2.7 Carbonyl sulphide

Carbonyl sulphide is registered as an active constituent in Australia (registrant, BOC Limited). However, there are no end use products registered so this active constituent is not currently available in Australia for use as an alternative chemical treatment to methyl bromide.

3.2.8 Propylene oxide

Propylene oxide is registered as an active constituent in Australia. However, there are no end use products registered so this active constituent is not currently available in Australia for use as an alternative chemical treatment to methyl bromide.

3.2.9 Ethanedinitrile

Ethanedinitrile or EDN is registered in one end use product in Australia as a pre-plant fumigant and for use on timber logs. This active constituent along with sulfuryl fluoride are the only substances registered for use on timber logs in Australia other than methyl bromide. The use pattern currently approved by the APVMA is:

Table 12: Australian registered use situations for Ethanedinitrile

Situation	Pests controlled
Pre-plant soil fumigation	Soil borne pathogens
Timber and logs in sealed fumigation chambers or in shipping containers under tarpaulins or as a stack sealed under tarpaulins	Fungi infesting timber Insect pests of timber

The treatment rate currently on the product label is 50 g/m^3 for either 6 hours (fungi) or 10 hours (insect pests). The registrant, Draslovka Services, has advised that a label change extension is currently submitted to the APVMA for approval.

3.3 Alternatives approaching market readiness

Advice has been received from Ensystex, the registrant of one of the sulfuryl fluoride products, ZYTHOR Gas Fumigant, that they are in the process of making it easier for ZYTHOR Gas Fumigant, to be used for quarantine purposes by updating the label to specify it may be used to meet Department of Agriculture, Water and the Environment QPS specifications. The proposed updated uses are subject to APVMA approval and will seek registration for control of Brown mamorated stink bug and other quarantine pests as notified by DAWE.

Advice was received from Draslovka Services for three potential alternative fumigants to replace methyl bromide. Two are currently registered in Australia and the third, HCN is yet to be registered but an application has been submitted to the APVMA.

Details for alternatives approaching market readiness are summarised in the following table:

Table 13: Alternative options for methyl bromide uses

Product/Fumigant	Commodities	Purpose	Approval
Sulfuryl fluoride	Treatment of Brown marmorated stink bug	Import	Currently submitted to APVMA for approval.
	Other quarantine pests as notified by DAWE.	Import/Export	
EDN™ containing Ethanedinitrile as active ingredient	Timber, logs and wood products	Export/import	EDN™ is approved for proposed commodities. A label change extension is currently being considered by APVMA
Bluefume™ containing HCN as active ingredient	Control of stored product insects and rodents in empty ship cargo, airplanes and other transportation means.	Export/import	An application for the approval of Bluefume™ was submitted to the APVMA in 2020.
	Treatment of Brown marmorated stink bug on the cars and equipment imported into Australia	Import treatment	Efficacy data are available to support this target pest. Approval for this use by DAWE will be sought once Bluefume™ is registered in Australia
	Treatment of stored product commodities pests including Khapra beetle	Export/import	It is intended to register Bluefume™

Table 13: Alternative options for methyl bromide uses

Product/Fumigant	Commodities	Purpose	Approval
			treatment on grains export/import
Ethyl formate	Control of table grapes pests that are concern to Australian trading partners -Asian countries	Export treatment	Registered in Australia for table grapes use
	Control of Citrus pests that are concern to Australian trading partners -Asian countries	Export treatment	Registered in Australia for table grapes use
	Control of Mango pests that are concern to Australian trading partners -Asian countries	Export treatment	Not registered for Mango
	Treatment of Brown marmorated stink bug on the cars and equipment imported into Australia	Import treatment	Efficacy data are available to support its use on this pest
	Other fresh fruits and vegetables	Export/import	Registered in Australia on selected fruits and vegetables

3.4 Factors impeding uptake of alternatives

Two of the main factors impeding the use of alternatives identified by survey respondents were cost (and less flexibility in regard to what the products can be used to treat) and importing country requirements. It was advised that Profume (sulfuryl fluoride) is significantly more expensive to use and has additional compliance issues. A further response noted that sulfuryl fluoride is not as common as methyl bromide as it is an expensive alternative with less flexibility in regards to the products it can be used on.

With respect to use on pulses, it was noted that fumigation alternatives approved for this use are limited given most pulses are destined for human consumption. Australian Government approvals was identified as an impediment with some respondents observing that fumigants are used based on directives from DAWE. To this point, for pre-shipment fumigation requirements are driven by the importing country. Any registered fumigant can be used for export if the importing country allows its use as a quarantine treatment. For example, Malaysia and China approved sulfuryl fluoride as an alternative treatment for logs. Malaysia has approved the use of Cyanogen (EDN) as an approved quarantine treatment for forest products. These chemicals can be used as an alternative to methyl bromide for these markets.

In one detailed response, regulatory and phytosanitary approvals were stated as the major reasons for impeding uptake alternative fumigants in Australia. It was advised that EDN fumigant can be applied using the same technology as methyl bromide. Bluefume (HCN) can be also applied using a "user friendly" application system. While ethyl formate had issues with the application system, it has been advised that a revised application method is available which reduces the application time by nearly 10 times compared with the current system. These points were expanded as follows:

1. Regulatory issues:

a) In the current approval, the APVMA has imposed some controls on use that the registrant considered to make the application of EDN commercially non-viable. These controls include: maximum 20% load factor, scrubbing system to recapture EDN, large buffer zone. Draslovka Services Australia has submitted an application to increase the dose rate, extend fumigation time and remove all these restrictions based on a new data that prove the safety and efficacy of EDN Fumigant.
b) EDN Fumigant is approved by the APVMA but it is not approved by the Department of Agriculture, Water and the Environment (DAWE) as a quarantine treatment for export or import. Draslovka services is currently working with DAWE for EDN approval. DAWE has noted that the approval for export is based on the recognition of the treatment by the country of import. Currently, Malaysia approved the fumigation of logs with EDN. Export allows fumigation of logs exports to Malaysia.
c) HCN is neither registered nor approved as a quarantine treatment in Australia
d) Ethyl formate is registered but it is not approved by DAWE as a quarantine treatment for export or import. Again, DAWE notes that approval for export is based on the recognition of the treatment by the country of import. Once approved by the country of import, DAWE does not stop its use.

Some respondents observed that DAWE could devise a phytosanitary approval process with a timeframe that will help in bringing new products into the market as an alternative to methyl bromide. At this stage there is no defined pathway and timeframe for approval. In addition, methyl bromide was approved as a quarantine treatment with limited efficacy data. However, new products proposed as a replacement have to go through rigorous approval process with expensive studies. Moreover, there are no specialized laboratories available to rear the timber insects and conduct the efficacy testing.

2. Commercial issues:

Concern was expressed that methyl bromide was approved as a quarantine treatment with limited efficacy data. However, new products are required to meet rigorous approval requirements underpinned by expensive efficacy data. As there is not a deadline for the methyl bromide phase out, fumigators therefore prefer to use methyl bromide.

DAWE advises that there are mandatory requirements for assessing the efficacy of a fumigant and approving its use as a quarantine treatment.

Further, DAWE advise that their export program has been working with a number of markets for approving alternatives to methyl bromide as quarantine treatment with success. For example, they successfully obtained approval for phosphine fumigation of wheat to Pakistan, Barley to

Bangladesh, some African markets and removal of mandatory fumigation for wheat and barley to Iran. They are currently working with several South American countries for allowing phosphine fumigation as a quarantine treatment.

3.5 Barriers preventing the adoption of alternatives to methyl bromide

The barriers discussed in this section are those highlighted by stakeholders in the participants' survey. There other barriers cited in peer reviewed journal articles however they are not discussed in this report. It is recommended they be considered in the next report.

The requirements of the importing country, efficacy and exposure time were stated by survey respondents as potential barriers.

Two further detailed responses were provided for this issue.

One respondent considered the main barrier to sulfuryl fluoride being more readily used is DAWE only specifying methyl bromide, when sulfuryl fluoride is registered and suitable for the job; or giving the fumigators the option of using either methyl bromide or sulfuryl fluoride. They consider that this usually leads to methyl bromide being used since the fumigator uses this more frequently at ports, or due to the lower price.

A second respondent considered the major export markets such Asian countries should approve EDN for timber and logs, ethyl formate for fresh commodities as a QPS treatment prior to its application. The respondent noted that currently Asian countries mainly accept methyl bromide treatment, despite alternatives being available to control Brown marmorated stink bug on cars and equipment's imported into Australia. NZMPI has considered these products as a replacement for methyl bromide.

DAWE notes that sulfuryl fluoride may be approved as quarantine treatment for BMSB.

3.6 Alternatives to methyl bromide being considered in particular markets.

Two responses were provided for this issue.

Ensystex Australasia Pty Ltd advised that sulfuryl fluoride is widely used by the grains industry in Australia, and sometimes for the control of Brown marmorated stink bugs (BMSB). Methyl bromide is more commonly used for BMSB though since it is specified by DAWE.

Draslovka Services advise that Malaysia, Korea and Russia have approved EDN as an alternative to methyl bromide. EDN is approved under permit in Czech Republic, and it is used on the timber and logs exported to China. DAWE has reported it allows EDN fumigation for logs to Malaysia. Logs to Korea are not regulated article. Australia does not export forest products to Russia

Draslovka services successfully completed a ship-hold treatment in December 2021. With respect to this treatment, DAWE inspected and certified a phytosanitary certificate outwards to Malaysia.

DAWE approved EDN for treating hitchhiker Burnt pine long horn beetle during flying season in New Zealand. Draslovka Services Australia is working with New Zealand EPA to get the approval of both countries.

eFUME (ethyl formate) is currently assessed by USDA APHIS for controlling pests on the table grapes imported from Chile to USA.

NZMPI is assessing Bluefume (HCN) as an export/import treatment alternative to methyl bromide.

4 Destruction/recapture technologies for methyl bromide

Parties to the Montreal Protocol are urged to minimise emissions of methyl bromide in situations where they still use methyl bromide and are unable to adopt non-ozone depleting alternatives. In situations where methyl bromide is used and alternative non-methyl bromide treatments are not feasible, one approach to minimising emissions is to adopt recapture technology, with subsequent destruction, disposal or reuse of the methyl bromide.

Providers of methyl bromide recapture systems (Nordiko Quarantine Systems Pty Ltd and Genera Group), and destruction technology (EIM Technologies Pty Ltd) were consulted through telephone and email contact to assist with information for this section of the report. Their responses are included in the following sub-sections as provided.

4.1 Destruction technologies

At the time of the last report undertaken by Cox (2017), there were no methyl bromide destruction technologies approved by the Montreal Protocol. Since then, one process by Australian company EIM Technologies Pty Ltd has become available. This technology involves thermal decay of methyl bromide from dilute sources of methyl bromide and was recently approved as a Destruction Process under Decision XXIX/4. The technology is based on destruction of methyl bromide by thermal decay in a single pass destruction step, followed by conversion of the by-products through a water-based scrubbing system. The TEAP Destruction Taskforce determined that the destruction and removal efficiency (DRE) >99.99%, HBr, CO and particulate emissions met the performance criteria.

In view of this technology being approved by the Parties in 2018, a technology now exists, in addition to the recapture technologies, which can be considered for destruction of methyl bromide from the remaining controlled critical uses and all QPS non-soil applications with potential for accessing credit for destroyed material.

An overview of the TEAP assessment and recommendation from the September 2018 TEAP Report: Volume 1 follows:

> The technical application submitted by one company (Australia) is described as a portable system for the capture and destruction of methyl bromide, at locations where it is used as a fumigant. The technology is based on destruction of methyl bromide by thermal decay in a single pass destruction step, followed by conversion of the by-products through a water-based scrubbing system. This technology is more than a capture system alone and, based on the information provided, falls within the scope of an assessment as a destruction technology. The Supplement to the April 2018 Task Force Report on Destruction Technologies provided an assessment of the technology against the performance and technical capability criteria, based on the information available at that time, which showed that destruction and removal efficiency (DRE), HBr and particulate emissions meet performance criteria. A test to measure for brominated dioxins/furans emissions was not feasible in the circumstances, and CO emissions exceeded the performance criteria, based on the measurements made at that time.

Since then, the technology developer has made several modifications to the overall process, which have the objective of improving the overall combustion and scrubbing processes. New analytical measurements were provided for CO emissions only. Improvements to the combustion process have reduced CO emissions. The new analytical data provided confirms that CO emissions have been reduced compared to the data reported in the Supplement Report. The CO concentration in the exhaust gases was measured as 40 mg/m^3, based on an average of 3 analytical results corrected to standard conditions of dry gas at normal conditions of 0^{o}C and 101.3 kPa, and with the stack gas corrected to 11% oxygen. This meets the performance criterion and is considerably below the CO emissions (283 mg/m^3) reported for combustion without the new component.

In addition, the combustion process operating temperature has been reduced, but still remains in the range where dioxins/furans could be formed. The technology developer indicates that changes to improve combustion should not have impacted on the methyl bromide DRE, which was >99.99% for the previously reported destruction system operation. No data is available for the emissions of brominated dioxins/furans, and therefore no change in recommendation can be made.

Thermal Decay of Methyl Bromide is recommended as *high potential* for methyl bromide destruction.

Additional information has been provided by EIM Technologies Pty Ltd with respect to this technology. EIM constantly monitors for outlet concentrations of methyl bromide and bromide, with detection of either tripping sensor alarms (set for 0 ppm alarm level) and stopping machine operation until the reason for the breakthrough being identified and rectified. The most recent tests confirm a minimum destruction rate of 99.9996% (not detectable at the parts per billion level).

4.2 Recapture technologies

The commercially available recapture systems globally are reported in MBTOC (2018) and include:

- Recapture systems onto active carbon (for example, Australia and Pacific countries) – absorption of methyl bromide from gas emissions from chambers after fumigation. Despite commercial processes available to recover the methyl bromide for reuse, at present all methyl bromide recovered from the recapture process is deep buried. It is done so on the understanding that methyl bromide degrades in soil, and it reduces emissions to the atmosphere. At present the captured methyl bromide on carbon cannot be reused or recycled as there is no permit or licence to do so.
- Carbon sorption plus scrubbing using potassium thiosulphate or a proprietary scrubbing technology is being used in the US and under trial currently in New Zealand. In the US two systems as shown above have been commercially operating for 5 years and this has reduced the need for constant review by US regulators.
- Carbon sorption and regenerative scrubbing systems are currently in trial operation in New Zealand for recapture of methyl bromide from large scale log fumigations. The US

carbon sorption and regeneration systems have been operating at two commercial installations for the past 4 and 5 years respectively. Operations at the two sites have removed over 57 tonnes of methyl bromide from over 1,500 fumigations.

- In addition to the above technologies, New Zealand has imposed a policy to ensure all methyl bromide applications, including QPS use recapture systems since 2020. This is stepwise process which required all containerized methyl bromide treatments to use recapture by August 2017. The US has also recently (August 2018) announced a new rule to make recapture of methyl bromide mandatory in North Carolina for QPS treatment of logs.
- Trials in Australia have used recaptured methyl bromide on carbon to fumigate soils in the strawberry runner industry which have an exemption to use methyl bromide under the 'Critical Use' provisions of the Montreal Protocol. These trials have presently not been scaled up for commercial use nor is the product registered for use given the difficulties in assuring consistent quality and consistency.

The situation in New Zealand has been revised from that described by MBTOC. The New Zealand EPA decision for the reassessment of methyl bromide was released on 11 August 2021 (New Zealand EPA, 2021). With respect to use of recapture technology, the Committee decided that incremental steps towards higher recapture rates will be more achievable than a single target rate set to be achieved in five or ten years' time and will have the effect of reducing risks to people and the environment to negligible over that time. For fumigations of containers, (that is, enclosed spaces excluding fumigations under sheets, or ship's holds), the recapture performance for each fumigation increases from 80% (from 1 January 2023) to 99% (from 1 January 2031). For fumigations under sheets: the proportion of fumigations to have recapture technology applied increases from 50% (from 1 January 2022) to 100% (from 1 January 2025), minimum recapture performance increases from 30% (from 1 January 2022) to 99% (from 1 January 2035), and annual average recapture performance for a given site increases from 55% (from 1 January 2022) to 99% (from 1 January 2035).

Genera has advised that it uses a carbon-based system for recapture of methyl bromide used in fumigation of fresh produce and containers, and a liquid based system for logs. The carbon-based system is used in Australia and passes air flow through activated carbon which then extracts the methyl bromide. The liquid-based system is a destruction mechanism which destroys the bromide. This system is not available in Australia. However, the applicant (Stakeholders in Methyl Bromide Reduction Incorporated - STMBR) to the New Zealand reassessment considered this liquid scrubbing technology to be the only feasible methyl bromide recapture method for use in log fumigation. STMBR noted that the moisture content of logs reduces the efficiency of carbon-based recapture technologies. In addition, it contended that carbon-based recapture technologies generate an enormous amount of toxic waste (which is made bigger when recapturing from high-moisture commodities, as the carbon adsorbs water). The applicant also stated that other recapture technologies were either not technically or economically feasible, not amenable to port operations, not transferable from the recapture of methyl bromide from container fumigation to log stack fumigation or had a combination of these issues.

Nordiko Quarantine Systems Pty Ltd provides an activated carbon based methyl bromide recapture system. This is a dry system and does not utilise liquid chemicals. It works on adsorption of methyl bromide to activated carbon filters. Once the activated carbon filters

become full (saturated) they are disposed of. The filter comes in a variety of sizes. 75 kg is the smallest filter and the largest filter is approximately 2000 L with holds 900 kg activated carbon. Adsorption efficiency is dictated by several parameters such as temperature and relative humidity. Industry applies a 1:10 ratio so 100 kg carbon can absorb up to 10 kg methyl bromide. Track record has been audited by a 3rd party saying this system can recapture >99% of remaining methyl bromide. The system can be used regardless of commodity or fumigation vessel (container, silos, tarp).

4.3 Barriers preventing the adoption of recapture or destruction technologies

EIM Technologies Pty Ltd has identified some barriers to destruction / recapture adoption listed as follows in decreasing order of impact as follows:

- Non uniformity of destruction / recapture legislation across States, regions or jurisdictions, there needs to be an industry wide recapture requirement. Exemptions create competitive inequities between industry competitors. Feedback showed companies are happy to adopt destruction / recapture, but only if everyone is in the same situation, and no competitive advantage is or can be gained by not having to destroy or recapture the methyl bromide;
- Higher capital expenditure and operating costs;
- Disposal costs (not applicable to EIM system, as by-products are recycled back into bromine manufacture or a mining consumable);
- Scale of recapture required limits the cost effectiveness of carbon recapture systems on large volume operations; and
- Regional or remote location operations.

Methyl bromide use in New Zealand is roughly equivalent to that in Australia and is forecasted to increase with export logs to Asia. In New Zealand >90% of usage is in logs export which have some recapture requirement, subject to the volume of fumigation. A major barrier to adoption of recapture technologies in Australia is cost. Recapture will add 20-50% onto the cost of fumigation, depending on the application. Nordiko advise it had seen a spike of interest from organisations who want to start their own fumigation facilities rather rely on a third party. For fresh produce, methyl bromide recapture is more economical due to the higher value products being fumigated, and less methyl bromide is used per volume of commodity fumigated.

According to GENERA, the main barrier to adoption of recapture technologies relates to cost. If recapture is not required fumigators will not do it.

4.4 Estimation of methyl bromide available for recapture and/or destruction

GENERA: The carbon based recapture system will remove >90% of what remains in containers or fumigation systems at the end of fumigation. The liquid system is re-circulated so is more geared towards big bulk fumigation systems. It can achieve recovery of up to 80% of methyl

bromide remaining at the end of fumigation. Currently in New Zealand, this recapture system is applied to approximately 80% of log stacks and 100% of container fumigations.

NORDIKO: Hard to quantify as it is seasonal, and commodity based. There are a number of variables that impact the amount recovered including number of times fumigation is undertaken, the number of commodities, end requirement and methyl bromide retention requirements.

5 Potential improvements to survey

During the previous and current surveys, the issue most frequently mentioned by users as a concern was the number of agencies which collect information on methyl bromide use. DAWE gathers its AIMS data as record of completion of treatment of imported goods under quarantine direction. That record, the record of fumigation, includes a description of the goods, dose rate and quantity applied. Although the initial quarantine direction is in an accessible database, the record of fumigation is scanned, but not entered. On the export side, a Notice of Intention to Export Prescribed Goods must be presented to and approved by an authorised officer, under the terms of the Export Control Act 1982. This notice provides information on goods descriptions, the place and date of departure and the destination, together with a statement of compliance with regulatory conditions. Entered into EXDOC it is possible at a later date, to extract commodities by tonnage, date and destination. Methyl bromide use can be extrapolated from these data based on potential use for specific destinations.

The Ozone and Climate Protection Section of DAWE requires users to maintain detailed records of every fumigation in addition to a summary record of use. In the main these records are intended to mimic record keeping requirements under other Commonwealth, state or territory laws, to prevent duplication. These records potentially capture all methyl bromide use, QPS and non QPS and include information on the date, commodity treated and total usage. Obtaining these records may assist in any future surveys. Individual state authorities may capture similar data.

The lack of use of computerised methods of record keeping as reported to AIMS or EXDOC is surprising. It may be possible to develop a suitable application that allows fumigators to electronically enter information pertaining to methyl bromide use and submit online to a central DAWE database at the time of fumigation. This would eliminate the need for the current paper based record keeping system. Assuming all relevant sections within DAWE have access to this database, it may reduce uncertainty relating to use estimation. The industry survey component of this project would also no longer be required.

Abbreviations used in this report

Term	Definition
AIMS	Australian Import Management System
APVMA	Australian Pesticides and Veterinary Medicines Authority
AWPCS	Australian Wood Packing Certification System
BICON	Biosecurity Import Conditions Database
BMSB	Brown marmorated stink bug
DAWE	Department of Agriculture, Water and the Environment
EXDOC	Export Documentation System
FID	Full Import Declaration
GWP	Global Warming Potential
MICoR	Manual of Importing Country Requirements
NZMPI	New Zealand Ministry for Primary Industries
PEMS	Plant Export Management System
QPS	Quarantine and Pre-Shipment
TEAP	Technology and Economic Assessment Panel
UNEP	United Nations Environment Programme

References

Cox D, 2017. Quarantine and Pre-Shipment uses of Methyl Bromide 2013-2016 and the Potential for its Replacement. Report to the Australian Government Department of the Environment and Energy. September 2017. Report available online.

MBTOC, 2018. United Nations Environment Programme (UNEP)2018 Report of the Methyl Bromide Technical Options Committee. Report available online.

Meibusch P, Williams R and Mayer J, 2019. Review of Grain Devitalisation Methods. Meat and Livestock Australia Limited. 11 November 2019. Report available online.

New Zealand EPA, 2021. Decision: Modified reassessment of methyl bromide. APP203660. 11 August 2021. Decision report available online.

UNEP, 1999. Methyl Bromide Phase-Out Strategies. A Global Compilation of Laws and Regulations. OzonAction Programme of the United Nations Environment Programme Division of Technology, Industry and Economics.

Appendix A: Survey questions – Use of Methyl Bromide in Australia from 2017 to 2020

DAWE of Agriculture, Water and the Environment seeks data on quarantine and pre-shipment (QPS) uses of methyl bromide from 2017 to 2020.

Privacy Consent Statement

The Australian Environment Agency Pty Ltd (AEA) is conducting a survey for the purposes of providing a report to DAWE of Agriculture, Water and the Environment on use of methyl bromide for quarantine and pre-shipment fumigations in Australia and adoption of alternatives or reduction measures.

In addition to information on the use of methyl bromide, the survey will collect personal information from you such as your name, email address and other contact details in accordance with DAWE's privacy policy (1). However, AEA will ensure that the final report only includes de-identified and aggregated data andwill not include any personal or company details.

The survey will be conducted using Microsoft Forms under Microsoft's Security and Privacy policy (2) andMicrosoft 365 Statement (3).

The responses to the survey will be stored on AEA's Microsoft 365 drive until at such time as the report is complete and no later than 1 July 2022 and then it will be deleted. DAWE may retain a copy of theinformation you supplied for its records, but it will only be used for the purpose for which it was collected. You can contact AEA with any questions at info@aeapl.com.au (mailto:info@aeapl.com.au).

(1) https://www.awe.gov.au/about/com
mitment/privacy
(2) https://support.microsoft.com/en-us/office/security-and-privacy-in-microsoft-forms-7e57f9ba-4aeb- 4b1b-9e21-b75318532cd9 (https://support.microsoft.com/en-us/office/security-and-privacy-in-microsoft-forms-7e57f9ba-4aeb-4b1b-9e21-b75318532cd9)
(3) https://docs.microsoft.com/en-us/office365/servicedescriptions/office-365-platform-service- description/privacy-security-and-transparency (https://docs.microsoft.com/en-us/office365/servicedescriptions/office-365-platform-service-description/privacy-security-and-transparency)

1. By clicking Yes and participating in the survey, you consent to the use of theinformation provided for the purposes described above.

   ◯ Yes

◯ No

Volumes of Use

The following sections request information on volumes of use including:

Total volumes;

Export (Pre-Shipment): for use on goods being shipped from Australia;Import (Quarantine): for use on goods entering Australia; and Domestic: for use on goods being shipped interstate.

Please ensure that this information is close at hand as it is not possible to save this survey and return to it later.

Methyl Bromide Use Statistics - Total volume of use

Please provide the total methyl bromide volumes you have used for the years 2017-2020:

2. 2017 - Total use (kg)

3. 2018 - Total use (kg)

4. 2019 - Total use (kg)

5. 2020 - Total use (kg)

Methyl Bromide Use Statistics - Export uses

Export (Pre-Shipment) methyl bromide uses are for fumigation on goods being shipped from Australia. Please only report quantities >100 kg and list the amount for different commodities. Commodity examples include Cereal grains (including rice); Wood and Timber; Hay (including cereal straw); Pulses; and Cottonseed.

6. 2017 - Export use (kg)

7. 2018 - Export use (kg)

8. 2019 - Export use (kg)

9. 2020 - Export use (kg)

Methyl Bromide Use Statistics - Import uses

Import (Quarantine) methyl bromide uses are for fumigation on goods entering Australia. Please only report quantities >50 kg and list the amount for different commodities. Commodity examples include Disinfestation(insects, ticks, spiders); Furniture and personal effects; Equipment/parts/components; Steel and steel scrap; and Flours and meals (including meat meals).

10. 2017 - Import use (kg)

11. 2018 - Import use (kg)

12. 2019 - Import use (kg)

13. 2020 - Import use (kg)

Methyl Bromide Use Statistics - Domestic uses

Import (Quarantine) methyl bromide uses are for fumigation on goods entering Australia. Please only report quantities >50 kg and list the amount for different commodities. Commodity examples include fresh fruit andvegetables.

14. 2017 - Domestic use (kg)

15. 2018 - Domestic use (kg)

16. 2019 - Domestic use (kg)

17. 2020 - Domestic use (kg)

Recapture and destruction technologies

An area of interest in this project is to identify existing or new methyl bromide recapture or destructiontechnologies that are available in Australia and internationally.

18. In undertaking QPS fumigation do you use methyl bromide recapture or destructiontechnologies?

- ◯ Yes
- ◯ No

19. If you answered "Yes" to the above question, can you briefly describe the technologyused?

Alternatives to Methyl Bromide

In some cases there are alternative fumigants to methyl bromide.

20. Do you use alternatives to methyl bromide?

- ◯ Yes
- ◯ No

21. Please list alternatives to methyl bromide that you know about.

22. Please provide the reasons why you are unable to use alternative fumigants.

Identification

23. What is your name?

24. What is the name of the company you are responding for?

25. Please provide your best contact number:

26. Please provide your best email contact address:

27. Do your answers cover all branches of your company?

- ◯ Yes
- ◯ No

28. If you answered "No" can you please provide details of other

Company contacts weshould be sending the survey to (name and telephone and/or email address):

Other information

29. Please provide any comments or other information you would like to provide.

30. What do you think is a reasonable timeframe for DAWE to undertake thissurvey?

- ◯ 2 years
- ◯ 3 years
- ◯ 4 years
- ◯ Other