Re-evaluation Note REV2007-12

Preliminary Risk and Value Assessments of Thiophanate-Methyl

The purpose of this Re-evaluation Note is to inform registrants, pesticide regulatory officials and the Canadian public that Health Canada's Pest Management Regulatory Agency (PMRA) has completed preliminary risk and value assessments of thiophanate-methyl.

This Re-evaluation Note summarizes these preliminary assessments based on the data and information reviewed. The preliminary assessments identified potential risks to the environment, to workers both during application and during re-entry activities and to the general population through drinking water exposure. The PMRA is requesting further data/information to finalize the risk and value assessments as well as to propose regulatory action.

Therefore, the PMRA is soliciting information that may be used to refine these preliminary assessments and/or mitigate risks. The PMRA will accept written comments and information up to 60 days from the date of publication of this document. Please forward all comments to Publications at the address listed below.

The PMRA will review the information received, revise the risk and value assessments as necessary and propose regulatory action in a future document.

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Table of Contents

1.0 Purpose

This document describes the PMRA's preliminary risk and value assessments of the fungicide thiophanate-methyl and its end-uses. It includes a human health assessment, an environmental assessment and information on the value of thiophanate-methyl to pest management in Canada.

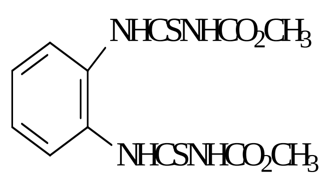
By way of this document, the PMRA is soliciting comments and input to the risk and value assessments of thiophanate-methyl from interested parties. Such comments and input could include, for example, additional data or information to further refine the risk assessment or could address the PMRA's risk assessment approaches and assumptions as applied to thiophanate-methyl. Further information regarding the effectiveness and extent of use of the alternatives to thiophanate-methyl could refine the value assessment.

2.0 Re-evaluation of Thiophanate-Methyl

Thiophanate-methyl is included in the list of pesticides subject to re-evaluation in Canada as announced in the Re-evaluation Document REV2004-06, *PMRA Re-evaluation Program Workplan (April 2004 to June 2005)*. Thiophanate-methyl is a broad-spectrum, Resistance Management Group 1 (methyl benzimidazole carbamate) fungicide. Thiophanate-methyl is a precursor of carbendazim, the biologically active molecule. It is a systemic fungicide with protective and curative action. The systemic action of this fungicide results in the disruption of fungal mitosis and the mode of action is by the inhibition of tubulin formation.

2.1 Chemical Identification

Chemical name

IUPAC	Dimethyl 4,4'-(*o*-phenylene)bis(3-thioallophanate)
CAS	Dimethyl [1,2-phenylenebis(iminocarbonothioyl)]bis[carbamate]
CAS number	23564-05-8
Molecular formula	$C_{12}H_{14}N_4O_4S_2$
Structural formula	

2.1.1 Identity of Relevant Impurities of Toxicological, Environmental and/or Other Significance

No impurities of toxicological concern as identified in Section 2.13.4 of Regulatory Directive DIR98-04, *Chemistry Requirements for the Registration of a Technical Grade of Active Ingredient or an Integrated System Product*, or any Toxic Substances Management Policy (TSMP)Track 1 substances as identified in Appendix II of its Regulatory Directive DIR99-03 are expected to be present in the starting materials used to manufacture the product nor are they expected to be formed during the manufacturing process.

2.2 Description of Registered Uses of Thiophanate-Methyl

Thiophanate-methyl is registered for use to control fungal diseases of fruit trees, small fruits and ornamentals and is used as seed treatment for potato, corn and bean. Thiophanate-methyl is sold either in dust/powder, wettable powder or granular form.

2.2.1 Description of Uses Considered in the Risk Assessments

Appendix I lists all thiophanate-methyl products registered with the PMRA. Appendix II lists all the Commercial and Domestic Class uses for which thiophanate-methyl is presently registered. All registered uses are supported by the registrant and were considered in the health and environmental risk assessments of thiophanate-methyl. In addition to the fully registered uses of thiophanate-methyl, the emergency use of this active ingredient on mushrooms was also assessed and is included in this re-evaluation document.

Uses of thiophanate-methyl belong to the following use-site categories:

- Greenhouse Non-Food Crops (mushroom emergency use);
- Greenhouse Food Crops (mushroom emergency use);
- Terrestrial Food Crops;
- Ornamentals Outdoor (Commercial and Domestic);
- Turf; and
- Seed Treatments for Food and Feed.

3.0 Effects Having Relevance to Human Health

3.1 Toxicology Summary

The toxicology database for thiophanate-methyl and carbendazim is based primarily on registrant-supplied data. Available published studies were also considered. Both carbendazim and thiophanate-methyl were of low acute toxicity by oral and dermal administration in various laboratory animal species, and of low (carbendazim) or slight (thiophanate-methyl) toxicity by the inhalation route. Clinical signs of acute oral and inhalation thiophanate-methyl toxicity included tremors, increased sensitivity to touch, clonic/tonic convulsions, ataxia and ptosis. Liver pathology, testicular and spermatogenic effects were noted in acute studies with carbendazim. Carbendazim and thiophanate-methyl were minimally or non-irritating to eyes and skin. Thiophanate-methyl was a skin sensitizer in the guinea pig, whereas carbendazim was negative. Thiophanate-methyl as well as carbendazim undergo rapid systemic absorption and distribution following oral exposure, with greater than 80% excretion via the urine and feces within 24 hours. Tissue retention was minimal, with the liver and kidney showing the highest tissue concentrations for both compounds, in addition to the thyroid for thiophanate-methyl. Thiophanate-methyl is metabolized by hydroxylation and hydrolysis to carbendazim, which is further metabolized to 5-methoxycarbendazim sulfate, the major urinary metabolite. The major carbendazim metabolite is 5-hydroxy-2-benzimidazole carbamate.

In short- and long-term animal toxicity studies, the liver was the primary target for both compounds. Thiophanate-methyl produced additional effects in the thyroid and kidney, and carbendazim also induced testicular toxicity. The dog was the species most sensitive to thiophanate-methyl induced thyroid hormone effects. Although no specific neurotoxicity studies were submitted for thiophanate-methyl, potential evidence of neurotoxicity at high dose levels was noted in a one-year study in dogs, based on tremors occurring within two to four hours of dosing, and in a two-generation reproduction study in which postweanling male pups showed reduced performance in an open-field test. The neurotoxic effects of carbendazim were limited to mild transient effects that occurred at high doses only, without histological evidence of neuropathy. Both thiophanate-methyl and carbendazim induced liver tumours in male and female mice. Thiophanate-methyl also induced thyroid tumours in male rats, and ovarian granulosa cell tumours and leuteomas were noted in one strain of mice treated with carbendazim. Carbendazim and thiophanate-methyl were not mutagenic, but are well-known aneugens, with carbendazim inducing aneugenic effects at lower doses than thiophanate-methyl. However, 2-aminobenzimidazole, a minor metabolite of both carbendazim and thiophanate-methyl was mutagenic, and thiophanate-methyl and some of its metabolites share a thiourea moiety implicated in thyroid tumour formation.

Resorptions, craniofacial and/or rib malformations were observed in carbendazim-treated rats, rabbits and hamsters in the absence of maternal toxicity in all species tested, indicating fetal sensitivity. More severe effects occurred as a result of gavage dosing compared to dietary administration, although fetal sensitivity was noted with both routes. Thiophanate-methyl is metabolized to carbendazim, yet the developmental effects induced by thiophanate-methyl were less severe than those induced by carbendazim. Multiple supernumery ribs in rabbit fetuses were noted at maternally toxic doses of thiophanate-methyl. Developmental concerns regarding thiophanate-methyl stem from the fact that short- and long-term exposures to thiophanate-methyl caused decrements in circulating thyroid hormones in rats, mice and dogs. Adequate circulating levels of thyroid hormones are critical for normal development of the mammalian fetal and neonatal brain and persistent decreases in thyroid hormone levels increase the potential for neurodevelopmental deficits in the young. Thus, a developmental neurotoxicity study is warranted. No reproductive toxicity was observed with either compound in guideline studies; however, a number of published and unpublished studies on carbendazim reported sperm and testicular changes (inhibition of spermatogenesis and sperm reduction, germinal epithelium degeneration, lower testis weight) with high-dose, short-term gavage and dietary dosing.

Reference doses were established for each compound based on no observed adverse effect levels (NOAELs) for the most relevant endpoints. These included neurotoxic symptoms, developmental toxicity and thyroid effects for thiophanate-methyl, and sperm effects, developmental toxicity and systemic toxicity for carbendazim. These reference doses incorporate uncertainty factors to account for extrapolating between animals and humans, and for variability within human populations. Additional safety/uncertainty factors were also applied to take into consideration the severity of effects, fetal sensitivity and any residual uncertainty in either database. Quantitative cancer risk assessments were conducted for both thiophanate-methyl and carbendazim-induced mouse liver tumours.

The toxicology endpoints used in the risk assessment of thiophanate-methyl and carbendazim are summarized in Appendix IV, Table 1 and Table 2.

3.2 Occupational and Non-Occupational Risk Assessments

Workers can be exposed to thiophanate-methyl through mixing, loading or applying the pesticide and when re-entering a treated site to conduct activities such as handling treated crops.

Occupational and residential risks are estimated by comparing potential exposures with the most relevant endpoint from toxicology studies to calculate a margin of exposure (MOE). This is compared to a target MOE incorporating safety factors protective of the most sensitive subpopulation. If the calculated MOE is less than the target MOE, it does not necessarily mean that exposure will result in adverse effects. However, MOEs that are less than the target MOE require risk mitigation.

Thiophanate-Methyl

To estimate the risk from short-term dermal exposure to thiophanate-methyl (< 30 days), a NOAEL of 100 mg/kg bw/day from a 21-day dermal study in rabbits was selected. This NOAEL was based on decreased body weight and food consumption at 300 mg/kg bw/day. The target MOE is 300. This accounts for interspecies extrapolation (10-fold) and intraspecies variability (10-fold) with an additional factor (3-fold) for the lack of acute, subchronic and developmental neurotoxicity studies. Because a dermal NOAEL is used, no dermal absorption factor is required for route-to-route extrapolation.

To estimate the risk from short-term inhalation exposure to thiophanate-methyl (< 30 days), a NOAEL of 10 mg/kg bw/day from a rabbit developmental toxicity study was selected. An oral endpoint was used as a repeat-dose inhalation study was not available. The NOAEL was based on decreased maternal body weight and food consumption at the lowest observed adverse effect level (LOAEL) of 20 mg/kg bw/day. The target MOE is 300. This accounts for interspecies extrapolation (10-fold) and intraspecies variability (10-fold) with an additional factor (3-fold) for the lack of acute, subchronic and developmental neurotoxicity studies. Because an oral NOAEL is used, an inhalation absorption factor of 100% is assumed for route-to-route extrapolation.

To estimate the risk from intermediate-term (1–6 months) and chronic (> 6 months) dermal and inhalation exposures to thiophanate-methyl, a NOAEL of 8 mg/kg bw/day from a 1-year dog and a 2-year rat study was selected, based on increased thyroid weight and decreased serum thyroxine in male dogs at 40 mg/kg bw/day, testicular atrophy and reduced thyroid follicular cell colloid in male rats at 32 mg/kg bw/day, and thyroid follicular cell hypertrophy and reduced body-weight gain in both species. This is supported by a NOAEL of 8.8 mg/kg bw/day from a second 2-year dietary study in rats, based on thyroid, kidney and liver effects, increases in serum thyroid stimulating hormone (TSH) and cholesterol levels and decreased thyroid hormone levels in rats at 54.4 mg/kg bw/day. The target MOE is 1000. This accounts for interspecies extrapolation (10-fold) and intraspecies variability (10-fold) with an additional factors for the use of an endocrine endpoint (3-fold thyroid effects) and for residual uncertainties concerning potential neuroendocrine sensitivity in the young due to possible thyroid interactions (3-fold). There were no dermal absorption studies submitted by the registrant for thiophanate-methyl or carbendazim. Risks from carbendazim, the primary metabolite of thiophanate-methyl, are also considered in the assessment. Based on the apparent dermal absorption and the physical-chemical properties of thiophanate-methyl, including the high log *n*-octonol–partition coefficient (K_{ow}), a small molecular weight and the low-water solubility, a dermal absorption factor of 25% was used for the re-evaluation of thiophanate-methyl and carbendazim.

The availability of a 21-day dermal toxicity study obviated the use of the dermal absorption factor in calculating the daily dermal dose for thiophanate-methyl because short-term dermal exposures were compared to the dermal endpoint. However, the dermal absorption factor (DAF) was used in calculating the daily dermal dose for intermediate-term exposure scenarios because it was compared to an oral endpoint and was also used in estimating the systemic dose from dermal exposure for estimation of cancer risk.

A quantitative risk assessment for tumorigenicity was conducted based on increased hepatocellular tumours in male mice. Female mice also had an increase in liver tumours. A cancer potency factor (Q_1*) of 1.32×10^{-2} (mg/kg bw/day)$^{-1}$ was used.

Carbendazim

To estimate the risk from short- to intermediate-term dermal and inhalation exposure to carbendazim (< 30 days), a NOAEL of 10 mg/kg bw/day from both rat and rabbit developmental toxicity studies were selected. An oral endpoint was used, as a repeat-dose dermal study did not address the endpoint of concern noted in the oral developmental studies. This NOAEL was based on an increased incidence of fetal malformations at the LOAEL of 30 mg/kg bw/day in rats and increased resorptions at the LOAEL of 20 mg/kg bw/day in rabbits, both in the absence of maternal toxicity. The target MOE is 1000 to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold), with an additional factor of 10-fold for fetal sensitivity and severity of effects (malformations in the absence of maternal toxicity) and the lack of a developmental neurotoxicity study. This endpoint and target MOE is also protective of the sperm effects noted in rats after receiving a single oral dose. Because an oral NOAEL is used, dermal and inhalation absorption factors are required for route-to-route extrapolation.

A quantitative risk assessment for tumorigenicity was conducted based on increased hepatocellular tumours in female mice. An increase in liver tumours was also noted in male mice. A Q_1* of 1.6×10^{-2} $(mg/kg\ bw/day)^{-1}$ was used.

No chemical-specific data were available to determine the percent dermal absorption of carbendazim. In the absence of chemical-specific data, the PMRA assesses dermal absorption of chemicals based on a weight-of-evidence approach. For carbendazim, based on the physical-chemical properties including water solubility and log K_{ow}, and by a comparison of these properties to a structurally-related compounds having similar toxicological effects (i.e. benomyl that has a chemical-specific dermal absorption study available), the default dermal absorption value was reduced to 25%.

3.2.1 Occupational Mixer/Loader/Applicator Exposure

There are potential exposures to mixers, loaders, applicators and other handlers. Based on typical use pattern, the major scenarios identified were the following:

- aerial application to lowbush blueberries and white beans;
- groundboom application to berries, white beans, sugar beets, outdoor ornamentals and turf;
- low-pressure handwand and backpack application to aspen and poplar greenhouse potted ornamentals, berries, outdoor ornamentals and turf;
- high-pressure handwand application to aspen and poplar, greenhouse potted ornamentals and outdoor ornamentals;
- airblast application to aspen and poplar, stone fruits and outdoor ornamentals;
- right-of-way sprayer for aspen and poplar;
- push rotary spreader and tractor drawn spreader to turf;
- ready-to-use (shaker can) for roses, flowers and evergreens (residential);
- slurry machines and hand mixing for application to dry common beans;
- seed box treatment to sweet corn;
- spawning application to mushrooms; and
- convenient container or by dust attachment over belt application to cut seed potatoes.

Based on the number of applications, workers applying thiophanate-methyl would generally have a short-term (< 30 days) duration of exposure. Exceptions would be for the following:

- ornamentals;
- lowbush blueberries;
- white beans (custom applicator only);
- turf (for the granular formulation only);
- dry bean and sweet corn seed treatment (commercial) that could represent an intermediate duration of exposure (> 30 days–6 months); and
- greenhouse potted ornamentals and mushrooms that could represent a long-term duration of exposure (> 6 months).

The PMRA estimated handler exposure based on different levels of personal protective equipment (PPE):

- Minimum PPE: a long-sleeved shirt and long pants, chemical-resistant gloves, with and without respirator.

- Mid-level PPE: coveralls over a long-sleeved shirt and long pants, chemical-resistant gloves, with and without respirator.
- Maximum PPE: chemical-resistant coveralls over a long-sleeved shirt and long pants, chemical-resistant gloves and a respirator.

- Engineering controls: Represents the use of an appropriate engineering control such as closed tractor cab or closed loading system (water soluble packaging). For groundboom and airblast applicators, the engineering controls comprised closed cabs. Engineering controls are limited for handheld application methods.

Mixer/loader/applicator exposure estimates are based on the best available data at this time. The assessment might be refined with exposure data more representative of modern application equipment and engineering controls. Biological monitoring data might also further refine the assessment.

No chemical-specific handler exposure data were submitted for thiophanate-methyl; therefore, dermal and inhalation exposures were estimated using the data from the Pesticide Handlers Exposure Database (PHED), Version 1.1. The PHED is a compilation of generic mixer/loader/ applicator passive dosimetry data with associated software that facilitates the generation of scenario-specific exposure estimates based on formulation type, application equipment, mix/load systems and level of PPE. In most cases, the PHED did not contain appropriate data sets to estimate exposure to workers wearing chemical-resistant coveralls or a respirator. This was estimated by incorporating a 90% clothing protection factor for chemical-resistant coveralls and a 90% protection factor for a respirator into the unit exposure data.

For some scenarios (e.g. hand-held equipment), estimating exposure for mix/load with wettable powder was not possible using the PHED. In these situations, exposure for mix/load/apply with open pour liquid for high-pressure handwand and backpack would be comparable for wettable powder formulations in water-soluble packaging.

3.2.1.1 Seed Treatment

Thiophanate-methyl is registered for seed treatment use on sweet corn, dry beans and potato cut seed as dust on-farm (short-term exposure), as well as in commercial seed treatment facilities (intermediate-term exposure). The PHED was not used to estimate exposure because it is not considered representative for this exposure scenario. For treating sweet corn and dry bean seed on-farm, the unit exposure numbers were from a published study (Fenske et al. 1990).

The registrant does not currently have access to any commercial seed treatment studies. The United States Environmental Protection Agency (USEPA) Policy 14 values were cited only to indicate that the target MOEs for commercial seed treatment for corn and dry beans may not be reached. In addition, the USEPA Policy 14 may underestimate exposure for commercial seed treatment with a dust formulation.

A published study by Stevens and Davis (1981) was used to assess the potato cut seed exposure. However, this study had several limitations, including a small number of replicates (3–18 for various job functions) and reported only the summary data, monitoring periods that were short (maximum of 2 hours), no inclusion of quality assurance/quality control data and no detailed information on PPE. The PMRA could not therefore verify any of the study results as raw data were not reported.

Assumptions regarding application rate and the amount of seeds handled per day were used in conjunction with unit exposure values to determine thiophanate-methyl occupational exposures (Table 3.2.1.1).

Table 3.2.1.1 Seed Treatment Crops Exposure Assessment Assumptions

Crop	Equipment	Rate	Amount of Seed Handled per Day	Area Planted per Day
On Farm				
Sweet corn	Seed treatment box	0.70 g a.i./kg of seed	1320	60 ha
Dry bean	Slurry machine or hand mixing	0.73 g a.i./kg of seed	1920–4980 (3000)[a]	60 ha
Potato[b]	Container or dust attachment over belt	0.50 g a.i./kg of seed	45 000 (10 000)[a]	N/A
Commercial				
Sweet corn	Seed treatment box	0.70 g a.i./kg of seed	60 000	N/A
Dry bean	Slurry machine or hand mixing	0.73 g a.i./kg of seed	68 000	N/A

a Proposed maximum amount of seed handled per day in order to reach target MOEs.
b The on-farm potato seed treatment assessment covers farm and coop/commercial level treatment scenarios.

Mushroom Spawn

Thiophanate-methyl is registered for emergency use on mushrooms for the control of Trichoderma green mould as a wettable powder to be applied application at spawning at a rate of 1.25 g of product with 50–62 g of gypsum, limestone or chalk per 1 kg of spawn. Calculated MOEs for hand and mechanical spreading of treated spawn do not meet the target MOE of 1000. Details of the full exposure risk assessment can be found in Appendix VII.

3.2.1.2 Occupational Exposure Non-Cancer Risk Estimates

Calculated MOEs exceed target MOEs for application, mixing and loading for the majority label uses, provided engineering controls or PPE are used as summarized in Appendix Va.

As noted above, the calculated MOEs are less than target MOEs for commercial seed treatment and for mushroom spawn treatments, even after consideration of more feasible engineering controls (e.g. PPE). The calculated MOEs are also less than the target MOEs for greenhouse potted ornamentals, white beans, outdoor ornamentals and roses.

For on-farm seed treatment (sweet corn and dry bean), only mixing/loading and application to treated seeds were assessed. There was no data to assess planting treated seed. By limiting the amount of seed treated for dry beans (which results in an MOE of 400), there is room in the risk cup to allow for the potential exposure from planting treated seed. A study to fill this data gap would be required for continued registration.

For potato cut seed, in order to reach the target MOE of 300, the maximum amount of cut seed handled per day would need to be limited to 10 000 kg. The PPE was not specified in the study. Therefore, the label would require the following information: coveralls over a long-sleeved shirt and long pants, chemical-resistant gloves and a NIOSH/MSHA/BHSE-approved dust/mist filtering respirator. Due to the low confidence in the published study used to assess exposure for potato cut seed treatment, a study to fill this data gap would be required for continued registration (Appendix Va).

Table 3.2.1.2 summarizes the occupational non-cancer MOEs that do not meet the target MOE with maximum PPE and/or engineering controls. See Appendix Va for all use scenarios.

Table 3.2.1.2 Intermediate-Term Occupational Exposure Scenarios

Crop	Formulation	Application Equipment	Application Rate	Area Treated per Day (ha or L)	Combined MOE [a] (target = 1000)	
					Level PPE[b]	Maximum PPE[c]
USC 6—Greenhouse Non-Food Crops						
Potted ornamentals	WSP	High-pressure handwand	0.000595 (kg a.i./L)	3750 L	399	532
USC 10—Seed Treatments for Food and Feed						
Dry common beans—Commercial	WSP	Multiple activities	0.73 g a.i./kg of seed	68 000 kg of seed	488	N/A
Sweet corn—Commercial			0.70 g a.i./ kg of seed	60 000 kg of seed	575	N/A
USC 14—Terrestrial Food Crops						
White beans	WP	Groundboom	1.59 (kg a.i./ha)	300 ha	11	12
	WSP				160	193
		CC groundboom			247	284
	WP	M/L for aircraft		400 ha	9	10
	WSP				408	N/A
	WP/WSP	Aircraft			354	N/A
Mushrooms	WP	Hand spreading	8.75 kg a.i./ha	0.16 ha	29	46
		Mechanical			N/A	289–489
USC 27—Ornamentals Outdoor						
Outdoor ornamentals and roses (Commercial)	WSP	High-pressure handwand	0.000525 (kg a.i./L)	3750 L	453	603
	WP	Airblast	0.525 (kg a.i./ha)	16 ha	302	319
	WSP				536	555
		CC airblast			5059	N/A

[a] Combined MOE = 1 / [(1 / dermal MOE) + (1 / inhalation MOE)] where dermal MOE = dermal exposure / dermal NOAEL and inhalation MOE = inhalation exposure / inhalation NOAEL (the dermal and inhalation NOAEL are 8 mg/kg bw/day and the target dermal NOAEL and inhalation MOE are 1000).

[b] Mid-level PPE = coveralls over a single layer of clothing, gloves, with and without respirator

[c] Maximum PPE = chemical-resistant coveralls over a single layer of clothing, gloves and a respirator

N/A = not applicable
WSP = water-soluble packaging
WP = wettable powder
CC = closed-cab tractor

3.2.1.3 Occupational Exposure Cancer Risk Estimates

To estimate cancer risk, exposure was amortized over a lifetime to estimate a lifetime average daily dose (LADD). Assumptions made include that each application is done in one day, that the maximum number of yearly applications is made at the maximum label rate and that a working lifetime comprises 35 years of a 70-year life span.

Lifetime cancer risk estimates associated with mixing/loading/applying thiophanate-methyl for occupational handlers are not of concern if additional PPE or engineering controls (for water-soluble powder) are used (see Appendix IVa for details), with the exception of mushrooms, white beans, sweet corn and dry beans (commercial seed treatment) where the cancer risk is > 1×10^{-4} (Table 3.2.1.3). A lifetime cancer risk in the range of 1 in 10^{-5} to 1 in 10^{-6} in worker populations is generally considered acceptable.

Table 3.2.1.3 Occupational Exposure Cancer Risk Estimates

Crop	Formulation	Application Equipment	Mid-Level PPE With Respirator[a, b]		Maximum PPE[c]	
			LADD[d]	Cancer Risk[e]	LADD[d]	Cancer Risk[e]
USC 10—Seed Treatments for Food and Feed						
Dry common beans (Commercial)	WSP	Multiple activities	0.00135	1.78×10^{-5}	N/A	N/A
Sweet corn (Commercial)	WSP	Multiple activities	0.00114	1.51×10^{-5}	N/A	N/A
USC 14—Terrestrial Food Crops						
Mushrooms	WP	Dispersal by hand	0.0346	4.56×10^{-4}	0.0214	2.83×10^{-4}
		Mechanical	0.002–0.0034	$2.7–4.5 \times 10^{-5}$	N/A	N/A
White beans	WP	Groundboom (custom)	0.0435	5.74×10^{-4}	0.0267	3.52×10^{-4}
	WSP		0.00235	3.10×10^{-5}	0.0017	2.25×10^{-5}
		CC groundboom	0.0014	1.84×10^{-5}	0.0012	1.59×10^{-5}
	WP	M/L for aircraft	0.0556	7.34×10^{-4}	0.0338	4.46×10^{-4}
	WSP		0.000807	1.06×10^{-5}	0.000551	7.27×10^{-6}
	WP/WSP	Aerial application	0.000928	1.22×10^{-5}	N/A	

a The unit exposure values from the USEPA Policy 14 for the seed treatment uses are different in terms of PPE: a single layer of clothing and gloves is for multiple activities.

b Mid-level PPE = coveralls over a single layer of clothing and gloves

c Maximum PPE = chemical-resistant coveralls over a single layer of clothing, gloves and a respirator

d Lifetime average daily dose, amortizing 35 years of occupational exposure over a 70-year lifetime for workers.

e Cancer risk = LADD (mg/kg/day) × Q_1^* (0.0132)

Shaded cells indicate a cancer risk for workers (> 1×10^{-5}).

3.2.1.4 Occupational Postapplication Exposure and Risk Assessment

The postapplication occupational risk assessment considered exposures to workers entering treated sites, including orchard crops, mushrooms, field crops, turf, greenhouse ornamentals and outdoor ornamentals (commercial sites, including short rotation intensive culture sites [i.e. aspen and poplar]). Based on the thiophanate-methyl use pattern, there is potential for short-term (1–30 days) postapplication exposure for sugar beets, white beans, and turf (wettable powder formulation) and intermediate-/long-term (1–6 months, > 6 months) postapplication exposure to thiophanate-methyl residues for workers for all other crops. Postapplication exposure includes activities such as thinning, pruning, harvesting, training, pinching, propping, scouting, weeding, mowing, irrigation and tying.

Dislodgeable foliar residue (DFR) data and turf transferable residue (TTR) data were used to estimate postapplication exposure to thiophanate-methyl resulting from contact with treated foliage at various times after application. Restricted-entry intervals (REIs) are calculated to determine the minimum length of time required before workers or others can safely re-enter. An REI is the duration of time that must elapse before residues and/or air concentrations decline to a level so entry into a treated area to perform a specific activity results in exposures above the target MOE (i.e. > 300 for short-term and > 1000 for intermediate-/long-term exposures). When compared to agronomically feasible REIs, which range from 2 to 7 days, target MOEs are not met for intermediate-term postapplication exposure scenarios for thiophanate-methyl.

Postapplication cancer risks for re-entry workers were based on average residues for 7 or 14 days, starting on the day when target MOEs were met. For crops where REIs were not considered agronomically feasible (based on non-cancer risk estimates), postapplication cancer risks were based on average residues starting on the proposed agronomically feasible REI. Postapplication cancer risk estimates range from 1×10^{-3} to 9×10^{-7}. Details are in Appendix Vb. Cancer and non-cancer risk are summarized in Table 3.2.1.4.1 and Table 3.2.1.4.2.

Table 3.2.1.4.1 Summary of Commercial Postapplication Exposure Risk Estimates

Crop[a]	Activity (transfert coefficient or TC)	Target DFR[b]	Study Site[c]	Day to Reach Target MOE	Agronomically Feasible REI (PHI)	TPM Cancer Risk
Short-Term Postapplication Exposure Scenarios (target MOE = 300)						
Aspen, poplar	Handline irrigation (1100)	2.65	NY	0	5	1.20×10^{-5}
			WA	0		1.10×10^{-3}
Sugar beets	Scouting (1500)	2.65	NC	0	7 (21)	8.59×10^{-6}
Raspberries	Harvest, pruning, thinning (1500)	1.944		1	3 (1)	5.53×10^{-5}
Strawberries		1.944		1	3 (1)	
White beans	Harvest (2500)	1.167		3	7	1.49×10^{-5}

Crop[a]	Activity (transfert coefficient or TC)	Target DFR[b]	Study Site[c]	Day to Reach Target MOE	Agronomically Feasible REI (PHI)	TPM Cancer Risk
Intermediate-Term Postapplication Exposure Scenarios (target MOE = 1000)						
Greenhouse potted ornamentals	All (400—refined) Not applicable to cut flowers	0.7	GCF	20	2	4.48×10^{-4}
Peach, nectarine, plum, prune, cherry	Thinning (3000)	0.093	NY	20	3 (1–7)	4.58×10^{-5}
			WA	> 50		1.27×10^{-4}
Apples, pears			NY	21		7.84×10^{-6}
			WA	> 50		2.18×10^{-4}
Lowbush blueberries	Harvest (1500)	0.1867	NC	4	3 (60)	1.00×10^{-5}
Roses, ornamentals	400—refined Not applicable to cut flowers	0.7		2	5	1.05×10^{-6}
	7000—cut flowers	0.04		6		1.84×10^{-5}

[a] Most labels do not specify the maximum number of applications or the minimum interval between applications. Current uses would need to be limited to two applications, seven days apart.

[b] Target DFR for short-term exposure scenarios is based on a NOAEL of 100 000 µg/kg bw/day × 70 kg / (TC × 8 h × SF of 300). Target DFR for intermediate postapplication exposure scenarios are based on a NOAEL of 8000 µg/kg bw/day × 70 kg / (TC × 8 h × SF of 1000 × dermal absorption factor of 25%).

[c] NY = New York apple DFR study where predicted DFR were used and corrected for Canadian rates; WA = Washington apple DFR study site where predicted DFR were used and corrected for Canadian rates; NC = North Carolina strawberry DFR study where predicted DFR values were used and corrected for Canadian rates; GCF = greenhouse cut flower study where predicted DFR data for roses were used.

Table 3.2.1.4.2 Summary of Commercial Turf Postapplication Exposure Risk Estimate

Crop and Application Rate	Activity (TC)	Target TTR[a]	Study Site[c]	Day to Reach Target MOE	Agronomically Feasible REI	Cancer Risk[d]
Short-Term Postapplication Exposure Scenarios						
Turf (17.5 kg a.i./ha)	Mowing (6800)	0.4289	PA	> 7	0	3.85×10^{-4}
			CA	2		1.14×10^{-4}
			GA	4		2.20×10^{-4}
Intermediate-Term Postapplication Exposure Scenarios						
Turf (3 kg a.i./ha) (granular formulation)	Mowing (6800)	0.0412	PA	> 7	0	6.59×10^{-5}
			CA	4		1.96×10^{-5}
			GA	5		3.78×10^{-5}

a Target TTR for short-term exposure scenarios is based on a NOAEL of 100 000 µg/kg bw/day × 70 kg / (TC of 6800 × 8 h × SF of 300). Target DFR for intermediate postapplication exposure scenarios are based on a NOAEL of 8000 µg/kg bw/day × 70 kg / (TC of 6800 × 8 h × SF of 1000 × dermal absorption factor of 25%).

c PA = Pennsylvania site where the R^2 value was less than 0.85; therefore, actual data points were used and corrected for Canadian rates; CA = California site where the R^2 value was greater than 0.85; therefore, predicted values were used and corrected for Canadian rates; GA = Georgia site where the R^2 value was greater than 0.85; therefore, predicted values were used and corrected for Canadian rates.

d Cancer risk estimates are based on TTR values averaged over 7 days, starting on day 0 (agronomically feasible REI).

Mushrooms were not assessed for postapplication exposure because no detectable residues were found for thiophanate-methyl or carbendazim (with an limit of quantification of 0.01 ppm), based on a magnitude of residue study on agaricus mushrooms.

Postapplication exposure was also assessed for the degradate of thiophanate-methyl, carbendazim. As some of the DFR/TTR studies used for estimating thiophanate-methyl residues had a number of limitations that may underestimate carbendazim, they were not used quantitatively for residues of carbendazim. Additionally, the strawberry DFR study and all turf studies did not report residues of carbendazim separately or report daily carbendazim residues.

Therefore, for most scenarios, it is assumed that 15% of thiophanate-methyl residues degrade to carbendazim. This is based on the apple DFR study (Washington site) where the maximum residue of carbendazim (0.395 µg/cm^2) was divided by the maximum residue of thiophanate-methyl (2.53 µg/cm^2). For greenhouse ornamentals, carbendazim values are estimated based on the highest reported value from cut flower study (0.35 µg/cm^2) and corrected for the Canadian label rate.

Target MOEs were met for all crops for carbendazim residues, with the exception of greenhouse ornamentals and turf. For turf, target MOEs are met for carbendazim with the exception of the highest rate (17.5 kg a.i./ha) for mowing, which resulted in an MOE of 803. This is considered a conservative estimate because predicted TTRs are based on 15% of thiophanate-methyl residues for 2 applications, 7 days apart (current label allows for one application at the highest rate of 17.5 kg a.i./ha).

Lifetime postapplication cancer risk estimates for carbendazim were considered acceptable ($< 1 \times 10^{-5}$) with the exception of turf (wettable powder) and greenhouse ornamentals. Postapplication risk estimates for carbendazim are detailed in Appendix Vb.

There were a number of refinements in the postapplication assessment for thiophanate-methyl:

- using chemical-specific DFR and TTR studies;
- extrapolating DFR data from apples and strawberries to all orchard crops, a variety of berries, ornamentals, aspen, poplar, sugar beets and beans;
- limiting the number of applications to two, with a minimum retreatment interval of seven days; and
- refining TCs for greenhouse and outdoor ornamentals (excluding cut flowers).

Postapplication exposure estimates also included a number of conservative inputs for both thiophanate-methyl and carbendazim, such as:

- the assumption that workers are exposed to residues following the maximum number of applications (in some cases) at the maximum rate;
- using default assumptions for residues of carbendazim. It was assumed that 15% of thiophanate-methyl degrades to carbendazim;
- using high-end exposure frequency estimates based on the USEPA Reregistration Eligibility Document (RED) (e.g. up to 180 days/year); and
- only one application is specified on the label for turf (wettable powder formulation at 17.4 kg a.i./ha). However, available DFR or TTR studies were limited to 2 applications, 7 days apart; therefore, these may overestimate residues.

3.2.2 Non-Occupational Exposure

Residential risk assessment estimates risks to the general population, including children/youths, during or after pesticide application.

Homeowners have potential for short- (1–30 days) to intermediate-term (1–6 months) exposure to thiophanate-methyl during application of a dust formulation to roses, evergreens, conifers and other ornamental flowers and shrubs. Residential exposures have been estimated based on the label application frequency, the estimated seasonal length and the persistence of thiophanate-methyl. It is estimated that thiophanate-methyl could be applied up to six times in a season to ornamentals by homeowners.

3.2.2.1 Non-Occupational Applicator Exposure Estimates and Cancer Risk

Exposure estimates for domestic applicators are based on Outdoor Residential Exposure Task Force (ORETF) data. For the residential scenario, the exposure estimates assume that individuals wear short pants, a short-sleeved shirt and no gloves.

Calculated MOEs for short- and intermediate-term exposure risk estimates exceed the target MOEs for application, mixing and loading for the current label use (roses, evergreens, conifers and other ornamental flowers and shrubs); therefore, these MOEs were not of concern (Appendix Vc).

The lifetime cancer risk associated with mixing/loading/applying thiophanate-methyl for non-occupational handlers is estimated as 5×10^{-7}. A lifetime cancer risk of 1 in 10^6 for the residential populations is generally considered acceptable (Appendix Vc).

3.2.2.2 Non-Occupational Postapplication Exposure Risk Estimates and Cancer Risk

Two groups, adults and youths, are potentially exposed (short-term) to thiophanate-methyl after the application of thiophanate-methyl products in residential settings and golf courses. Homeowners may be exposed to pesticide residues following treatment to ornamentals around their residences. Because these exposures could occur from a variety of activities, the PMRA estimate is based on a representative activity that results in a conservative exposure estimate. Youth assisting with gardening activities may incur exposures similar to adults gardening. For homeowner exposures, it is assumed that the duration for postapplication exposure is 40 minutes (0.67 hours) per day for pruning/thinning/harvesting roses and ornamentals. Inhalation exposures are not considered in the postapplication exposure assessment because of the low vapour pressure of thiophanate-methyl (1.3×10^{-5} mm Hg) and because the uses (and primary exposures) are outdoors thus, allowing for significant dilution.

The REIs are not considered a viable regulatory tool for reducing risks in residential settings. Therefore, for chemicals used in residential environments, or any other areas where the general population can be exposed, regulatory risk management currently considers the risks associated with a chemical on the day it is applied.

Postapplication non-cancer risk for gardeners is based on a strawberry DFR study (North Carolina site), and the predicted value for day 0 is considered refined. However, there is uncertainty in extrapolating from strawberry DFR data to ornamentals and evergreens. Postapplication non-cancer risk for golfers is based on the highest reported TTR value for day 0 from a Pennsylvania study site.

Cancer risk estimates are assessed based on the 7-day average DFR or TTR data following the day after treatment (day 0). The homeowner cancer risk from postapplication contact with treated ornamentals, as shown in Table 3.2.2.2.1, is estimated as 1.23×10^{-6}. This scenario applies to a homeowner who has treated ornamentals, e.g. rose bushes, treated with 2 applications, 7 days apart, at a rate of 1 kg a.i./ha, and who performs gardening activities for 40 minutes beginning on the day of application and does so in this manner 3 times a year for

50 years. It is also based on the average DFR values from the strawberry DFR study (North Carolina site) from day 0 to day 7.

For golfers, the calculated postapplication cancer risk ranged between 6 × 10^{-7} and 2 × 10^{-8}. This risk estimate is based on 2 applications to a golf course at the maximum rate of 17.5 kg a.i./ha or 3 kg a.i./ha (for granular formulations), assuming that a golfer is exposed 5 times a year for 4 hours on the last day of application and does so in this manner every year for 50 years. It is also based on the average TTR values from the TTR study (Georgia site) from day 0.5 to day 7. This is considered a conservative estimate. Risk estimates were refined for youth golfers by correcting the TC for body size (344 instead of 500 cm^2/h).

Table 3.2.2.2.1 Residential Postapplication Exposure Estimates for Gardening and Golfing

Scenario	Transfer Coefficient (cm^2/h)	Duration (h)	TPM DFR/TTR[a]		Short-Term (TPM) (target = 300)		LADD	Cancer Risk[c] (TPM)
			Non-Cancer	Cancer	Dermal Exposure (µg/kg/day)	Dermal MOE[b] (day 0)		
Gardeners (1.0 kg a.i./ha)								
Youth (39 kg)	4821	0.67	3.97	0.947	328.80	304	1.38 × 10^{-5}	1.82 × 10^{-7}
Adult (70 kg)	7000				265.99	376	9.31 × 10^{-5}	1.23 × 10^{-6}
Golfers (3.0 kg a.i./ha)								
Youths (39 kg)	344	4	0.764	0.119	26.96	3709	1.23 × 10^{-6}	1.63 × 10^{-8}
Adult (70 kg)	500				21.83	4581	8.32 × 10^{-6}	1.10 × 10^{-7}
Golfers (17.5 kg a.i./ha)								
Youths (39 kg)	344	4	4.46	0.697	157.29	636	7.22 × 10^{-6}	9.53 × 10^{-8}
Adult (70 kg)	500				127.37	785	4.87 × 10^{-5}	6.43 × 10^{-7}

a DFR value used for calculating non-cancer risk estimates is based on predicted day 0 value from a strawberry DFR study (NC site). TTR value based on highest reported TTR value (PA study site day 0.5 value). DFR value for cancer risk estimates is based on the average predicted (day 0 to day 7) value from strawberry DFR study (NC site). TTR value is based on the average predicted TTR (day 0.5 to day 7) value from the GA study site.

b Dermal MOE = NOAEL (100 mg/kg/day) / daily dermal dose (mg/kg/day). Dermal NOAEL is from a dermal study; therefore, no adjustment for dermal absorption.

c Cancer risk = LADD (mg/kg/day) × Q_1^* (0.0132); based on 50 years of exposure over a 70-year lifetime; exposure frequency of 3 days per year for gardeners and 5 days per year for golfers.

A non-occupational postapplication exposure scenario was also assessed for carbendazim, a degradate of thiophanate-methyl. Based on the uncertainties in the percentage of thiophanate-methyl that degrades to carbendazim at any time in the environment, coupled with limitations found in the chemical specific DFR/TTR studies, a default of 15% was selected to apply to the DFR/TTR data of thiophanate-methyl. For cancer risk, DFR/TTR values of carbendazim were estimated by taking 15% of the 7 or 14-day (or until residues were below the limit of quantification) average DFR value of thiophanate-methyl.

The target MOE (1000) for carbendazim was met for all scenarios with the exception of gardening youth (MOE of 810). For carbendazim cancer risk estimates, all residential postapplication scenarios were less than 1×10^{-6} (see Appendix Vc).

3.3 Dietary Exposure and Risk Assessment

In a dietary exposure assessment, the PMRA determines how much of a pesticide residue, including residues in fruits, vegetables, milk, meat, eggs and processed products, may be ingested daily. These dietary assessments are age-specific and incorporate the different eating habits of the population at various stages of life (infants, children, adolescents, adults and seniors). For example, assessments take into account differences in children's eating pattern, such as food preferences and greater consumption of food relative to their body weight compared with adults.

Carbendazim is not registered for use on food crops; however, thiophanate-methyl degrades to carbendazim, and both are identified as residues of concern. Independent estimates were made for dietary exposure to thiophanate-methyl and carbendazim. Where different endpoints were identified for each chemical, separate dietary exposure and risk estimates were made. Where a common endpoint was identified, the exposure estimates for both compounds were combined.

3.3.1 Acute Dietary Exposure and Risk Assessment (thiophanate-methyl)

To estimate acute dietary risk (1 day) for the general population, including infants and children, an acute dietary reference dose (ARfD) was set at 0.13 mg/kg bw. This was based on a NOAEL of 40 mg/kg bw/day for tremors that occurred within 2–4 hours of dosing at 200 mg/kg bw/day in a 1-year study in dogs. A safety factor (SF) of 300 was applied to account for interspecies extrapolation (10-fold), intraspecies variability (10-fold) and lack of an acute neurotoxicity study in rodents (3-fold). Neurotoxicity studies are required, based on evidence for potential neurotoxic effects in the database.

For females 13 to 50 years of age, an ARfD was set at 0.067 mg/kg bw. This was based on a fetal NOAEL of 20 mg/kg bw/day for multiple supernumerary ribs in a rabbit developmental study at 40 mg/kg bw/day. This effect is considered relevant to a single-dose exposure during pregnancy. A SF of 300 was applied to account for interspecies extrapolation (10-fold), intraspecies variability (10-fold) as well as the lack of acute neurotoxicity and developmental neurotoxicity studies, which are required based on evidence for potential neurotoxic effects in the database (3-fold).

The acute dietary risk assessment (DRA) is assessed at the 99.9^{th} percentile of exposure, with highly refined residue estimates based on food surveillance and plant metabolism data. Acute dietary exposure as a percentage of the reference dose is 0.5% for the general population, 3.4% for the most affected population of non-nursing infants and 0.5% for females of reproductive age. The acute dietary exposure to thiophanate-methyl is less than the reference dose for all Canadians; therefore, it is below the PMRA's level of concern.

3.3.2 Acute Dietary Exposure and Risk Assessment (carbendazim)

To estimate acute dietary risk (1 day) for males, a LOAEL of 50 mg/kg bw was selected. This was based on a published study on the acute testicular effects of carbendazim in rats, where an absence of immature germ cells with round spermatids (stage I and II) and elongated spermatids sloughed from stage VII epithelium were noted on day 2 post-treatment. An overall uncertainty factor (UF) of 1000 is required to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold), 3-fold for the use of a LOAEL and 3-fold for severity of effect. This effect can be irreversible at higher doses, and the capacity for reversal at 50 mg/kg bw is unknown. The ARfD was calculated to be 0.05 mg/kg bw (50 mg/kg bw ÷ 1000).

To estimate acute dietary risk (1 day) in females 13 to 50 years of age, a NOAEL of 10 mg/kg bw/day from rat and rabbit developmental toxicity studies on carbendazim was selected. This NOAEL was based on an increased incidence of fetal malformations at 30 mg/kg bw/day in rats and increased resorptions at 20 mg/kg bw/day in rabbits, both in the absence of maternal toxicity. An overall UF of 1000 is required to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold), with an additional factor of 10-fold for fetal sensitivity and severity of effects (malformations in the absence of maternal toxicity), and the lack of a developmental neurotoxicity study. The ARfD for females 13 to 50 years of age was calculated to be 0.01 mg/kg bw (10 mg/kg bw/day ÷ 1000).

The acute DRA is assessed at the 99.9th percentile of exposure, with highly refined residue estimates based on food surveillance and plant metabolism data. Acute dietary exposure as a percentage of the reference dose is 1.3% for the general population, 7.1% for the most affected population of non-nursing infants, and 3.6% for females of reproductive age. The acute dietary exposure to carbendazim is less than the reference dose for all Canadians: therefore, it is below the PMRA's level of concern.

3.3.3 Chronic Dietary Exposure and Risk Assessment (thiophanate-methyl)

Chronic dietary exposure is calculated using the average consumption of different foods and average residue values on those foods over a 70-year lifetime. This expected intake of residues is compared to the acceptable daily intake (ADI), which is the dose at which an individual could be exposed over the course of a lifetime and expect no adverse health effects. When the expected intake from residues is less than the ADI, this intake is not considered to be of concern.

To estimate the risk from chronic dietary exposure to thiophanate-methyl and the carbendazim metabolite, a NOAEL of 8 mg/kg bw/day from a 1-year dog and a 2-year rat study with thiophanate-methyl were selected, based on increased thyroid weight and decreased serum thyroxine in male dogs at 40 mg/kg bw/day, testicular atrophy and reduced thyroid follicular cell colloid in male rats at 32 mg/kg bw/day as well as thyroid follicular cell hypertrophy and reduced body-weight gain in both species. This is supported by a NOAEL of 8.8 mg/kg bw/day from a second 2-year dietary study with thiophanate-methyl in rats, based on thyroid, kidney and liver effects, increases in TSH and cholesterol levels and decreased thyroid hormone levels in rats at 54.4 mg/kg bw/day. An overall UF of 1000 is required to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold) 3-fold for the use of an endocrine endpoint (thyroid effects) and 3-fold for residual uncertainties concerning potential neuroendocrine sensitivity in the young due to possible thyroid interactions. The ADI was calculated to be 0.008 mg/kg bw/day (8 mg/kg bw ÷ 1000). This value was considered protective of all populations exposed to thiophanate-methyl and carbendazim.

As with the acute DRA, the chronic dietary exposure and risk assessment for thiophanate-methyl used highly refined residue estimate based on food surveillance and plant metabolism data. Chronic dietary risk is less than 0.9% of the ADI for all populations.

3.3.4 Chronic Dietary Exposure and Risk Assessment (carbendazim)

To estimate the risk from chronic dietary exposure to carbendazim, an ADI was set at 0.009 mg/kg bw/day. A NOAEL of 9 mg/kg bw/day from a 2-year dietary study in dogs was selected, based on reduced body-weight gain, increased alkaline phosphatase, reduced clotting time, increased organ/body-weight ratio (liver, pituitary, thyroid) and testicular effects (atrophic tubules, inflammatory cell infiltration) at 81 mg/kg bw/day. An overall UF of 1000 was applied to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold), with an additional factor of 10-fold for fetal sensitivity and severity of effects in the absence of maternal toxicity in both the rat and rabbit developmental studies and the lack of a developmental neurotoxicity study.

As with the acute DRA, the chronic dietary exposure and risk assessment for carbendazim used highly refined residue estimates based on food surveillance and plant metabolism data. Chronic dietary risk is less than 0.8% of the ADI for all populations.

3.3.5 Cancer Dietary Exposure and Risk Assessments (thiophanate-methyl and carbendazim)

A quantitative risk assessment for tumorigenicity was conducted based on increased hepatocellular tumours in male mice. Female mice also had an increase in liver tumours. A cancer potency factor (Q_1*) of 1.32×10^{-2} (mg/kg bw/day)$^{-1}$ and of 1.6×10^{-2} (mg/kg bw/day)$^{-1}$ was used for thiophanate-methyl and carbendazim, respectively.

The cancer risk from dietary exposure to thiophanate-methyl and the carbendazim metabolite are estimated using the chronic dietary exposure and the Q_1* for the respective chemicals. As these share a common cancer endpoint, the risk estimates were combined to give the total lifetime dietary risk. The food-only cancer risk is 5.5×10^{-7}. Cancer risks of less than 1×10^{-6} are below the PMRA's level of concern.

3.4 Drinking Water Exposure (thiophanate-methyl and carbendazim)

Drinking water exposure was addressed by calculating drinking water levels of comparison (DWLOC) and comparing these target values to the chronic drinking water estimated concentration (DWEC). The DWLOCs can only be calculated if all other exposures are not of concern to the PMRA, as the DWLOC simply expresses the difference between the reference dose and the non-drinking water exposure. Model derived estimated environmental concentrations (EEC) were used to determine the DWECs for thiophanate-methyl and carbendazim.

For thiophanate-methyl, the chronic DWLOCs ranged from 79 µg/L for the most affected subpopulation of non-nursing infants to 280 µg/L for the general population. The acute DWLOCs ranged from 1260 µg/L for non-nursing infants to 4530 µg/L for the general population.

For carbendazim, the chronic DWLOCs ranged from 90 µg/L for the most affected subpopulation of non-nursing infants to 314 µg/L for the general population. The acute DWLOCs ranged from 465 µg/L for non-nursing infants to 1730 µg/L for the general population.

As noted in Section 3.3.5, the cancer risk from both thiophanate-methyl and carbendazim are combined based on the general population to provide the lifetime exposure estimate. The dietary cancer DWLOC is 1.0 µg/L.

The acute and chronic DWECs for thiophanate-methyl and carbendazim are presented in Section 4.0 and are summarized in Appendix VI. The largest acute and chronic DWECs for thiophanate-methyl of 56 and 3.4 µg/L, respectively, are less than the respective DWLOCs, indicating that the combined exposure from food and water are acceptable. For carbendazim, the acute DWEC of 181 µg/L is less than the most conservative acute DWLOC; however, the chronic DWEC of 162 µg/L exceeds the DWLOC for infants and children, and is of concern. The dietary DWLOC for cancer includes potential exposure from both thiophanate-methyl and carbendazim. Therefore, it is appropriate to compare this to the combined chronic/cancer DWEC of 164 µg/L, expressed in carbendazim equivalents. This exceeds the DWLOC; therefore, exposure through drinking water is of concern.

3.5 Aggregate Exposure and Risk Assessment

Aggregate exposure is the total exposure to a single pesticide that may occur from food, drinking water, residential and other non-occupational sources as well as from all known or plausible exposure routes (oral, dermal and inhalation).

3.5.1 Acute Aggregate Exposure and Risk Assessment (thiophanate-methyl and carbendazim)

The acute aggregate assessment is encompassed by the dietary and drinking water assessments. As discussed in sections 3.3.1 and 3.3.2, acute exposure from food and water are not of concern, and therefore acute aggregate risk is also acceptable. Residential non-dietary exposure to thiophanate-methyl and carbendazim is considered in the short-term aggregate exposure assessment (see Section 3.5.2).

3.5.2 Short-Term Aggregate Exposure and Risk Assessment (thiophanate-methyl)

Reduction in body weight and food consumption was observed in short-term repeat dosing studies via both oral and dermal routes of exposure in the 21-day dermal toxicity study in rabbits and the rabbit developmental toxicity study. No repeat-dose inhalation studies were available, but it was assumed that these effects would be relevant to this route as well. The NOAEL/LOAEL for body-weight effects were 10/20 mg/kg bw/day in the rabbit developmental study and 100/300 mg/kg bw/day in the 21-day rabbit dermal study. A target MOE of 300 was based on standard UFs (10-fold for interspecies variation, 10-fold for intraspecies variation), with an additional 3-fold SF to account for the lack of acute and subchronic neurotoxicity as well as developmental neurotoxicity studies. This assessment is protective of all populations including females of child-bearing age (females 13–50 years).

Residential exposure to thiophanate-methyl may occur through gardening and from golfing on treated turf. Exposure assessments are made for adult applicators for gardening, and postapplication exposure to adults and youth for gardening and golfing. For the purposes of aggregation, this short-term residential exposure is combined with the chronic dietary and drinking water exposures. For the short-term aggregate assessment, exposure through golfing and gardening are assumed to occur independently and are therefore not combined.

Short-term aggregate exposure estimates for youth and adults exceed the target MOE of 300 for all scenarios. In addition, the aggregate DWLOCs exceed the chronic DWECs of 3.4 µg/L for all scenarios. Therefore, the short-term aggregate risk from thiophanate-methyl is acceptable.

Table 3.5.2.1 Youth and Adult Short-Term Aggregate Exposure (thiophanate-methyl)

<table>
<tr><th rowspan="3"></th><th rowspan="3">Scenario</th><th colspan="4">Exposure (mg/kg/bw)</th></tr>
<tr><th colspan="2">Applicator</th><th rowspan="2">Postapplication Dermal</th><th rowspan="2">Dietary</th></tr>
<tr><th>Dermal</th><th>Inhalation</th></tr>
<tr><td rowspan="3">Adult</td><td>Garden</td><td>0.00911</td><td>0.0001</td><td>0.266</td><td rowspan="3">0.000019</td></tr>
<tr><td>Golf (3 kg/ha)</td><td colspan="2" rowspan="5">N/A</td><td>0.0218</td></tr>
<tr><td>Golf (17.5 kg/ha)</td><td>0.127</td></tr>
<tr><td rowspan="3">Youth</td><td>Garden</td><td>0.329</td><td rowspan="3">0.000012</td></tr>
<tr><td>Golf (3 kg/ha)</td><td>0.027</td></tr>
<tr><td>Golf (17.5 kg/ha)</td><td>0.157</td></tr>
</table>

Table 3.5.2.2 Youth and Adult Short-Term Aggregate Risk Assessment (thiophanate-methyl)

	Scenario	Applicator MOE		Postapplication MOE	Dietary MOE[c]	Aggregate MOE[d] (target = 300)	Aggregate DWLOC[e] (µg/L)
		Dermal[a]	Inhalation[b]	Dermal			
Adult	Garden	10 972	143 449	376	526 316	362	201
	Golf (3 kg/ha)	N/A		4580		4541	1090
	Golf (17.5 kg/ha)			785		784	720
Youth	Garden			304	833 333	304	9
	Golf (3 kg/ha)			3709		3693	597
	Golf (17.5 kg/ha)			636		635	343

a Dermal MOE = dermal NOAEL / dermal exposure. The dermal NOAEL is 100 mg/kg bw/day, and the target MOE is 300.

b Inhalation MOE = NOAEL / inhalation exposure. The inhalation NOAEL is 10 mg/kg bw/day, and the target MOE is 300.

c Dietary MOE = dietary NOAEL / dietary exposure. The dietary NOAEL is 10 mg/kg bw/day, and the target MOE is 300.

d Aggregate MOE = $1 / [(1 / MOE_{dermal\_applicator}) + (1 / MOE_{inhalation}) + (1 / MOE_{dermal\_post\_application.}) + (1 / MOE_{dietary})]$.

e DWLOC = NOAEL × $[1 / MOE_{target} - 1 / MOE_{exposure}]$ × bw (kg) / water consumption (L). Body weight = 70 and 39 kg for adults and youth, respectively. Water consumption = 2 L/day.

3.5.3 Short-Term Aggregate Exposure and Risk Assessment (carbendazim)

With respect to route of exposure, there was no systemic toxicity in short-term dermal exposure studies with carbendazim. However, the oral route of exposure (rat and rabbit developmental studies) confirmed that decreases in body weight and/or body-weight gain were consistent endpoints of concern. Despite the absence of repeat-dose inhalation data, it was assumed that body-weight effects would also be a critical endpoint by this route of exposure. Thus, the most relevant study to assess short-term aggregate exposure was the repeat-dose developmental toxicity studies in rats and rabbits, which established a NOAEL of 20 mg/kg bw/day based on decreased body weight and body-weight gain. A target MOE of 300 was established for the general population, including children. This was based on standard UFs (10-fold for interspecies variation, 10-fold for intraspecies variation) and an additional 3-fold SF to account for potential sensitivity to the young.

For females of childbearing age (females 13–50 years), an additional endpoint of concern for short-term aggregate exposure to carbendazim was the increased incidence of fetal malformations at 30 mg/kg bw/day in rats and increased resorptions at 20 mg/kg bw/day in rabbits, both in the absence of maternal toxicity. It was assumed that this effect could manifest via either oral, dermal or inhalation routes of exposure. The NOAEL was 10 mg/kg bw/day. A target MOE of 1000 was established, which included standard UFs (10-fold for interspecies extrapolation, 10-fold for intraspecies variation) and an additional SF of 10-fold to account for fetal sensitivity and severity of effects (malformations in the absence of maternal toxicity) as well as the lack of a developmental neurotoxicity study.

As no systemic toxicity via dermal exposure was identified in the general population, the only relevant route of short-term exposure to carbendazim is through the diet or drinking water. Dermal exposure is relevant to females of childbearing age; therefore, potential postapplication exposure from the gardening and golf scenarios was assessed. Dermal risk assessments incorporate a 25% absorption value. Residential exposure to carbendazim is only encountered as a transformation product of thiophanate-methyl, thus only postapplication exposure is assessed. For the purposes of aggregation, this short-term residential exposure is combined with the chronic dietary and drinking water exposures. As with the thiophanate-methyl assessment, short-term exposure through golf and gardening activities are assumed to occur independently and are therefore not combined.

Short-term aggregate MOE for youth and adults exceed the target MOEs of 300 for the general population, and 1000 for females of reproductive age for all scenarios with the exception of youths gardening. In addition, drinking water exposure is of concern for female gardeners (adult and youth), and for females (adult and youth) re-entering turf treated at the maximum rate of 17.5 kg a.i./ha. For these scenarios, the chronic DWEC of 162 µg/L exceeds the DWLOC, and is therefore of concern. All other short-term aggregate risks are below the level of concern.

Table 3.5.3.1 Youth and Adult Short-Term Aggregate Exposure and Risk Assessment (carbendazim)

	Scenario	Dietary Exposure		Aggregate MOE[b] (target = 300)	Aggregate DWLOC[c] (µg/L)
		mg/kg/bw	MOE[a]		
Adult	Garden	1.80×10^{-5}	1 111 111	1 111 111	2333
	Golf (3 kg/ha)				
	Golf (17.5 kg/ha)				
Youth	Garden	1.30×10^{-5}	1 538 462	1 538 462	1300
	Golf (3 kg/ha)				
	Golf (17.5 kg/ha)				

a Dietary MOE = dietary NOAEL / dietary exposure. The dietary NOAEL is 20 mg/kg bw/day, and the target MOE is 300.

b Aggregate MOE = short-term aggregate dietary MOE. No short-term systemic toxicity via dermal route.

c DWLOC = NOAEL × [1 / MOE_{target} − 1 / $MOE_{exposure}$] × bw (kg)/water consumption (L).
Body weight = 70 and 39 kg for adults and youths, respectively. Water consumption = 2 L/day.

Table 3.5.3.2 Youth and Adult Female Short-Term Aggregate Exposure and Risk Assessment (carbendazim)

	Scenario	Postapplication Dermal Exposure		Dietary Exposure		Aggregate MOE[c] (target = 1000)	Aggregate DWLOC[d] (µg/L)
		mg/kg/bw	MOE[a]	mg/kg/bw	MOE[b]		
Adult	Garden	0.00997	1002	1.30×10^{-5}	769 231	1001	0.22
	Golf (3 kg/ha)	0.00082	12 213			12 022	284
	Golf (17.5 kg/ha)	0.00478	2094			2088	162
Youth	Garden	0.0123	810	1.30×10^{-5}	769 231	809	N/A[e]
	Golf (3 kg/ha)	0.00101	9890			9764	175
	Golf (17.5 kg/ha)	0.0059	1695			1691	80

a Dermal MOE = dermal NOAEL / dermal exposure. The dermal NOAEL is 10 mg/kg bw/day, and the target MOE is 1000.
b Dietary MOE = dietary NOAEL / dietary exposure. The dietary NOAEL is 10 mg/kg bw/day, and the target MOE is 1000.
c Aggregate MOE = 1 / [(1 / $MOE_{dermal.}$) + (1 / $MOE_{dietary}$)].
d DWLOC = NOAEL × [1 / MOE_{target} − 1 / $MOE_{aggregate}$] × bw (kg) / water consumption (L).
Body weight = 39 and 62 kg (adult and youth). Water consumption = 2 L/day.
e Non-drinking water exposure exceeds target; therefore, a DWLOC cannot be determined.

3.5.4 Aggregate Cancer Exposure and Risk Assessment (thiophanate-methyl and carbendazim)

A quantitative risk assessment for tumorigenicity was conducted based on increased hepatocellular tumours in male mice. Female mice also had an increase in liver tumours. A Q_1^* of 1.32×10^{-2} (mg/kg bw/day)$^{-1}$ and of 1.6×10^{-2} (mg/kg bw/day)$^{-1}$ was used for thiophanate-methyl and carbendazim, respectively.

Cancer risk estimates take into consideration multiple exposure scenarios (i.e. aggregate exposure estimates) and the frequency of exposure scenarios. Over a lifetime, non-occupational exposure scenarios may include exposure to thiophanate-methyl and carbendazim via re-entering treated turf, contact with treated ornamentals, from food and water as a youth. In addition to these, adults may also be exposed through the application of thiophanate-methyl as a homeowner. The aggregate residential cancer risk estimates are presented in Table 3.5.4.1. Note that the risk estimates for youth and adult exposure have not been combined, nor has potential exposure from the golf and gardening scenarios been combined.

As with the non-cancer aggregate assessment, drinking water exposure was assessed by calculating DWLOC and comparing these target values to model derived chronic DWEC. The DWLOCs can only be determined if the non-water exposure is acceptable. The cancer risks from thiophanate-methyl and carbendazim are combined; therefore, the DWLOCs are expressed as carbendazim equivalents, based on the ratio of molecular weights. The molecular weight of thiophanate-methyl and carbendazim are 342.4 and 191.2 g/mol, respectively.

The lifetime cancer risks from thiophanate-methyl and carbendazim range from 5.7×10^{-7} to 2.3×10^{-6} before water is considered. The combined DWEC for thiophanate-methyl and carbendazim of 164 µg/L exceeds the DWLOC of < 1 µg/L for all exposure scenarios and populations; therefore, it is of concern.

Table 3.5.4.1 Youth and Adult Aggregate Cancer Exposure and Risk Assessment (thiophanate-methyl and carbendazim)

	Scenario	Non-Dietary LADD[a] (mg/kg/bw)	Dietary LADD[b] (mg/kg/bw)	Individual Chemical Lifetime Cancer Risk[c]	Combined Lifetime Cancer Risk	Aggregate Cancer DWLOC[d] (µg/L)
	Thiophanate-Methyl					
Adult	Garden (apply and re-entry)	1.16×10^{-4}	1.09×10^{-5}	1.78×10^{-6}		
	Golf (3 kg/ha)	8.32×10^{-6}		3.61×10^{-7}		
	Golf (17.5 kg/ha)	4.87×10^{-5}		8.94×10^{-7}		
Youth	Garden	1.38×10^{-5}		4.33×10^{-7}		
	Golf (3 kg/ha)	1.23×10^{-6}		2.67×10^{-7}		
	Golf (17.5 kg/ha)	7.22×10^{-6}		3.46×10^{-7}		
	Carbendazim					
Adult	Garden	1.40×10^{-5}	1.80×10^{-5}	5.12×10^{-7}	2.29×10^{-6}	N/A
	Golf (3 kg/ha)	1.25×10^{-6}		3.08×10^{-7}	6.69×10^{-7}	0.72
	Golf (17.5 kg/ha)	7.31×10^{-6}		4.05×10^{-7}	1.30×10^{-6}	N/A
Youth	Garden	2.07×10^{-6}		3.21×10^{-7}	7.54×10^{-7}	0.54
	Golf (3 kg/ha)	1.85×10^{-7}		2.91×10^{-7}	5.58×10^{-7}	0.96
	Golf (17.5 kg/ha)	1.08×10^{-6}		3.05×10^{-7}	6.51×10^{-7}	0.76

[a] Non-dietary LADD = dermal exposure × dermal absorption factor (25%) × (3 days of exposure for gardening or 5 days for golfing / 365 days) × (50 years of exposure / 70-year lifetime)

[b] Dietary exposure as per Appendix IV

[c] Cancer risk = LADD × Q_1*. Thiophanate-Methyl Q_1* = 0.0132 and carbendazim Q_1* = 0.0160 $(mg/kg/bw)^{-1}$.

[d] DWLOC = [(1×10^{-6}-non-water risk) / Q_1*] (1000µg/mg) (70 kg bw) / 2L/day, based on the carbendazim Q_1* = 0.0160 $(mg/kg/bw)^{-1}$ and expressed in carbendazim equivalents.

3.5.5 Chronic Aggregate Risk Assessment (thiophanate-methyl and carbendazim)

Chronic aggregate exposure to thiophanate-methyl and carbendazim is considered to arise from dietary and drinking water exposures only, and is compared to the ADI. Residential exposure is not included, as all the relevant timeframes and exposure routes are considered in the short-term aggregate risk assessment. As discussed in Section 3.3, chronic aggregate exposure from food and water are not of concern for thiophanate-methyl; however, chronic aggregate exposure from carbendazim is of concern, based on the model derived DWECs.

4.0 Environmental Assessment

This review is based in part upon the USEPA RED document (2004) for thiophanate-methyl and carbendazim.

Liquid application rates evaluated in this risk assessment ranged from a minimum of 2 applications at 0.392 kg a.i./ha used on sugar beets up to a maximum of a single application at 17.5 kg a.i./ha used on turf. In addition, the risk from thiophanate-methyl used as a granular product on turf (3.036 kg a.i./ha) was also assessed.

In assessing the environmental risk of thiophanate-methyl and carbendazim, a deterministic approach was used. In this standard PMRA approach, risk to terrestrial and aquatic organisms from exposure to thiophanate-methyl are characterized using the risk quotient (RQ) method where the RQ = EEC / toxicity endpoint of concern. Risk levels are classified on a logarithmic scale. For example, RQ < 0.1 is negligible risk, RQ ≥ 0.1 to < 1.0 is low risk, RQ ≥1.0 to < 10.0 is moderate risk, RQ ≥10.0 to < 100.0 is high risk and so on. The PMRA does not regard RQ ≤ 1 (negligible and low risk) to be a significant environmental concern. Risk quotients > 1 indicate that there is risk of effects on non-target organisms.

Initial and cumulative EECs were calculated for soil, water and wildlife food sources for the spray formulations of thiophanate-methyl and its transformation product, carbendazim. The EECs were based on the assumption of 100% deposit of the application rate. A range of application rates were used to calculate the EECs along with the maximum number of applications and minimum intervals between applications. The cumulative EECs were estimated by adjusting the sum of the applications for dissipation between applications using the time for 50% decline (DT_{50}) for the appropriate environmental media. To assess the risk to aquatic organisms from runoff, concentrations of thiophanate-methyl were predicted using the Pesticide Root Zone Model/Exposure Analysis Modeling System (PRZM/EXAMS). Effects endpoints included both acute and chronic, chosen from the range of toxicity tests on species available. Effects endpoints, chosen from the most sensitive species, were used as surrogates for the wide range of species that can be potentially exposed following treatment with thiophanate-methyl and its major transformation product, carbendazim.

The granular formulation of thiophanate-methyl provides a unique exposure scenario for birds that use grit to aid in the digestion of food. In this assessment, the number of granules required to reach the lethal dose to 50% (LD_{50}) for a particular size of bird and the number of granules available per m^2 were compared to determine risk.

4.1 Environmental Fate

Thiophanate-methyl has an intermediate vapour pressure (1.3×10^{-5} mm Hg), indicating that it can volatilize from dry soils. However, it is not expected to volatilize from moist soils.

Thiophanate-methyl is a short-lived non-persistent chemical in the terrestrial environment. In soil, it transforms rapidly to carbendazim. In the soil environment, carbendazim can be up to 83% of the applied parent product. Thiophanate-methyl is soluble in water and is expected to be relatively mobile. The major transformation product, carbendazim, is relatively persistent and slightly mobile in the soil environment.

Phototransformation is an important route of transformation in the soil (half-life in soil is < 7 days). The major transformation product is carbendazim. Carbendazim is stable to phototransformation in soil. Aerobic biotransformation is the most important route of transformation of thiophanate-methyl in soil (half-life < 1 day in soil). The major transformation product is carbendazim. Carbendazim is very persistent in soils, with an aerobic soil biotransformation half-life of 320 days. Other minor transformation products identified include FH-432 and DX-105 (< 10% of applied thiophanate-methyl).

The adsorption of thiophanate-methyl to soils is relatively weak. Thiophanate-methyl readily desorbs from soils, indicating a potential to be mobile in soil and to leach. Carbendazim adsorption is much stronger than thiophanate-methyl, mainly to the organic fraction of the soil. It does not readily desorb; therefore, it is much less mobile than thiophanate-methyl. Soil column leaching studies confirm that carbendazim is immobile in the soil.

Terrestrial field dissipation of thiophanate-methyl is rapid. The transformation products are carbendazim and allophanate. Although thiophanate-methyl transforms rapidly to carbendazim in the soil environment, it transforms more slowly on foliage under dry conditions. In foliage residue studies, the maximum half-life of thiophanate-methyl on apple orchards was 31 days.

Hydrolysis is an important route of transformation of thiophanate-methyl in alkaline waters. Thiophanate-methyl is stable to hydrolysis under acid conditions, but the half-life decreases rapidly with increasing pH. Under neutral conditions, the hydrolysis half-life is 36 days, and under alkaline conditions, it is 0.9 days. The main transformation products of hydrolysis are carbendazim and AV-1951. Phototransformation is an important route of transformation of thiophanate-methyl in the aquatic environment. The phototransformation half-life is < 3 days. The main transformation product of phototransformation is carbendazim. In the aquatic environment, thiophanate-methyl transforms rapidly to carbendazim. In the aquatic environment, carbendazim can be up to 66% of the applied thiophanate-methyl. Thiophanate-methyl is not expected to volatilize from water. The major transformation product, carbendazim, has a low solubility.

An anaerobic aquatic biotransformation study of thiophanate-methyl indicates a half-life of < 1 day. The major transformation product is carbendazim. Carbendazim is very persistent under anaerobic conditions with a half-life of 743 days.

There are no aerobic aquatic biotransformation studies available for thiophanate-methyl. However, based on the rapid rates of phototransformation, hydrolysis and anaerobic aquatic biotransformation, thiophanate-methyl is expected to be short-lived in the aquatic environment under aerobic conditions. The half-life of carbendazim in an aerobic aquatic biotransformation study was 61 days, which indicates moderate persistence under aerobic conditions.

4.2 Environmental Toxicology

4.2.1 Terrestrial

The LD_{50} of thiophanate-methyl to the honeybee is > 100 µg a.i./bee. The lowest acute oral LD_{50} for birds from two studies available is 4640 mg a.i./kg bw for the mallard. The no observed effect levels (NOELs) are not available for this species. The acute dietary toxicity for mallard duck and bobwhite quail are > 10 000 mg a.i./kg diet. The no observed effect concentrations (NOECs) for the effects on body weight and feed consumption were not determined from the dietary studies. With respect to reproductive effects, the lowest NOEC from the three studies is > 103 mg a.i./kg diet based on the effects on egg production and body weight in the mallard.

The acute lethal concentration to 50% (LC_{50}) of thiophanate-methyl to the rat is > 5000 mg a.i./kg bw. For reproductive effects, the NOEL is 130 mg a.i./kg bw for the mouse, which is converted to a NOEC of 1300 mg a.i./kg diet.

There is no toxicity data available for birds or mammals with carbendazim.

4.2.2 Aquatic

The LC_{50} for *Daphnia magna* for both thiophanate-methyl and carbendazim is 5.4 mg a.i./L. The NOECs from acute tests are not available. For chronic (life cycle) effects on freshwater invertebrates, the NOEC of carbendazim is 0.003 mg a.i./L based on survival of *D. magna*. Thiophanate-methyl transforms rapidly to carbendazim in the aquatic environment and so the chronic toxicity will be for carbendazim rather than thiophanate-methyl. The lowest acute LC_{50} of thiophanate-methyl from two studies is 8.3 mg a.i./L for rainbow trout. The NOECs are not available from acute toxicity tests. For early-life stage (chronic) tests with carbendazim, the NOEC is 0.002 mg a.i./L for the channel catfish. There is no chronic data available for cold water species with carbendazim.

For estuarine/marine invertebrates, the lowest LC_{50} of thiophanate-methyl from 2 studies is 1.1 mg a.i./L for the mysid shrimp. For chronic (life cycle) effects, the lowest NOEC is for mysid shrimp survival (0.025 mg a.i./L). Although the chronic toxicity tests were conducted with thiophanate-methyl, it is likely that thiophanate-methyl transformed to carbendazim during the test; therefore, the results indicate the toxicity of carbendazim.

For estuarine/marine fish, the lowest 96-h LC_{50} is for sheepshead minnow (40 mg a.i./L). The acute NOEC is 17 mg a.i./L. There is no chronic (early-life stage) toxicity data available for estuarine/marine fish for thiophanate-methyl or its major transformation product, carbendazim.

The lowest NOECs from five studies with aquatic plants and algae are 0.43 mg a.i./L for the freshwater diatom (*Navicula pelliculosa*) and 0.11 mg a.i./L for the marine diatom (*Skeletonema costatum*).

4.3 Concentrations in Drinking Water

The provincial and territorial governments along with Environment Canada and the Department of Fisheries and Oceans were contacted to request water monitoring data for thiophanate-methyl and carbendazim. Because monitoring data were not available, concentrations of thiophanate-methyl and carbendazim in Canadian drinking water sources were modelled using PRZM/EXAMS for surface water as well as Leaching Estimation and Chemistry Model (LEACHM) for groundwater. The drinking water values were estimated using crop-specific input parameters and fate input parameters.

The acute EECs in drinking water sources for thiophanate-methyl were 0 µg a.i./L for groundwater, 217 µg a.i./L for reservoirs and 65 µg a.i./L for dugouts. The acute EECs for drinking water sources for the transformation product carbendazim following thiophanate-methyl applications were 165 µg a.i./L for groundwater, 181 µg a.i./L for reservoirs and 223 µg a.i./L for dugouts.

The chronic EECs for thiophanate-methyl in drinking water sources were 0 µg a.i./L in groundwater, 17.4 µg a.i./L in reservoirs and 9.6 µg a.i./L in dugouts. The chronic drinking water EECs for carbendazim following thiophanate-methyl applications to drinking water sources were 162 µg a.i./L for groundwater, 30 µg a.i./L for reservoirs and 113 µg a.i./L for dugouts. The high EECs for carbendazim occur because of its greater persistence in soil and water, as compared to thiophanate-methyl.

Model inputs were refined for thiophanate-methyl based on its use in British Columbia, Ontario, Quebec and Nova Scotia. The refined inputs resulted in thiophanate-methyl EECs in reservoir drinking water sources being lowered to 56 µg/L (acute) and 3.4 µg/L (chronic).

It was concluded from consideration of the quality of the information and data available on carbendazim that it would not be possible to refine model inputs in order to significantly lower the EECs. Thus, drinking water EECs as derived by the models for the transformation product carbendazim, from the use of thiophanate-methyl exceed the DWLOCs and thus indicate a potential concern. In view of the uncertainties in the data and subsequent conservative assumptions used in the models, further data are required to either confirm or dispel the predictions of the models. The data are required to support any regulatory decisions that may be made. Confirmatory groundwater and surface water monitoring data are required to evaluate actual acute and chronic concentrations of carbendazim in the drinking water sources. This monitoring information should be generated from a multiyear sampling programme involving groundwater and surface water in multiple agricultural locations to represent different use sites, crops, soil types and rainfall regimes and the water samples analyzed for carbendazim. The monitoring sites would need to be selected from areas where thiophanate-methyl is used. The registrant will be required to submit a draft protocol for review and comments, to ensure that the sampling locations, sampling times and procedures are sufficient to assess the drinking water concerns.

4.4 Terrestrial Risk Assessment

Larger birds, such as the mallard, feeding on a diet contaminated by thiophanate-methyl are unlikely to be at risk. The time taken to reach the NOEL for the mallard is greater than the threshold of 1 day, which is designated as a significant risk. However, smaller birds such as the American robin and the field sparrow are at risk from the highest application rate of thiophanate-methyl (17.5 kg a.i./ha). The time taken to reach the NOEL is less than one day. Based on the acute dietary NOEC's, the risk to the mallard from dietary consumption of food sources contaminated by thiophanate-methyl ranged from negligible to low (RQ < 1). The acute dietary risk to the bobwhite ranged from low (RQ < 1) to moderate risk (RQ = 3.1). For the robin, the risk ranged from negligible (RQ < 0.1) to moderate (RQ = 2.0) and for the sparrow, low (RQ < 1) to moderate (RQ = 2.9). The percentage of the diet contaminated with thiophanate-methyl at the maximum application rate (17.5 kg a.i./ha) that would result in an acute dietary risk to birds ($RQ \geq 1$) varies from 33% to 50% depending upon the birds species. Therefore, risk to small birds can occur at this application rate.

There was no toxicological data to assess the risk to birds from carbendazim.

The reproductive risk to the mallard from dietary consumption of thiophanate-methyl ranged from low (RQ = 0.24) to moderate (RQ = 5.7). Seventeen percent of the diet contaminated with thiophanate-methyl would cause a reproductive risk to the mallard at the maximum application rate (17.5 kg a.i./ha). The mallard is more sensitive to reproductive effects than the bobwhite. There is no toxicity data available to assess the risk to birds from consumption of carbendazim. Birds such as the mallard and the American robin are not at acute risk from consumption of granular applications of thiophanate-methyl as grit or food sources (application rate of 3.036 kg a.i./ha). However, there is a potential acute risk to very small birds such as the field sparrow from consumption of thiophanate-methyl granules. The threshold for risk on an areal basis is 5.4 LD_{50}/m^2, which was exceeded by the field sparrow (9.2 LD_{50}/m^2). The actual risk would depend on whether the field sparrow would ingest enough granules in a day to reach the LD_{50}. Because the granules are corn based, they could be consumed as a food source by the sparrow rather than as grit. Based on the ratio of the food consumption rate of the sparrow and the LD_{50} for thiophanate-methyl, the sparrow is able to consume 3.3 times the LD_{50} in a single day. If the total diet ingested consisted of 31% thiophanate-methyl granules, it would be equivalent to the LD_{50}. This indicates that thiophanate-methyl granules are a risk to small birds.

Small mammals feeding on a diet contaminated by thiophanate-methyl are unlikely to exceed the acute NOEL. Thiophanate-methyl presents some risk of reproductive and acute dietary effects to small mammals, particularly at the higher use rates. The risk of acute dietary effects ranges from moderate (RQ = 1.3) to high (RQ = 30). The risk of reproductive effects for the mouse ranges from low (RQ = 0.28) to moderate (RQ = 6.8). The percentage of the diet contaminated with thiophanate-methyl that would result in a reproductive risk to small mammals ($RQ \geq 1$) ranges from 0.15% to 3.6%. The percentage of contaminated diet that would cause an acute dietary risk ranges from 3.3% to 79%, depending on the application rate. Therefore, small mammals living or foraging in treated areas will be at significant risk from thiophanate-methyl, particularly at the rate used on turf (17.5 kg a.i./ha).

There was no toxicological data available to assess the risk to small mammals from carbendazim.

With respect to terrestrial invertebrates, the risk from thiophanate-methyl exposure to the honeybee ranges from negligible (RQ = 0.07) to moderate (RQ = 1.6). The risk to the earthworm from thiophanate-methyl exposure could not be assessed because no toxicological data are available for the earthworm. In addition, there are no toxicological data available on the effects of carbendazim to the honeybee or the earthworm.

4.5 Aquatic Risk Assessment

A screening level aquatic risk assessment was done for thiophanate-methyl and carbendazim. The scenario is direct application to a water body 30-cm deep. The risk assessment indicated acute and chronic risks (RQs > 1) for freshwater and estuarine/marine fish and invertebrates for both thiophanate-methyl and carbendazim. Thiophanate-methyl and carbendazim were also found to be an acute risk to aquatic plants and algae.

A refined risk assessment for thiophanate-methyl and carbendazim in runoff to a wetland adjacent to a treated area was also carried out. The EECs of thiophanate-methyl and carbendazim as a result of runoff to a 1 hectare wetland 80-cm deep following thiophanate-methyl applications 10-ha drainage area were predicted using the PRZM/EXAMS in specific geographical locations and crop scenarios. The 90th percentile of the peak annual concentrations (maximum EECs) over the simulation time period was used in the acute risk assessment of freshwater and estuarine/marine fish. In the assessment of the risk of chronic effects to freshwater and estuarine/marine fish, the 90th percentile of the average of the yearly concentrations (minimum EECs) over the simulation time period were used. The acute risk to the rainbow trout from runoff of thiophanate-methyl ranges from negligible (RQ = 0.07) to moderate (RQ = 1.4), the risk level increasing with the application rate. The only risk identified as a concern to rainbow trout occurred at the highest application rate used on turf. The risk of acute effects from runoff is negligible (RQ < 0.1) for the bluegill sunfish. The chronic risk from runoff to the early-life stage of channel catfish is moderate (RQ = 2.5 to 8.6). The risk of acute effects from runoff of thiophanate-methyl to estuarine/marine fish is negligible (RQ < 0.1).

The EECs of thiophanate-methyl and carbendazim resulting from runoff in specific geographical locations and crop scenarios were predicted using the PRZM/EXAMS for aquatic invertebrates. The 90th percentile of the peak annual concentrations (highest predicted EECs) over the simulation time period was used in the acute risk assessment of freshwater and estuarine/marine invertebrates. For chronic risk assessment from carbendazim exposure, the 90th percentile of the 21-d concentrations over the simulation time period were used for freshwater and estuarine/marine invertebrates. The acute risk from runoff of thiophanate-methyl and carbendazim to freshwater invertebrates ranges from negligible to low (RQ < 1). The risk of chronic effects to freshwater invertebrates from carbendazim in runoff ranges from moderate (RQ = 3.9) to high (27.8). The risk of acute effects to estuarine/marine invertebrates from thiophanate-methyl in runoff ranges from negligible to low (RQ < 1). The risk of chronic effects to estuarine/marine invertebrates from carbendazim runoff ranges from low (0.17) to moderate (3.5).

For the risk from runoff of thiophanate-methyl and carbendazim to aquatic plants and algae, the 90th percentile of the 21-d concentrations over the simulation time period was used. The risk of acute effects to aquatic macrophytes, green algae and diatoms from thiophanate-methyl and carbendazim in runoff is negligible to low (RQ < 1).

There are no mesocosm studies available to refine the aquatic risk assessment further.

4.6 Preliminary Environmental Assessment Conclusions

Thiophanate-methyl is a dietary and reproductive risk to birds (field sparrow, American robin, bobwhite or mallard) at the highest application rate used on turf (17.5 kg a.i./ha). Granular applications of thiophanate-methyl (3.036 kg a.i./ha) are also a potential risk to very small birds (field sparrow) at the highest application rate on turf. The percentage of the diet required to reach the LD_{50} of the sparrow is 31%, indicating risk to small birds from consumption of the corn based granules. Thiophanate-methyl was identified as a dietary and a reproductive risk to small mammals (rat and mouse). The percentage of the diet contaminated with thiophanate-methyl that would result in a RQ $\leq$ 1 for the rat ranges from 3.3% to 79%. The risk to birds and wild mammals is limited to the elimination of a particular use of the product, reduction in label rates and number of applications, along with label statements indicating that the product is toxic to birds and wild mammals. Mitigation of the highest risks to birds and mammals can be achieved by eliminating the use of thiophanate-methyl on turf.

Thiophanate-methyl is not a risk to bees except at the highest application rate used on turf (17.5 kg a.i./ha). Exposure may occur from direct contact with spray droplets, contact with residuals on foliage and through drinking of contaminated water. The risk of honeybee exposure can be decreased if application of thiophanate-methyl spraying is limited to times when the bees are not expected to be in the field (i.e. at night, during cooler temperatures and postflowering of both the crop and weeds).

Thiophanate-methyl and its major transformation product, carbendazim, are highly mobile compounds; therefore, they are prone to runoff into the aquatic environment. Carbendazim is also prone to leaching. In the aquatic environment, the screening level risk assessment (direct application to water) indicated that thiophanate-methyl does not present a risk to fish or aquatic invertebrates, except at the highest application rate used on turf (17.5 kg a.i./ha). However, the transformation product, carbendazim, presents a significant risk to fish and aquatic invertebrates at all application rates. Thiophanate-methyl in runoff was not a significant risk to fish or aquatic invertebrates. However, the transformation product, carbendazim, in runoff was a significant risk to fish and to aquatic invertebrates at all application rates. Although the screening level assessment indicated that thiophanate-methyl and carbendazim were a significant risk to marine diatoms, there were no significant risks from thiophanate-methyl and carbendazim in runoff.

5.0 Value

All uses of thiophanate-methyl and carbendazim are supported by the registrants. The preliminary risk assessments have revealed some concerns regarding most uses.

5.1 Commercial Class Products

Appendix II lists some of the use information considered in the PMRA's preliminary risk and value assessments for those supported uses of thiophanate-methyl. This information includes the maximum single application rate of active ingredient applied to the crop, the typical cumulative rate of active ingredient applied to the crop per year, the maximum number of applications to the specific crop per year and the minimum interval between applications when applicable.

5.2 Alternatives to Thiophanate-Methyl Commercial and Domestic Uses

All Domestic Class uses of thiophanate-methyl are supported by the registrant. While the PMRA has limited information about the extent of use of the single thiophanate-methyl Domestic Class product, the preliminary risk assessment has raised some concerns for the use of thiophanate-methyl to control black spot and powdery mildew on roses, flowers and ornamentals as well as juniper blight. The single end-use Domestic Class product is co-formulated with two other insecticide active ingredients and another fungicide, all of which are currently under re-evaluation. There are registered alternative active ingredients for the fungicidal uses mentioned above.

The registered chemical alternatives for the supported uses of thiophanate-methyl for which risk concerns have been identified are listed in Appendix III. One or more alternative active ingredients are available for most site-pest combinations, except for the use of thiophanate-methyl to control powdery mildew on turf and raspberries, septoria leafspot on aspen and poplars and green mould control in mushrooms. The PMRA has not commented on the availability and extent of use of these alternative chemicals.

Most sources of non-chemical alternatives are focussed on general cultural practices (including reducing initial inoculum by destroying infected plant material, weed control because they can harbor disease, crop rotation, resistant varieties, appropriate soil cultivation and modification of habitat to minimize environmental factors that may favour disease development or spread). The PMRA searched for information available for specific site-pest combinations and found a number of non-chemical pest control measures that are summarized in Appendix III. The effectiveness and extent of use of these non-chemical control measures have not been verified.

The PMRA welcomes feedback on the availability and extent of use of the chemical alternatives to thiophanate-methyl in Appendix III. This information will allow the PMRA to refine sustainable pest management options for the listed site-pest combinations. Further information regarding the availability, effectiveness and extent of use of non-chemical control methods for any of the site-pest combinations listed in these appendices is also welcomed.

5.3 Value of Thiophanate-Methyl

Thiophanate-methyl and other historical benzimidazole fungicides have been used extensively in Canada. However, the over-reliance on this family of fungicides has resulted in the development of resistance on many site-pest combinations in some areas of the country. Although several alternative active ingredients and new chemistries are now available for many site-pest combinations in areas of the country where benzimidazole resistance is not present, thiophanate-methyl still plays a role in resistance management by allowing rotation with the use of these new fungicides on some sites. Resistance management and fungicide rotation are important especially for sites that have only a few alternative registered fungicides such as greenhouse ornamentals.

In this preliminary risk and value assessments, some of the site-pest combinations for which thiophanate-methyl is the only registered chemical control method have been identified as requiring further refinement. There are no alternative registered active ingredients in Canada for the following site-pests combinations:

- Trichoderma green mold on mushroom;
- powdery mildew on turf (greens and tees);
- septoria leafspots on aspen and poplars; and
- powdery mildew on raspberries.

Thiophanate-methyl is also of economic value for some other uses where risk issues have been raised:

- Dry common beans (seed treatment); despite the availability of alternative active ingredients, thiophanate-methyl is still the preferred active ingredient for this use in many large Canadian bean growing areas.

- Turf (greens and tees); despite the availability of alternative turf fungicides to control various fungal pests on this site, thiophanate-methyl is preferred for some uses. Some golf superintendents have a preference for a fertilizer-fungicide granular product that contains thiophanate-methyl. This product is registered in Canada under the *Fertilizers Act*.

- Greenhouse potted ornamentals; despite the availability of alternative fungicides, this industry because of its small cultivated area, lacks alternative new products. Nevertheless, they produce high value crops that require very high standards of phytosanitary quality, especially for exports. Despite the small size of this industry in terms of cultivated area and pesticide market size for the pesticide manufacturers, they constitute a significant economic player in Canadian agribusiness and the economy of some Canadian provinces. The impact of the potential loss of the use of thiophanate-methyl on this site is unknown at this time.

6.0 Other Assessment Considerations

6.1 Toxic Substance Management Policy

During the review of thiophanate-methyl and its major transformation product, carbendazim, the PMRA has taken into account the federal TSMP[1] and has followed its Regulatory Directive DIR99-03[2]. It has been determined that these active ingredients do not meet the TSMP criteria for a Track 1 substance.

6.2 Formulant Issues

Products containing thiophanate-methyl are subject to all the requirements outlined in Regulatory Directive DIR2006-02, *Formulants Policy and Implementation Guidance Document*.

7.0 Summary of Preliminary Risk Assessment and Consultation

The preliminary risk assessment was conducted with the information available to the PMRA at this time and indicates a level of concern for workers and the environment for the uses of thiophanate-methyl. The PMRA is soliciting the public and all interested parties to submit information that may be used to refine these assessments and/or mitigate exposure risks. The PMRA will review all information received, revise the risk assessments as necessary and propose mitigation measures in a future document.

8.0 Additional Data Requirements

At this time, the preliminary risk assessment has identified additional data that will be required as a result of re-evaluation. The data are required to address gaps in the core database, and may also serve to refine the preliminary risk assessment. These may be revised in the future as part of the proposed decision.

8.1 Data Related to Toxicology

Potential clinical signs of neurotoxicity (tremors/convulsions) was noted in a 1-year oral dog study with thiophanate-methyl, and in a two-generation reproduction study in which postweanling male pups showed reduced performance in an open-field test. Thiophanate-methyl may also have direct antithyroid activity. Thyroid hormones are critical for the development of

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1 The federal Toxic Substances Management Policy is available through Environment Canada's website at www.ec.gc.ca/toxics.

2 Regulatory Directive DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*, is available through the Pest Management Information Service. Phone: 1-800-267-6315 within Canada or 613-736-3799 outside Canada (long distance charges apply); fax: 613-736-3758; e-mail: pmra_infoserv@hc-sc.gc.ca; or through our website at www.pmra-arla.gc.ca.

mammalian fetal and neonatal brain. A deficiency of thyroid hormones at an early developmental stage can lead to mental retardation and stunted growth. As well, thiophanate-methyl rapidly metabolizes to carbendazim, which induces severe central nervous system and craniofacial malformations.

Safety factors have been applied to account for the uncertainties and data gaps in the toxicity data base. The following confirmatory data on thiophanate-methyl are required to refine the risk assessment.

DACO 4.3.6 or 4.3.7	Repeat-dose inhalation study
DACO 4.5.12	Acute neurotoxicity in rats
DACO 4.5.13	Subchronic neurotoxicity in rats
DACO 4.5.14	Developmental neurotoxicity in rats

Any other studies conducted with thiophanate-methyl in response to the USEPA RED (2001)

In addition, the following data for carbendazim, as requested in the USEPA 2001 RED, are to be submitted. As noted above, thiophanate-methyl rapidly metabolizes into carbendazim. Carbendazim induces severe central nervous system and craniofacial malformations in rats in the absence of maternal toxicity as well as in hamsters at maternally toxic doses. Safety factors have been applied to account for the uncertainties and data gaps in the toxicity data base. The following cabendazim data may be required to support any expansion of thiophanate-methyl use.

DACO 4.5.14	Developmental neurotoxicity in rats
DACO 4.3.6 or 4.3.7	Repeat-dose inhalation study

Any other studies conducted in response to the USEPA RED (2001)

8.2 Data Related to the Occupational Exposure

To refine the M/L/A exposure and risk estimates, chemical-specific exposure data for thiophanate-methyl must be submitted to address the following:

- commercial seed treatment and seed planting studies for beans and corn;
- dermal absorption study for thiophanate-methyl and carbendazim; as well as
- mushroom spawning study.

DACO 5.4 or 5.5	Mixer/loader/applicator—Passive dosimetry data or biological monitoring data for mushroom spawning use, for potato seed treatment and planting as well as for commercial seed treatment and on-farm planting for dry common beans and sweet corn
DACO 5.8	In vivo dermal absorption study

8.3 Data Related to the Dietary Exposure

DACO 6.2	Animal metabolism
DACO 7.2	Analytical methodology to determine the full residue of concern
DACO 7.3	Freezer storage stability
DACO 7.4	Contemporary field trial data for domestic and import uses
DACO 7.5	Contemporary residue data for livestock

Note that additional data may be required to support future expansion for use.

8.4 Data Related to Environment

Carbendazim is the major transformation product of thiophanate-methyl, which can be up to 66% of the parent in the aquatic environment. Because it is persistent in the aquatic environment (half-life in water 61–743 d), aquatic organisms can be exposed to significant concentrations of carbendazim. The risk assessment from chronic exposure to carbendazim for freshwater and estuarine/marine fish could not be fully completed because of the lack of toxicological data.

DACO 9.5.3.1	Chronic (Early life stage) NOEC—Freshwater fish (Rainbow trout OPPTS 850.1075)
DACO 9.5.3.1	Chronic (Early life stage) NOEC—Estuarine/Marine fish (Sheepshead minnow OPPTS 850.1400)
DACO 9.2.3.1	Acute toxicity—Earthworms

Confirmatory groundwater and surface water monitoring data (as indicated in Section 4.3)

In addition, the registrants must submit data on the analytical methodology used for detection of thiophanate-methyl and carbendazim in environmental media such as soil and water vegetation.

List of Abbreviations

µg	microgram(s)
ADI	acceptable daily intake
ARfD	acute reference dose
a.i.	active ingredient
BHSE	British Health and Safety Executive
bw	body weight
CAZ	carbendazim
CC	closed-cab tractor
cm	centimetre
d	day(s)
DACO	data code
DAF	dermal absorption factor
DFR	dislodgeable foliar residue
DNT	developmental neurotoxicity study
DRA	dietary risk assessment
DT_{50}	time required for 50% dissipation
DWEC	drinking water estimated concentration
DWLOC	drinking water level of concern
EDC	endocrine disrupting compound
EEC	expected environmental concentration
EXAMS	Exposure Analysis Modeling System
g	gram(s)
GCF	greenhouse cut flower
GR	granular
h	hour(s)
ha	hectare(s)
kg	kilogram
K_{oc}	organic carbon partition coefficient
K_{ow}	*n*-octanol–water partition coefficient
L	litre
LADD	lifetime average daily dose
LC_{50}	mean lethal concentration
LD_{50}	mean lethal dose
LEACHM	Leaching Estimation and Chemistry Model
LOAEL	lowest observed adverse effect level
LOQ	limit of quantification
MAFF	Ministry of Agriculture, Fisheries and Food (United Kingdom), renamed Department for Environment, Food and Rural Affairs (DEFRA) in 2001
m	metre
mg	milligram
M/L/A	mixer/loader/applicator
mm	millimetre
mm Hg	millimetre of mercury
MOE	margin of exposure

mol	mole
MRL	maximum residue limit
MSHA	Mining Safety and Health Administration
N/A	not applicable
NIOSH	National Institute of Occupational Safety and Health
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NOEL	no observed effect level
ORETF	Outdoor Residential Exposure Task Force
PACR	Proposed Acceptability for Continued Registration
PHED	Pesticide Handlers Exposure Database
PHI	preharvest interval
PMRA	Pest Management Regulatory Agency
PPE	personal protective equipment
PRZM	Pesticide Root Zone Model
Q_1*	cancer potency factor
RED	Reregistration Eligibility Document
REI	restricted-entry intervals
RQ	risk quotient
SF	safety factor
SRL	safe residue limit
TC	transfert coefficient
TPM	thiophanate-methyl
TSH	thyroid stimulating hormone
TSMP	Toxic Substances Management Policy
TTR	turf transferable residue
UF	uncertainty factor
URMULE	User Requested Minor Use Label Expansion
USEPA	United States Environmental Protection Agency
WP	wettable powder
WSP	water-soluble packaging

Appendix I Thiophanate-methyl Products Currently Registered (excluding discontinued products or products with a submission for discontinuation) as of 7 April 2006

Registration Number	Marketing Class	Registrant	Product Name	Formulation Type	Guarantee
22710	Technical	NIPPON SODA CO. LTD.	Thiophanate-methyl Technical Fungicide	N/A	Thiophanate-Methyl 95%
14851	Domestic	KING HOME & GARDEN INC.	Gardal Rose, Flower & Evergreen Dust	Dust or powder	Thiophanate-Methyl 3%; Malathion 4%; Captan 5%; Carbaryl 5%
12279	Commercial	ENGAGE AGRO CORPORATION	Senator 70 WP 1 Systemic Fungicide	Wettable powder	Thiophanate-Methyl 70%
14599	Commercial	ENGAGE AGRO CORPORATION	Senator Pspt 1 Potato Seed Piece Treatment	Dust or powder	Thiophanate-Methyl 10%
14986	Commercial	NORAC CONCEPTS INC.	DCT Dual Purpose Seed Treatment Powder	Wettable powder	Thiophanate-Methyl 14%; Diazinon 6%; Captan 18%
16660	Commercial	NU-GRO IP INC.	Proturf Granular Systemic Fungicide	Granular	Thiophanate-Methyl 2.3%
19465	Commercial	SCOTTS CANADA LTD.	Green Cross Easout Turf & Ornamental Fungicide	Wettable powder	Thiophanate-Methyl 70%
25343	Commercial	ENGAGE AGRO CORPORATION	Senator 70WP Systemic Fungicide	Wettable powder	Thiophanate-Methyl 70%
26236	Commercial	ENGAGE AGRO CORPORATION	Senator PSPT Potato Seed Piece Treatment	Dust or powder	Thiophanate-Methyl 10%
26987	Commercial	NORAC CONCEPTS INC.	Caption CT Fungicide Seed Treatment	Wettable powder	Thiophanate-Methyl 14%; Captan 18%
27297	Commercial	ENGAGE AGRO CORPORATION	Senator 70 WP WSB1	Wettable powder	Thiophanate-Methyl 70%
27539	Manufacturing Concentrate	ENGAGE AGRO CORPORATION	Senator 70W MUP Systemic Fungicide	Wettable powder	Thiophanate-Methyl 70%
28160	Commercial	BAYER CROPSCIENCE INC.	Genesis XT potato seed-piece treatment	Dust or powder	Thiophanate-Methyl 3%; Imidacloprid 1.25%; Mancozeb 6%

Appendix II Registered Canadian Uses of Thiophanate-Methyl as of 27 July 2005

Site(s)	Pest(s)	Marketing Class[a]	Formulation Type[b]	Application Methods and Equipment	Application Rate (g a.i./ha) unless otherwise stated		Maximum Number of Appl. per Year	Typical Number of Days Between Applications	Supported Use?[c]	Comments
					Max. Single	Max. Cumulative				
All uses are supported by the registrant, including those that were registered through an URMULE OR an Emergency Use										
USC 5—Greenhouse Food Crops										
Mushroom (emergency use only)	Trichoderma green mould	C	WP	Spawn treatment, hand mixing or mechanical mixing with a cement mixer	0.875 g a.i./m^2	0.875 g a.i./m^2	1 (per production cycle)	Not applicable	Y	This is an emergency use. Additional data/information on this use was provided to the PMRA by various stakeholders and taken account of when appropriate in this preliminary risk assessment.
USC 6—Greenhouse Non-Food Crops										
Greenhouse potted ornamentals (drench)	Stem, crown and root rots caused by Fusarium and Rhizoctonia	C	WP	Watering equipment	5950	11 900	2	15	Y	Drench treatment assuming 10 000 L/ha of dilute solution applied per application.
Greenhouse potted ornamentals (foliar)	Powdery mildew, Botrytis and leaf spots	C		Ground, hydraulic sprayers	595	1785	3	7	Y	Foliar application with hydraulic spraying equipment.
USC 10—Seed Treatments for Food and Feed										
Potatoes (seed treatment— cut seed)	Verticillium wilt, fusarium rot, silver scurf (*Helminthosporium solani*) and aids in control of seed piece decay and black leg infections	C	DU	Dry seed treatment container or seeder box	1160	1160	1	Not applicable	Y, M (silver scurf only)	The use for the control of silver scurf was registered through an URMULE.
Dry common bean (seed treatment)	Seedborne anthrachnose	C	WP	Slurry machines or hand mixing with paddle or shovel	42	42	1	Not applicable	Y	
Sweet corn (seed treatment)	Seedborne *Penicillium* spp.	C	WP	Seed box treatment	Not available (14.7 g assuming seeding rate of 21 kg/ha)	Not available (14.7 g assuming seeding rate of 21 kg/ha)	1	Not applicable	Y	

Site(s)	Pest(s)	Marketing Class[a]	Formulation Type[b]	Application Methods and Equipment	Application Rate (g a.i./ha) unless otherwise stated		Maximum Number of Appl. per Year	Typical Number of Days Between Applications	Supported Use?[c]	Comments
					Max. Single	Max. Cumulative				
USC 14—Terrestrial Food Crops										
Apples and pears (Eastern Canada and British Columbia)	Apple scab, powdery mildew	C	WP	Ground, hydraulic sprayers	1575 (British Columbia only) or 437.5 (Eastern provinces)	4725 (British Columbia only) or 875 (Eastern provinces)	4	7	Y	Typically no more than 2 applications are made. A third application is rarely made. Thus, the typical cumulative rate for the purpose of risk assessment reflects 3 applications for British Columbia and 2 for the Eastern provinces. Registrant is supporting a maximum of 4 applications. Minimum interval between applications is 5 days from the label.
Lowbush blueberries	Blossom and twig blight	C	WP	Ground and Aerial hydraulic sprayers	770	1540	4	10	Y, M	Typically no more than 2 applications are made. The typical cumulative rate for the purpose of risk assessment reflects 2 applications. Registrant is supporting a maximum of 4 applications.
Peaches, nectarines, plums, prunes, cherries	Brown rot	C	WP	Ground, hydraulic sprayers	1225	2450	3	3	Y	Typically no more than 2 applications are made. The typical cumulative rate for the purpose of risk assessment reflects 2 applications. Registrant is supporting a maximum of 3 applications. Typical interval between applications is 7 days.

Site(s)	Pest(s)	Marketing Class[a]	Formulation Type[b]	Application Methods and Equipment	Application Rate (g a.i./ha) unless otherwise stated		Maximum Number of Appl. per Year	Typical Number of Days Between Applications	Supported Use?[c]	Comments
					Max. Single	Max. Cumulative				
Raspberries	Powdery mildew, fruit rots	C	WP	Ground, hydraulic sprayers	770	2310	4	7	Y	Typically no more than 2 applications are necessary. The typical cumulative rate for the purpose of risk assessment reflects 3 applications. Registrant is supporting a maximum of 4 applications.
Straw-berries	Fruit rot (Botrytis), leaf spot	C	WP	Ground, hydraulic sprayers	770	2310	4	3	Y	Typically no more than 2 applications are necessary. The typical cumulative rate for the purpose of risk assessment reflects 3 applications. Registrant is supporting a maximum of 4 applications. Typical interval between applications is 7 days.
White beans	White mould	C	WP	Ground and aerial sprayers	1575	3150	2	10 to 14	Y	
Sugar beets (for export only)	Leafspot (Cercospora)	C	WP	Ground, hydraulic sprayers	392	784	2	7	Y, M	Only applied to sugar beets for export
USC 27—Ornamentals Outdoor										
Roses, ornamental plants	Black spot, powdery mildew	C	WP	Ground, hydraulic sprayers	525	1575	3	10	Y	X
Aspen and poplar	Marssonnina and septoria leaf spots	C	WP	Ground, hydraulic sprayers	770	2310	3	10	Y	X
Roses, flowers and ornamentals	Black spot, powdery mildew	D	DU	Ground , squeeze duster	Not listed	Not listed	Not listed (typically 6)	Typically 10	Y	This Domestic class product is co-formulated with several other active ingredients that are currently under re-evaluation. Only the pests controlled by thiophanate-methyl are listed here. Typical data are from the registrant.
Junipers	Blight	D	DU	Ground , squeeze duster	Not listed	Not listed	Not listed (typically 6)	Typically 10	Y	

Site(s)	Pest(s)	Marketing Class[a]	Formulation Type[b]	Application Methods and Equipment	Application Rate (g a.i./ha) unless otherwise stated		Maximum Number of Appl. per Year	Typical Number of Days Between Applications	Supported Use?[c]	Comments
					Max. Single	Max. Cumulative				
USC 30—Turf										
Turf	Dollar spot (*Sclerotinia homoeocarpa*)	C	WP	Ground, hydraulic sprayers	21–175 g a.i./100 m^2	42–175 g a.i./100 m^2	2	5	Y	Only 1 application is made at the highest rate.
Turf	Brown patch (*Rhizoctonia solani*)	C	WP	Ground, hydraulic sprayers						
Turf	Powdery mildew (*Erysiphe graminis*)	C	WP	Ground, hydraulic sprayers						
Turf	Pink snow mould (*Fusarium nivale*)	C	WP	Ground, hydraulic sprayers						
Turfgrass	Brownpatch, dollar spot and copperspot	C	GR	Ground spreader	3036	18 216	6	14	Y	X A fertilizer-fungicide product similar to this product is registered in Canada under the *Fertilizers Act*

[a] C = Commercial, D = Domestic

[b] WP = wettable powder, DU = dust or powder, GR = granular

[c] Y = use is supported by the registrant; M = use was registered as a User Requested Minor Use Label Expansion (URMULE). X = data are suppressed because they were provided as confidential business information.

Appendix III Alternative Registered Active Ingredients to Thiophanate-Methyl as of 27 July 2005 for Those Site-Pest Combinations of Commercial Class Products for Which Risk Concerns Have Been Identified

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Apple	Apple scab	Minor (British Columbia and western provinces) to prevalent (eastern provinces)	Group 3: Flusilazole Group 9: Cyprodinil Group 11: Kresoxim-methyl, Trifloxystrobin, Group U: Dinocap[f] Group M: Lime sulphur or calcium polysulphide[f] Group M: Mancozeb[f], Metiram[f], Captan[f], Dodine[f]	Resistant Varieties (i.e. Liberty, Goldrush). Water management (shut off sprinklers to reduce leaf wetness). Orchard design and pruning to improve aeration and penetration. Reducing primary inoculum (i.e. removal or decomposition of leaf litter).	Y	Y
Pear	Pear scab	Rare except in Ontario where it is prevalent	Group 11: Kresoxim-methyl Group M: Lime sulphur or calcium polysulphide[f] Group M: Ferbam[f], Captan[f], Dodine[f]	Reducing primary inoculum (i.e. removal or decomposition of leaf litter).	Y	Y
	Powdery mildew	Rare	Group 11: Kresoxim-methyl,Trifloxystrobin, Group M: Lime sulphur or calcium polysulphide[f], Sulphur[g]	Avoid planting Anjou pears near susceptible apple cultivars. Bartlett and Flemish beauty are more resistant to powdery mildew.	Y	Y
Lowbush blueberries	Blossom blight and twig blight (Botrytis)	Minor / once every 5 years	Group 7: Boscalid Group 11: Pyraclostrobin Group 17: Fenhexamid Group M: Ferbam[f]	Burn-pruning every second or third crop cycle to reduce overwintering inoculum. Control weeds within and surrounding the field.	Y, M	Y
Raspberries	Fruit rot	Minor except in British Columbia, Ontario and Quebec where it is prevalent / every year	Group 2: Iprodione Group 7: Boscalid Group 17: Fenhexamid Group M: Captan[f]	Train canes to promote good air circulation. Avoid excessive nitrogen fertilization. Time overhead irrigation so that plants dry quickly.Cool harvested fruits quickly.	Y	Y
	Powdery mildew	Minor/more prevalent in dry years	None	Train canes to promote good air circulation. Use good row spacing. Remove diseased material and destroy in the fall .	Y	Y

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Strawberry	Fruit rot (Botrytis)	Minor except in Ontario, Quebec, New Brunswick, Nova Scotia and Prince Edward Island where it is prevalent / every year	Group 2: Iprodione[f], Vinclozolin[f] Group 7: Boscalid Group 17: Fenhexamid Group M: Captan[f], Folpet [f], Lime sulphur or calcium polysulphide[f] Thiram[f]	Weed control to reduce long periods of leaf wetness. Avoid excessive nitrogen fertilization. Irrigate during the day and for short periods. Use narrow rows to reduce plant density. Incorporate plant residues.	Y	Y
	Leafspots	Minor to moderate in Ontario and Quebec / every year	Group 17: Fenhexamid Group M: Captan[f], Dodine[f], Folpet[f], Copper as elemental, present as tribasic copper sulphate[f]	Plant resistant or less susceptible cultivars (i.e. Chambly, Vantage). Use certified plants for new plantings.	Y	Y
Peach	Brown rot	Moderate to prevalent in British Columbia and Ontario; minor elsewhere / every year	Group 2: Iprodione[f] Group 3: Fenbuconazole, Myclobutanil , Propiconazole[f], Triforine[f] Group 7: Boscalid Group 9: Cyprodinil Group 17: Fenhexamid Group M: Captan[f], Ferbam[f], Chlorothalonil[f], Sulphur[g], Thiram[f]	Prune out twigs killed by the fungus. Dispose of mummified fruits on the trees and soil surface. Avoid fruit bruising and punctures.	Y	Y
Nectarine	Brown rot	Moderate to prevalent in British Columbia and Ontario; minor elsewhere / every year	Group 3:Fenbuconazole, Myclobutanil , Propiconazole[f] Group 7: Boscalid Group 9: Cyprodinil Group 17: Fenhexamid Group M: Captan[f], Chlorothalonil[f]	Prune out twigs killed by the fungus. Dispose of mummified fruits on the trees and soil surface. Avoid fruit bruising and punctures.	Y	Y
Plums	Brown rot	Moderate to prevalent in British Columbia and Ontario; minor elsewhere / every year	Group 2: Iprodione[f] Group 3: Fenbuconazole, Propiconazole[f], Triforine[f] Group 7: Boscalid Group 9: Cyprodinil Group M: Captan[f], Ferbam[f], Sulphur[g]	Prune out twigs killed by the fungus. Dispose of mummified fruits on the trees and soil surface. Avoid fruit bruising and punctures.	Y	Y
Prunes	Brown rot	Moderate to prevalent in British Columbia and Ontario; minor elsewhere / every year	Group 2: Iprodione[f] Group 3: Fenbuconazole, Triforine[f] Group 7: Boscalid Group 9: Cyprodinil Group M: Captan[f], Ferbam[f], Sulphur[g]	Prune out twigs killed by the fungus. Dispose of mummified fruits on the trees and soil surface. Avoid fruit bruising and punctures.	Y	Y

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Cherries (sour and sweet)	Brown rot	Moderate to prevalent in British Columbia and Ontario, minor elsewhere / every year	Group 2: Iprodione [f] Group 3: Fenbuconazole, Myclobutanil , Propiconazole[f], Triforine[f] Group 7: Boscalid Group 17: Fenhexamid Group M: Captan,[f] Chlorothalonil[f], Ferbam[f], Sulphur[g], Copper as elemental, present as tribasic copper sulphate[f] (sour cherries only) or as copper oxychloride[f] (sour cherries only)	Prune out twigs killed by the fungus. Dispose of mummified fruits on the trees and soil surface. Avoid fruit bruising and punctures.	Y	Y
White beans	White mould	Major / every year	Group 2: Iprodione[f], Vinclozolin[f] Group 7: Boscalid Group 14: Dichloran[f] Group M: Captan[f]	Resistant cultivars (i.e. Rico 23). Rotation of 4 years. Plant spacing to allow air circulation. Avoid excess fertilization.	Y	P
Turf	Brown patch	Minor / every year in Ontario and Quebec; minor / 1 in 5 years elsewhere	Group 2: Iprodione[f] Group 3: Myclobutanil, Propiconazole[f] Group 11: Azoxystrobin, Trifloxystrobin Group 14: Quintozene[f] Group M: Captan[f], Chlorothalonil[f]	Balanced fertility. Adequate irrigation (i.e. avoid night watering). Cultivate to alleviate compaction. Thatch management and proper mowing height. Adapted species for the intended use and selection of resistant cultivars if available.	Y	Y
Turf	Dollar spot	Major / every year	Group 2: Iprodione[f] Group 3: Myclobutanil, Propiconazole[f] Group 7: Boscalid Group M: Anilazine, Chlorothalonil[f],Thiram[f]	Limit the amount and duration of leaf wetness, reduce shade, mow the turf in early morning to displace dew, avoid watering at night. Use adequate nitrogen fertilization. Use resistant cultivars.	Y	Y
	Copper spot	Minor	Group M: Anilazine	Velvet bentgrass is most susceptible. Use other turf species or resistant cultivars.	Y	Y
	Pink snow mould	Major / every year	Group 2: Iprodione[f] Group 3: Propiconazole[f] Group 7: Carbathiin[f], Oxycarboxin[f] Group 11: Azoxystrobin, Trifloxystrobin Group 14: Quintozene[f], Chloroneb[f] Group M: Chlorothalonil[f], Thiram[f]	Balanced fertility. Snow removal/ snow cover. Adequate irrigation. Cultivation to alleviate compaction. Thatch management and proper mowing height. Adapted species for the intended use and selection of resistant cultivars if available.	Y	Y
Turf	Powdery mildew	Rare	None	Increase sunlight penetration. Reduce humidity. Use resistant varieties.	Y	Y

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Rose and ornamental plants (outdoors)	Black spot	Minor / every year	Group 3: Myclobutanil, Triforine[f] Group M: Captan[f], Chlorothalonil[f],Copper as elemental, present as tribasic copper sulphate[f]	Prune and discard infected branches or leaves. Allow good air circulation. Use resistant cultivars.	Y	Y
	Powdery mildew	Major / every year	Group 3: Myclobutanil, Triforine[f] Group 5: Dodemorph-acetate[f] Group M: Copper as elemental, present as tribasic copper sulphate[f], Folpet[f] Non-conventional, biopesticide: *Pseudozyma flocculosa*	Use resistant cultivars. Prune and discard infected branches or leaves before new growth starts in the spring. Allow good air circulation.	Y	Y
Aspen and Poplar	Marssonnina and septoria leaf spots	Minor / every year	Group M: Chlorothalonil[f] (Marssonnina only, none registered for septoria leaf spot control)	Remove or bury diseased leaves. Use only cuttings from disease-free material. Use resistant clones in hybrid poplar plantations.	Y	Y
Greenhouse potted ornamentals	Powdery mildew	Moderate / every year	Group 3: Myclobutanil (roses, gerbera, aster and chrysanthemums) Group 5: Dodemorph-acetate[f] (greenhouse roses) Group M: Chlorothalonil[f]	Keep doors closed. Maintain smooth airflow. Use humidity control program. Use radiant heat to maintain a dry environment, reduce heat loss at night.	Y	Y

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Greenhouse potted ornamentals	Botrytis	Moderate / every year	Group 14: Dichloran[f] (roses, geraniums and chrysanthemums) Group 17: Fenhexamid Group M: Chlorothalonil[f]	Keep foliage and flowers dry. Avoid overhead watering. Provide good air circulation. Remove infected plant material. Use disease free propagating material.	Y	Y
	Fusarium stem, crown and root rots	Minor / every year	Group M: Captan[f] Non-conventional, biopesticide: *Streptomyces griseoviridis* strain K61(suppression) *Trichoderma harzianum* Rifai strain KRL-AG2 (suppression)	Avoid hot or cold temperature extremes. Irrigate consistently, avoid too wet or too dry extremes. Use appropriate media. Pasteurize soil if used. Use disease-free stocks for propagation.	Y	P
	Rhizoctonia stem, crown and root rots	Minor / every year	Group 2: Iprodione Group 11:Trifloxystrobin Group 14: Quintozene[f]	Use appropriate media. Pasteurize soil if used. Use disease-free stocks for propagation.	Y	P
	Leafspots	Minor / every year	Group M: Chlorothalonil[f], Captan[f] (Carnation leaf spot only)	Keep foliage and flowers dry. Avoid overhead watering. Provide good air circulation. Use disease-free propagating material.	Y	Y
Mushroom (Emergency use)	Trichoderma green mould	Moderate to major / every year	None	Use adequate compost with C/N ratio not higher than 15:1. Use a thorough sanitation and hygiene program.	Y	Y
Potato (seed treatment cut seed)	Black leg	Minor /every year	Group 12: Fludioxonil Group M: Captan[f]	Use disease-free seed. Warm seed tubers for 4 to 10 days before cutting. Plant cut seed immediately. Disinfect appropriately. Practice good sanitation procedures. Plant seed in warm soil (> than 10°C).	Y	Y

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Potato (seed treatment cut seed)	Fusarium rot	Moderate / every year	Group 12: Fludioxonil Group M: Mancozeb[f], Metiram[f]	Plant clean, disease-free seed. Plant cut seed immediately, or store under adequate ventilation, high humidity, and a temperature of 15°C prior to planting. Clean farm equipment. Harvest during dry, cool weather.	Y	Y
	Seed piece decay	Moderate / every year	Group M: Captan[f], Mancozeb[f], Metiram[f]	Avoid planting under unfavourable weather conditions.	Y	Y
	Silver scurf	Major / every year	Group 12: Fludioxonil	Plant certified silver scurf-free seed. Avoid planting in fields that had disease the previous season. Thoroughly disinfect storage areas. Harvest as soon as possible. Reduce the amount of soil and plant debris going into the storage. Use air to dry wet tubers. Remove field heat from tubers.	Y, M	Y
Potato (seed treatment cut seed)	Verticillium wilt	Rare to minor in Ontario, Quebec, New Brunswick, Nova Scotia and Prince Edward Island / every year	Group M: Captan[f]	Maintain optimum fertility. Do not overwater. Green manure incorporation may reduce disease severity. Practice a 3- to 4-year rotation. Avoid contamination with soil from diseased fields, diseased tubers or plant refuse.	Y	Y
Dry common beans (seed treatment)	Seed borne anthracnose	Major in Ontario and Manitoba / every year	Group 7: Carbathiin[f] + Group M : Thiram[f] Group 12: Fludioxonil + Group 4: Metalaxyl-m (mefenoxam)[f]	Follow a 3-year rotation. Use disease-free seed. Bury crop debris. Avoid entering fields during wet weather. Plant resistant cultivars to the delta race (i.e. OAC Seaforth).	Y	P

Site(s)	Pest(s)	Pest Status / Incidence[a]	Alternative Registered Active Ingredients[b] (Resistance Management Group No.)[c]	Non-Chemical Control Methods[a]	Registrant Supports Use of TMP (Y/N/M[d])	Preliminary Risk Assessment Concerns (Y/N/P[e])
Sweet corn (seed treatment)	*Penicillium* sp.	Rare to sporadic in Ontario and Quebec	Group 12: Fludioxonil Group 3: Difeconazole +Group 4: Metalaxyl-m (mefenoxam)[f]		Y, M	Y
Sugar beets (for export only)	Leafspots (Cercospora)	Major in Ontario / every year	Copper as elemental, present as tribasic copper sulphate[f], Copper as elemental, present as tribasic copper sulphate[f] Group M: Mancozeb[f], Metiram Group 11: Pyraclostrobin		Y, M	**N**

a Data from end-user surveys and research by the PMRA.

b This is a list of registered options only. The PMRA does not endorse any of the options listed.

c Fungicide Resistance Management Group Numbers (Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Initiative Based on Target Site/Mode of Action*):
2 = affect cell division, DNA and RNA synthesis and metabolism (dicarboximide); 3 = demethylation inhibitor (DMI): inhibition of demethylation in sterol biosynthesis (imidazoles or piperazine or pyridine or pyrimidines or triazoles [includes conazoles]); 4 = phenylamides (affect RNA synthesis) (acylamines or oxazolidinones or butyrolactones); 5 = morpholines (inhibition of an isomerase in sterol biosynthesis) (morpholines or piperidine or spiroketalamine);7 = oxathiin (affect mitochondrial transport chain);
7 = oxathiin (affect mitochondrial transport chain) (anilide[oxathiin]); 9 = anilinopyrimidine (inhibition of amino acid synthesis) (anilinopyrimidine); 11 = strobilurin type action and resistance (STAR) inhibition mitochondrial respiration (strobilurin or oxazolidinedione); 12 = phenylpyrroles (phenylpyrroles);
14 = aromatic hydrocarbons (chlorophenyl or thiadiazole); 17 = hydroxyanilide (hydroxyanilide);
18 = antibiotics (antibiotics); U = unknown miscellaneous (amino acid amide or carbamate or cyano-acetamide oxime or organotins); M = multisite activity (inorganics or dithiocarbamates and relatives or phthalimide or chloronitrile or sulphamide or guanidine or Anilazine or phenyl-pyridinamine or quinoxaline).

d Y = use is supported by the registrant, N = use is not supported by the registrant, M = use was registered as a User Requested Minor Use Label Expansion (URMULE).

e Y = There are some concerns, N = There is no concern, P = Partial risk concern for the use (e.g. PMRA has risk concerns only for some application methods of the use).

f These active ingredients are under re-evaluation [REV2004-06, *PMRA Re-evaluation Program Workplan (April 2004 to June 2005)*].

g The re-evaluation of sulphur is complete (Re-evaluation Decision Document RRD2004-19, *Sulphur*, published on 16 July 2004).

Appendix IV Toxicology Endpoints for Health Risk Assessment

Table 1 Toxicology Endpoints for Thiophanate-Methyl Health Risk Assessment

Exposure Scenario	Dose (mg/kg bw/day)	Endpoint	Study	UF/SF or MOE
Acute dietary general population	NOAEL = 40	Tremors 2–4 h postdosing	1 year—dog	300 (3-fold for lack of acute neurotoxicity)
	ARfD =0.13 mg/kg bw			
Acute dietary females 13–50	NOAEL = 20	Multiple supernumary ribs	Developmental toxicity—rabbit	300 (3-fold for lack of DNT)
	ARfD =0.067 mg/kg bw			
Chronic dietary	NOAEL = 8	Thyroid effects, decreased body weight gain, cholesterol changes	1 year—dog; 2-year chronic / cancer study - rat	1000 (10-fold for EDC and lack of DNT)
	ADI = 0.008 mg/kg bw/day			
Short-term[a] inhalation and incidental oral	Oral NOAEL = 10	Decreased body weight and food consumption	Developmental toxicity—rabbit	300
Short-term[a] dermal	Dermal NOAEL = 100	Decreased body weight and food consumption	21-day dermal—rabbit	300
Intermediate[b] and long-term dermal[c] and inhalation[c]	NOAEL = 8	Thyroid effects, decreased body-weight gain, cholesterol changes	1 year—dog; 2-year chronic / cancer study—rat	1000 (10-fold for EDC and lack of DNT)
Aggregate[c] (oral, dermal and inhalation)	Oral and inhalation NOAEL = 10 Dermal NOAEL = 100	Decreased body weight and food consumption	Developmental toxicity—rabbit; 21-day dermal—rabbit	300
Cancer Q_1*		Liver tumours in male mice	18-month dietary carcinogenicity—mice	1.32×10^{-2} $(\text{mg/kg bw/day})^{-1}$

a Duration of exposure is > 1–30 days
b Duration of exposure is 1–6 months
c A dermal absorption factor of 25% and an inhalation absorption factor of 100% was used in route-to-route extrapolation to an oral NOAEL.

EDC: endocrine disrupting compound
DNT: Developmental neurotoxicity study

Table 2 Toxicology Endpoints for Carbendazim Health Risk Assessment

Exposure Scenario	Dose (mg/kg bw/day)	Endpoint	Study	UF/SF or MOE
Acute dietary (males)	LOAEL = 50	Sperm effects	Acute oral—rat	1000 (LOAEL, severity)
	ARfD = 0.05 mg/kg bw			
Acute dietary (females 13–50 years old)	NOAEL = 10	Fetal malformations, resorptions	Developmental toxicity—rat and rabbit	1000 (sensitivity, severity, lack of DNT)
	ARfD = 0.01 mg/kg bw			
Chronic dietary	NOAEL = 9	Decreased body-weight gain, biochemical parameters	2 year—dog	1000 (sensitivity, severity, lack of DNT)
	ADI = 0.009 mg/kg bw/day			
Short-term[a] and intermediate-term[b] dermal[c] and inhalation[c] and aggregate[c] oral, dermal, and inhalation for females 13–50 years old	Oral NOAEL = 10	Fetal malformations, resorptions	Developmental toxicity—rat and rabbit	1000 (as above)
Aggregate[c] General population (oral and inhalation)	Oral and inhalation NOAEL = 20	Decreased body weight body-weight gain	Developmental toxicity— rat and rabbit	300 (sensitivity)
Cancer Q_1* $(mg/kg\ bw/day)^{-1}$		Liver tumours in female mice	2-year dietary carcinogenicity—mice	1.6×10^{-2}

a Duration of exposure is >1–30 days
b Duration of exposure is 1–6 months
c A dermal absorption factor of 25% and an inhalation absorption factor of 100% was used in route-to-route extrapolation to an oral NOAEL.
DNT: Developmental neurotoxicity study

Appendix Va Occupational Exposure and Risk Estimates

Table 1 Occupational Mixer/Loader/Applicator Exposure and Risk Assessment

Crop	Formulation	Application Equiment	Application Rate (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Dermal MOE[a]		Inhalation MOE[b]		Combined MOEs[c] (target = 300)		
					Mid-Level PPE[d]	Max. PPE[e]	Without Respirator	With Respirator	Mid-Level PPE		Maximum PPE
									Without Respirator	With Respirator	With Respirator
USC 10—Seed Treatments for Food and Feed											
Dry common beans— On farm	Dust	M/L/A	0.73 g a.i./kg of seed	3000 kg of seed	397	N/A	94 268		396		N/A
Sweet corn— On farm	Dust	M/L/A	0.70 g a.i./kg of seed	1320 kg of seed	939	N/A	222 816		935		N/A
Potatoes (cut seed)	Dust	Filling Duster	0.5 g a.i./kg of seed	10 000 kg of seed	538	N/A	414	828	234	326	N/A
		Cutting/ Sorting			6061	N/A	8235	16 471	3491	4430	N/A
		Planting			8974	N/A	10000	20 000	4730	6195	N/A
USC 14—Terrestrial Food Crops											
Apples and pears	WP	Airblast	1.58 (Western)	16	322	341	447	4466	187	301	317
	WSP				559	579	4630	47 741	499	552	572
Lowbush blue-berries	WP	M/L for aircraft	0.77	60	408	447	270	2696	162	355	383
	WSP				19 131	29 250	84 175	N/A	15 588	N/A	21 707 (no respirator)
	WP/ WSP	Aircraft			15 685	15 685	216 450	N/A	14 625	N/A	14 625 (no respirator)
	WP	Ground-boom		30	773	847	530	5301	314	674	730
	WSP				10 464	12 663	26 582	315 657	7508	10 128	12 175
	WP	Low-pressure handwand	0.00077	150 L	5239	6102	4259	42590	2349	4665	5337
	WSP				82 433	87 380	134 084	1 340 842	51 049	77 658	82 034
	WSP	Backpack			23 336	29 894	97 594	975 943	18 833	22 791	29006
Cherries, nectarines, plums, prunes, peaches	WP	Airblast	1.23	16	414	438	574	5737	241	386	407
	WSP				718	744	5948	61 326	640	709	735
Rasp-berries and straw-berries	WP	Ground-boom	0.77	30	773	847	530	5301	314	674	730
	WSP				10 464	12 663	26 582	315 657	7508	10 128	12 175
	WP	Low-pressure handwand	0.00077	150 L	5239	6102	4259	42 590	2349	4665	5337
	WSP				82 433	87 380	134 084	1 340 842	51 049	77 658	82 034
	WSP	Backpack			23 336	29 894	97 594	975 943	18 833	22 791	29 006

Crop	Formulation	Application Equiment	Application Rate (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Dermal MOE[a]		Inhalation MOE[b]		Combined MOEs[c] (target = 300)		
					Mid-Level PPE[d]	Max. PPE[e]	Without Respirator	With Respirator	Mid-Level PPE		Maximum PPE
									Without Respirator	With Respirator	With Respirator
White beans	WP	Ground-boom	1.59	100	112	123	77	770	46	98	106
White beans	WSP	Ground-boom	1.59	100	1520	1840	3862	45 860	1091	1471	1769
White beans	WP	Ground-boom	1.59	300	37	41	26	257	15	33	35
White beans	WSP	Ground-boom	1.59	300	507	613	1287	15 287	364	490	590
White beans	WP	M/L for aircraft	1.59	400	30	32	20	196	12	26	28
White beans	WSP	M/L for aircraft	1.59	400	1390	2125	6115	N/A	1132	N/A	N/A
White beans	WP	Aircraft	1.59	400	1139	1139	15 723	N/A	1062	N/A	N/A
Sugar beets	WP	Ground-boom	0.39	30	1526	1672	1047	10 467	621	1331	1442
Sugar beets	WSP	Ground-boom	0.39	30	20 659	25002	52 482	524 816	14 824	19 877	23 865
USC 27—Ornamentals Outdoor											
Aspen and poplar	WP	Airblast	0.77	16	662	700	916	9164	384	617	650
Aspen and poplar	WSP	Airblast	0.77	16	1147	1189	9501	95 014	1023	1133	1174
Aspen and poplar	WSP	Backpack	0.00077	150 L	23 336	29 894	97 594	975 943	18 833	22 791	29 006
Aspen and poplar	WP	Low-pressure handwand	0.00077	150 L	5239	6102	4259	42 590	2349	4665	5337
Aspen and poplar	WSP	Low-pressure handwand	0.00077	150 L	82 433	87 380	134 084	1 340 842	51 049	77 658	82 034
Aspen and poplar	WSP	High-pressure handwand	0.00077	3750 L	988	1327	1605	16 055	612	931	1226
Aspen and poplar	WP	Right-of-way sprayer	0.00077	3750 L	2708	3055	3961	39 612	1608	2535	2837
Aspen and poplar	WSP	Right-of-way sprayer	0.00077	3750 L	4557	5276	46 800	484 848	4153	4515	5219
Outdoor ornamentals and roses (Commercial)	WP	Low-pressure handwand	0.00053	150 L	7684	8950	6247	62 466	3446	6843	7828
Outdoor ornamentals and roses (Commercial)	WSP	Low-pressure handwand	0.00053	150 L	120 901	128 158	196 657	1 966 568	74 871	113 899	120 317
Outdoor ornamentals and roses (Commercial)	WSP	Backpack	0.00053	150 L	34 226	43 845	143 138	1 431 383	27 622	33 427	42 542
Outdoor ornamentals and roses (Commercial)	WSP	High-pressure handwand	0.00053	3750 L	1449	1946	2355	23 547	897	1365	1797
Outdoor ornamentals and roses (Commercial)	WP	Ground-boom	0.525	30	1133	1242	778	7775	461	989	1071
Outdoor ornamentals and roses (Commercial)	WSP	Ground-boom	0.525	30	15 347	18 573	38 986	462 963	11 012	14 854	17 856
Outdoor ornamentals and roses (Commercial)	WP	Airblast	0.525	16	970	1026	1344	13 441	564	905	954
Outdoor ornamentals and roses (Commercial)	WSP	Airblast	0.525	16	1682	1743	13 935	143 678	1501	1662	1722

Crop	Formulation	Application Equiment	Application Rate (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Dermal MOE[a]		Inhalation MOE[b]		Combined MOEs[c] (target = 300)		
					Mid-Level PPE[d]	Max. PPE[e]	Without Respirator	With Respirator	Mid-Level PPE		Maximum PPE
									Without Respirator	With Respirator	With Respirator
USC 30—Turf											
Golf course	GR	Push rotary spreader[f]	3	2	8642	N/A	7071	70 707	3889	7701	N/A
		Tractor drawn spreader		16	11 429	N/A	3838	38 377	2873	8806	N/A
	WP	Low-pressure turf gun[f]	17.5	2	524	N/A	131	1307	105	374	N/A
	WSP				429	N/A	1379	13 793	327	416	N/A
	WSP	Backpack		0.4	385	N/A	1610	16 103	311	376	N/A
	WP	Ground-boom		16	64	70	44	437	26	56	60
	WSP				863	1045	2193	21 930	619	831	997

a Dermal MOE = dermal exposure / dermal NOAEL. The dermal NOAEL is 100 mg/kg bw/day. The target dermal MOE is 300.

b Inhalation MOE = inhalation exposure/inhalation NOAEL. The inhalation NOAEL is 10 mg/kg bw/day. The target inhalation MOE is 300.

c Combined MOE = 1 / ((1/dermal MOE) + (1 / inhalation MOE))

d Mid-level PPE = coveralls over a single layer of clothing, chemical-resistant gloves, and or without respirator

e Maximum PPE = chemical-resistant coveralls over a single layer of clothing, chemical-resistant gloves and a respirator

f The dermal and inhalation values are from the ORETF. For mid-level PPE: long pants, a long-sleeved shirt, gloves and with and without a respirator. For the maximum PPE: coveralls over long pants, a long-sleeved shirt, gloves and a respirator.

Table 2 Dermal and Inhalation MOEs for Intermediate-Term Mixing/Loading and Applying Thiophanate-Methyl

Crop	Formulation	Application Equipment	Application Rate (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Dermal MOE[a]		Inhalation MOE[b]		Combined MOEs[c] (target = 1000)		
					Mid-Level PPE[d]	Max. PPE[e]	Without Respirator	With Respirator	Mid-Level PPE		Maximum PPE
									Without Respirator	With Respirator	With Respirator
USC 6—Greenhouse Non-Food Crops											
Potted ornamen-tals	WSP	Backpack	0.000595	150 L	9664	12 380	101 039	1 010 388	8820	9572	12 230
	WP	Low-pressure handwand			2170	2527	4409	44 094	1454	2068	2390
	WSP	Low-pressure handwand			34 137	36 186	138 817	1 388 166	27 399	33 317	35 266
	WSP	High-pressure handwand		3750 L	409	549	1662	16 621	328	399	532
	WP	Trickled irrigation	0.000595	1.2	8453	9252	13 956	139 558	5264	7970	8677
	WSP				396 118	605 648	4 360 000	43 600 000	363 108	392 549	597 000
USC 10—Seed Treatments for Food and Feed											
Dry common beans[f] (Com-mercial)	WSP	Loader/ Applicator	0.73 g a.i./kg of seed	68 000 kg of seed	892	N/A	150 916	1 509 157	887	892	N/A
		Loader/ Applicator			1140	N/A	150 916	1 509 157	1132	1339	N/A
		Sewer			3310	N/A	223 093	2 230 928	3262	3306	N/A
		Bagger			2255	N/A	320 696	3 206 960	2240	2254	N/A
		Multiple activities			489	N/A	32 070	320 696	481	488	N/A
Sweet corn[f] (Com-mercial)	WSP	Loader/ Applicator	0.70 g a.i./ kg of seed	60 000 kg of seed	1052	N/A	177 879	1 778 794	1046	1051	N/A
		Loader/ Applicator			1344	N/A	177 889	1 778 794	1334	1343	N/A
		Sewer			3902	N/A	262 952	2 629 521	3845	3896	N/A
		Bagger			2658	N/A	377 994	3 779 937	2640	2657	N/A
Sweet corn (Com-mercial)	WSP	Multiple activities	0.70 g a.i./ kg of seed	60 000 kg of seed	576	N/A	37 799	377 994	567	575	N/A

Crop	Formulation	Application Equipment	Application Rate (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Dermal MOE[a]		Inhalation MOE[b]		Combined MOEs[c] (target = 1000)		
					Mid-Level PPE[d]	Max. PPE[e]	Without Respirator	With Respirator	Mid-Level PPE		Maximum PPE
									Without Respirator	With Respirator	With Respirator
USC 14—Terrestrial Food Crops											
Lowbush blueberries	WP	M/L for aircraft	0.77	60	131	143	216	2157	81	123	134
	WSP				6122	9360	67 340	N/A	5612	N/A	N/A
	WP/ WSP	Aircraft			5019	5019	173 160	N/A	4878	N/A	N/A
	WP	Ground-boom		30	247	271	424	4241	156	234	255
	WSP				3348	4052	21 265	252 525	2893	3305	3988
	WP	Low-pressure handwand	0.00077	150 L	1677	1953	3407	34 072	1124	1598	1847
	WSP				26 378	27 962	107 267	1 072 674	21 172	25 745	27 251
	WSP	Backpack			7468	9566	78 075	780 754	6816	7397	9450
White beans	WP	Ground-boom	1.59	300	12	13	21	205	8	11	12
	WSP				162	196	1030	12 229	140	160	193
		CC ground-boom			248	289	4892	N/A	236	N/A	284
	WP	M/L for aircraft		400	9	10	16	157	6	9	10
	WSP				445	680	4892	N/A	408	N/A	N/A
	WP/ WSP	Aircraft			365	365	12 579	N/A	354	N/A	N/A
Mush-rooms	WP	Dispersal by hand	8.75	0.16	29	46	605	6050	N/A	N/A	46
Mush-rooms	Me-chanical spread-ing	Stevens and Davis	8.75	0.16	616	—	1183	2367	N/A	N/A	489
		Fenske et al.	8.75	0.16	289	—	117 647	1 176 471	N/A	N/A	289

Crop	Formulation	Application Equipment	Application Rate (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Dermal MOE[a]		Inhalation MOE[b]		Combined MOEs[c] (target = 1000)		
					Mid-Level PPE[d]	Max. PPE[e]	Without Respirator	With Respirator	Mid-Level PPE		Maximum PPE
									Without Respirator	With Respirator	With Respirator
USC 27—Ornamentals Outdoor											
Outdoor ornamen-tals and roses (Com-mercial)	WP	Low-pressure handwand	0.000525	150 L	2459	2864	4997	49 973	1648	2344	2709
	WSP				38 688	41 010	157 325	1 573 255	31 052	37 760	39 969
	WSP	Backpack			10 952	14 030	114 511	1 145 106	9996	10 849	13 861
	WSP	High-pressure handwand		3750 L	464	623	1884	18 837	372	453	603
	WP	Ground-boom	0.525	30	363	397	622	6220	229	343	374
	WSP				4911	5943	31 189	370 370	4243	4847	5849
	WP	Airblast		16	311	328	1075	10 753	241	302	319
	WSP				538	558	11 148	114 943	513	536	555
		CC airblast			5369	N/A	87 719	N/A	5059	N/A	N/A
USC 30—Turf											
Golf course	GR	Push rotary spreader[g]	3	2	2765	N/A	5657	56 566	1857	2637	N/A
		Tractor drawn spreader		16	3657	N/A	3070	30 702	1669	3268	N/A

a Dermal MOE = dermal exposure / dermal NOAEL. The dermal NOAEL is 8 mg/kg bw/day. The target dermal MOE is 1000.

b Inhalation MOE = inhalation exposure / inhalation NOAEL. The inhalation NOAEL is 8 mg/kg bw/day. The target inhalation MOE is 1000.

c Combined MOE = 1 / ((1 / dermal MOE) + (1 / inhalation MOE))

d Mid-level PPE = coveralls over a single layer of clothing, gloves, with or without respirator (unique PPE for commercial seed treatment, see footnote f)

e Maximum PPE = chemical-resistant coveralls over a single layer of clothing, gloves and a respirator

f The unit exposure values are from USEPA Policy 14 and have unique PPE scenarios: a single layer of clothing, no gloves for sewer and bagger, single layer of clothing and gloves for loader/applicator (1) and multiple activities and coveralls and gloves for loader/applicator (2). Data are not available for wettable powder formulation (only wettable powder packaged in water-soluble packaging).

g The dermal and inhalation values are from the ORETF. For mid-level PPE: long pants, a long-sleeved shirt, gloves, and with or without a respirator. For the maximum PPE: coveralls over long pants, a long-sleeved shirt, gloves and a respirator.

Table 3 Occupational M/L/A Cancer Risk Estimates

Crop	Formulation	Application Equipment	Application Rate[b] (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Frequency Exposure per Year	Cancer			
						Mid-Level PPE Without		Maximum PPE	
						LADD	Cancer Risk	LADD	Cancer Risk
USC 6—Greenhouse Non-Food Crops									
Potted ornamentals	WSP	Backpack	0.0006	150 L	30	3.73×10^{-5}	4.92×10^{-7}	2.69×10^{-5}	3.55×10^{-7}
	WP	Low-pressure handwand				2.26×10^{-4}	2.98×10^{-6}	1.38×10^{-4}	1.82×10^{-6}
	WSP					1.20×10^{-5}	1.58×10^{-7}	9.32×10^{-6}	1.23×10^{-7}
	WSP	High-pressure		3750 L		1.00×10^{-3}	1.32×10^{-5}	6.18×10^{-4}	8.16×10^{-6}
	WP	Trickled irrigation	0.595	1.2		6.25×10^{-5}	8.24×10^{-7}	3.79×10^{-5}	5.00×10^{-7}
	WSP					9.05×10^{-7}	1.20×10^{-8}	5.50×10^{-7}	7.27×10^{-9}
USC 10—Seed Treatments for Food and Feed									
On-farm									
Dry common beans	Dust	M/L/A	0.73 g a.i./kg of seeds	3000 kg of seeds	1	8.64×10^{-5}	1.14×10^{-6}	N/A	N/A
Sweet corn	Dust	M/L/A	0.70 g a.i./kg of seeds	1320 kg of seeds		3.65×10^{-5}	4.82×10^{-7}	N/A	N/A
Potatoes (cut seed)	Dust	Filling Duster	0.5 g a.i./kg of seeds	10 000 kg of seeds	10	8.01×10^{-7}	1.06×10^{-8}	N/A	N/A
		Cutting/ Sorting				6.48×10^{-8}	8.56×10^{-10}	N/A	N/A
		Planting				4.50×10^{-8}	5.94×10^{-10}	N/A	N/A
Commercial[a]									
Dry common beans	WSP	Multiple activities	0.73 g a.i./kg of seeds	68 000 kg of seeds	60	1.55×10^{-3}	2.05×10^{-5}	N/A	N/A
Sweet corn	WSP	Multiple	0.70 g a.i./kg	60 000 kg	60	1.32×10^{-3}	1.74×10^{-5}	N/A	N/A
USC 14—Terrestrial Food Crops									
Apples and pears	WP	Airblast	1.58	16	4	5.48×10^{-4}	7.23×10^{-6}	4.14×10^{-4}	5.46×10^{-6}
	WSP					2.57×10^{-4}	3.39×10^{-6}	2.38×10^{-4}	3.14×10^{-6}

Crop	Formulation	Application Equipment	Application Rate[b] (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Frequency Exposure per Year	Cancer			
						Mid-Level PPE Without		Maximum PPE	
						LADD	Cancer Risk	LADD	Cancer Risk
Lowbush blueberries	WP	M/L for aircraft	0.77	60	30	4.04×10^{-3}	5.33×10^{-5}	2.45×10^{-3}	3.24×10^{-5}
	WSP		0.77			5.86×10^{-5}	7.73×10^{-7}	4.00×10^{-5}	5.28×10^{-7}
	WP/WSP	Aircraft	0.77			6.74×10^{-5}	8.90×10^{-7}	6.74×10^{-5}	8.90×10^{-7}
	WP		0.77	30	30	2.81×10^{-4}	3.70×10^{-6}	1.72×10^{-4}	2.27×10^{-6}
	WSP	Ground-boom	0.77	30	4	1.52×10^{-5}	2.00×10^{-7}	1.10×10^{-5}	1.45×10^{-7}
	WP	Low-pressure handwand	0.00077	150 L	4	3.90×10^{-5}	5.15×10^{-7}	2.37×10^{-5}	3.13×10^{-7}
	WSP	Low-pressure handwand	0.00077	150 L	4	2.07×10^{-6}	2.73×10^{-8}	1.61×10^{-6}	2.12×10^{-8}
	WSP	Backpack	0.00077	150 L	4	6.43×10^{-6}	8.49×10^{-8}	4.64×10^{-6}	6.12×10^{-8}
Cherries, nectarines, plums, prunes and peaches	WP	Airblast	1.23	16	3	3.20×10^{-4}	4.22×10^{-6}	2.42×10^{-4}	3.19×10^{-6}
	WSP					1.50×10^{-4}	1.98×10^{-6}	1.39×10^{-4}	1.83×10^{-6}
Mushrooms	WP	Hand spreading	8.75	0.16	90	3.60×10^{-2}	4.76×10^{-4}	2.14×10^{-2}	2.83×10^{-4}
		Mechanical spreading (Fenske)	8.75	0.16	90	N/A	N/A	2.02×10^{-3}	2.66×10^{-5}
		(Stevens and Davis)	8.75	0.16	90	N/A	N/A	3.42×10^{-3}	4.51×10^{-5}
Sugar beets	WP	Ground-boom	0.39	30	2	7.11×10^{-5}	9.38×10^{-7}	4.36×10^{-5}	5.75×10^{-7}
	WSP					3.84×10^{-6}	5.07×10^{-8}	2.79×10^{-6}	3.69×10^{-8}
Raspberries and strawberries	WP	Ground-boom	0.77	30	4	2.81×10^{-4}	3.70×10^{-6}	1.72×10^{-4}	2.27×10^{-6}
	WSP					1.52×10^{-5}	2.00×10^{-7}	1.10×10^{-5}	1.45×10^{-7}
Raspberries and strawberries	WP	Low-pressure handwand	0.00077	150 L	4	3.90×10^{-5}	5.15×10^{-7}	2.37×10^{-5}	3.13×10^{-7}
	WSP					2.07×10^{-6}	2.73×10^{-8}	1.61×10^{-6}	2.12×10^{-8}
	WSP	Backpack				6.43×10^{-6}	8.49×10^{-8}	4.64×10^{-6}	6.12×10^{-8}

Crop	Formulation	Application Equipment	Application Rate[b] (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Frequency Exposure per Year	Cancer			
						Mid-Level PPE Without		Maximum PPE	
						LADD	Cancer Risk	LADD	Cancer Risk
White beans	WP	Ground-boom (farmer)	1.59	100	2	9.66×10^{-4}	1.27×10^{-5}	5.92×10^{-4}	7.82×10^{-6}
	WSP		1.59	100	2	5.21×10^{-5}	6.88×10^{-7}	3.78×10^{-5}	4.99×10^{-7}
	WP	Ground-boom (custom)	1.59	300	30	4.35×10^{-2}	5.74×10^{-4}	2.67×10^{-2}	3.52×10^{-4}
	WSP					2.35×10^{-3}	3.10×10^{-5}	1.70×10^{-3}	2.25×10^{-5}
	WP	M/L for aircraft	1.59	400		5.56×10^{-2}	7.34×10^{-4}	3.38×10^{-2}	4.46×10^{-4}
	WSP					8.07×10^{-4}	1.06×10^{-5}	5.51×10^{-4}	7.27×10^{-6}
	WP/WSP	Aircraft				9.28×10^{-4}	1.22×10^{-5}	9.28×10^{-4}	1.22×10^{-5}
USC 30—Turf									
Golf course	GR	Push rotary spreader	3	2	6	3.54×10^{-5}	4.67×10^{-7}	N/A	N/A
	GR	Tractor drawn spreader	3	16	6	3.94×10^{-5}	5.20×10^{-7}	N/A	N/A
	WSP	Low-pressure turf gun	17.5	2	1	8.97×10^{-5}	1.18×10^{-6}	N/A	N/A
		Backpack		0.4		9.74×10^{-5}	1.29×10^{-6}	N/A	N/A
	WP	Ground-boom		16		8.50×10^{-4}	1.12×10^{-5}	5.22×10^{-4}	6.88×10^{-6}
	WSP					4.59×10^{-5}	6.06×10^{-7}	3.34×10^{-5}	4.41×10^{-7}

Crop	Formulation	Application Equipment	Application Rate [b] (kg a.i./ha or kg a.i./L)	Area Treated per Day (ha or L)	Frequency Exposure per Year	Cancer			
						Mid-Level PPE Without		Maximum PPE	
						LADD	Cancer Risk	LADD	Cancer Risk
USC 27—Outdoor Ornamentals									
Aspen and poplar	WP	Right-of-way sprayer	0.00077	3750 L	3	4.83×10^{-5}	6.38×10^{-7}	3.47×10^{-5}	4.58×10^{-7}
	WSP					2.34×10^{-5}	3.09×10^{-7}	1.96×10^{-5}	2.58×10^{-7}
	WSP	Backpack		150 L		4.82×10^{-6}	6.37×10^{-8}	3.48×10^{-6}	4.59×10^{-8}
	WP	Low-pressure handwand				2.93×10^{-5}	3.86×10^{-7}	1.78×10^{-5}	2.35×10^{-7}
	WSP					1.55×10^{-6}	2.05×10^{-8}	1.21×10^{-6}	1.59×10^{-8}
	WSP	High-pressure handwand		3750 L		1.30×10^{-4}	1.71×10^{-6}	8.00×10^{-5}	1.06×10^{-6}
	WP	Airblast	0.77	16		2.00×10^{-4}	2.64×10^{-6}	1.51×10^{-4}	2.00×10^{-6}
	WSP					9.39×10^{-5}	1.24×10^{-6}	8.69×10^{-5}	1.15×10^{-6}
Outdoor ornamentals (Commercial)	WP	Low-pressure handwand	0.000525 (/L)	150 L	30	1.99×10^{-4}	2.63×10^{-6}	1.21×10^{-6}	1.60×10^{-6}
	WSP					1.06×10^{-5}	1.40×10^{-7}	8.23×10^{-6}	1.90×10^{-7}
	WSP	Backpack				3.29×10^{-5}	4.34×10^{-7}	2.37×10^{-5}	3.13×10^{-7}
	WSP	High-pressure handwand		3750 L		8.83×10^{-4}	1.17×10^{-5}	5.45×10^{-4}	7.20×10^{-6}
	WP	Ground-boom	0.525	30	30	1.44×10^{-3}	1.89×10^{-5}	8.80×10^{-4}	1.16×10^{-5}
	WSP					7.75×10^{-5}	1.02×10^{-6}	5.62×10^{-5}	7.42×10^{-7}
	WP	Airblast		16		1.36×10^{-3}	1.80×10^{-5}	1.03×10^{-3}	1.36×10^{-5}
	WSP					6.40×10^{-4}	8.45×10^{-6}	5.92×10^{-4}	7.82×10^{-6}

[a] The unit exposure values are from USEPA Policy 14 and have unique PPE scenarios. For multiple activities, the PPE is a single layer of clothing with gloves.

[b] The application rate is the maximum rate (average or typical rates were not available).

[c] Respirator is applied to mushroom, dry beans and sweet corn on-farm and for potato cut seed treatment.

Shaded cells indicate a cancer risk for workers (> 1×10^{-5}).

Appendix Vb Occupational Postapplication Exposure Risk Estimates Cancer

For Thiophanate-Methyl:

Activity	Transfer Coefficient [a] (cm²/h)	Short-Term (target = 300)				Intermediate-Term (target = 1000)			
		SRL[b] (µg/cm²)	Dermal Exposure[c] (µg/kg bw/day)	MOE[d] (day 0)	Proposed REI[e]	SRL[b] (µg/cm²)	Dermal Exposure[c] (µg/kg bw/day)	MOE[d] (day 0)	Proposed REI[e]
Lowbush blueberries (0.77 kg a.i./ha)									
Irrigate, scout, thin, prune	400	N/A	N/A	N/A	N/A	0.66	34.97	229	2
Hand harvest, prune	1500	N/A	N/A	N/A	N/A	0.19	131.13	61	4
Raspberries (0.77 kg a.i./ha)									
Weed, irrigate, scout	500	5.83	174.84	572	0	N/A	N/A	N/A	N/A
Hand harvest, prune, thin, train, tie	1500	1.94	250.19	191	1	N/A	N/A	N/A	N/A
Strawberries (0.77 kg a.i./ha)									
Irrigate, mulch, weed, scout, thin	400	7.29	139.89	715	0	N/A	N/A	N/A	N/A
Hand harvest, pinch, prune, train	1500	1.94	524.57	191	1	N/A	N/A	N/A	N/A
White beans (1.59 kg a.i./ha)									
Weed	100	29.17	72.21	**1385**	0	N/A	N/A	N/A	N/A
Irrigate, scout	1500	1.94	1083.09	92	2	N/A	N/A	N/A	N/A
Harvest	2500	1.17	1805.14	55	3	N/A	N/A	N/A	N/A
Sugar beets (0.39 kg a.i./ha)									
Thin, weed	100	29.17	17.71	5645	0	N/A	N/A	N/A	N/A
Irrigate, scout	1500	1.94	265.71	376	0	N/A	N/A	N/A	N/A
Apples and pears (1.58 kg a.i./ha—Western) (based on New York data)									
Weed, prop	100	N/A	N/A	N/A	N/A	2.8	10.28	778	2
Prune, scout, pinch, tie, train	500	N/A	N/A	N/A	N/A	0.56	51.42	156	11
Hand harvest	1500	N/A	N/A	N/A	N/A	0.19	154.25	52	17
Thin	3000	N/A	N/A	N/A	N/A	0.09	308.5	26	21

Activity	Transfer Coefficient[a] (cm^2/h)	Short-Term (target = 300)				Intermediate-Term (target = 1000)			
		SRL[b] (µg/cm^2)	Dermal Exposure[c] (µg/kg bw/day)	MOE[d] (day 0)	Proposed REI[e]	SRL[b] (µg/cm^2)	Dermal Exposure[c] (µg/kg bw/day)	MOE[d] (day 0)	Proposed REI[e]
Apples and pears (1.58 kg a.i./ha —Western) (based on Washington data)									
Weed, prop	100	N/A	N/A	N/A	N/A	2.8	8.2	976	2
Prune, scout, pinch, tie, train	500	N/A	N/A	N/A	N/A	0.56	41	33	>50
Hand harvest	1500	N/A	N/A	N/A	N/A	0.19	123	65	>50
Thin	3000	N/A	N/A	N/A	N/A	0.09	246	195	>50
Peaches, nectarines, plums, prunes and cherries (1.23 kg a.i./ha) (based on New York data)									
Weed, prop	100	N/A	N/A	N/A	N/A	2.8	8.01	999	0
Prune, scout, pinch, tie, train	500	N/A	N/A	N/A	N/A	0.56	40.03	200	9
Hand harvest	1500	N/A	N/A	N/A	N/A	0.19	120.08	67	16
Thin	3000	N/A	N/A	N/A	N/A	0.09	240.16	33	20
Peaches, nectarines, plums, prunes and cherries (1.23 kg a.i./ha) (based on Washington data)									
Weed, prop	100	N/A	N/A	N/A	N/A	2.8	6.4	1250	0
Prune, scout, pinch, tie, train	500	N/A	N/A	N/A	N/A	0.56	32	42	> 50
Hand harvest	1500	N/A	N/A	N/A	N/A	0.19	96	83	> 50
Thin	3000	N/A	N/A	N/A	N/A	0.09	192	250	> 50
Aspen and poplar (0.77 kg a.i./ha) (based on New York data)									
Hand prune, scout, pinch, tie, train	500	5.83	100	1000	0	N/A	N/A	N/A	N/A
Hand-line irrigate	1100	2.65	220	455	0	N/A	N/A	N/A	N/A
Aspen and poplar (0.77 kg a.i./ha) (based on Washington data)									
Hand prune, scout, pinch, tie, train	500	5.83	80	1250	0	N/A	N/A	N/A	N/A
Hand-line irrigate	1100	2.65	176	568	0	N/A	N/A	N/A	N/A
Roses and ornamental plants outdoor (0.525 kg a.i./ha)									
All activities (excluding cut flowers)	400[f]	N/A	N/A	N/A	N/A	0.7	27.02	296	2
Cut roses	7000	N/A	N/A	N/A	N/A	0.04	472.8	17	6
Greenhouse potted ornamentals (0.595 kg a.i./ha) (2 applications, DFR based on greenhouse study with roses and mums)									
All activities for potted ornamen-tals	400 (refined)[f]	N/A	N/A	N/A	N/A	0.7	21.38	374	20
Hand harvest, hand prune, pinch, thin	7000	N/A	N/A	N/A	N/A	0.04	374.2	21	74

Activity	Transfer Coefficient [a] (cm^2/h)	Short-Term (target = 300)				Intermediate-Term (target = 1000)			
		SRL[b] (µg/cm^2)	Dermal Exposure[c] (µg/kg bw/day)	MOE[d] (day 0)	Proposed REI[e]	SRL[b] (µg/cm^2)	Dermal Exposure[c] (µg/kg bw/day)	MOE[d] (day 0)	Proposed REI[e]
Turf									
Scout, irrigate, aerate (3 kg a.i./ha)	500	N/A	N/A	N/A	N/A	0.55	2.81	2844	0
Scout, irrigate, aerate (17.5 kg a.i./ha)	500	5.83	65.64	1524	0	N/A	N/A	N/A	N/A
Mowing (3 kg a.i./ha)	6800	N/A	N/A	N/A	N/A	0.04	38.26	209	4
Mowing (17.5 kg a.i./ha)	6800	0.43	892.67	112	2	N/A	N/A	N/A	N/A

a Transfer coefficients are from the Science Advisory Council for Exposure Agricultural Transfer Coefficient document (revised, 7 August 2000) and any amendments thereof.

b Safe residue limit (SRL) = DFR / TTR represent the value at the day of safe re-entry (proposed REI)

c Dermal exposure at day 0 = DFR × TC × 8 h / 70 kg.

d Safety factor of 300 for short-term based on the short-term dermal NOAEL of 100 mg/kg/day. Safety factor of 1000 for intermediate-term based on the intermediate-term dermal NOAEL of 8 mg/kg/day

e The proposed REI in order reach a target MOE of 300 for short-term and 1000 for intermediate term postapplication exposure scenarios.

f TC of 400 cm^2/h has not been finalized and is subject to change once a full review of ARTF data has been completed.

Shaded cells have values lower than the target MOE.

For Carbendazim:

Activity	Transfer Coefficient (cm²/h)[a]	15% of the DFR/TTR Value at the Proposed REI[b]	Absorbed Daily Dermal Dose[c] (mg/kg/day)	Short/Intermediate-Term MOE[d] (target = 1000)	Long-Term MOE[d] (target = 1000)
Lowbush blueberries (0.77 kg a.i./ha)					
Irrigate, scout, thin, prune	400	0.0238	2.72×10^{-4}	36 807	N/A
Hand harvest, prune	1500		1.02×10^{-3}	9815	N/A
Raspberries (0.77 kg a.i./ha)					
Weed, irrigate, scout	500	0.2189	3.13×10^{-2}	3198	N/A
Hand harvest, prune, thin, train, tie	1500		9.38×10^{-2}	1066	N/A
Strawberries (0.77 kg a.i./ha)					
Irrigate, mulch, weed, scout, thin	400	0.219	2.50×10^{-3}	3996	N/A
Hand harvest, pinch, prune, train	1500		9.38×10^{-3}	1066	N/A
White beans (1.59 kg a.i./ha)					
Weed	500	0.1029	1.47×10^{-3}	6803	N/A
Irrigate, scout	1500		4.41×10^{-3}	2268	N/A
Hand harvest	2500		7.35×10^{-23}	1361	N/A
Sugar beets (0.39 kg a.i./ha)					
Thin, weed	100	0.2324	6.64×10^{-4}	15 063	N/A
Irrigate, scout	1500		9.96×10^{-3}	1004	N/A
Apples and pears (1.58 kg a.i./ha)—Western					
Weed, prop	100	0.0126	3.61×10^{-5}	276 990	N/A
Prune, scout, pinch, tie, train	500		1.81×10^{-4}	55 398	N/A
Hand harvest	1500		5.42×10^{-4}	18 466	N/A
Thin	3000		1.08×10^{-3}	9233	N/A
Peaches, nectarines, plums, prunes and cherries (1.23 kg a.i./ha)					
Weed, prop	100	0.0118	3.36×10^{-5}	297 619	N/A
Prune, scout, pinch, tie, train	500		1.68×10^{-4}	59 524	N/A
Hand harvest	1500		5.04×10^{-4}	19 841	N/A
Thin	3000		1.01×10^{-3}	9921	N/A
Aspen and poplar (0.77 kg a.i./ha)					
Hand prune, scout, pinch, tie, train	500	0.2631	3.76×10^{-3}	2661	N/A
Hand-line irrigate	1100		8.27×10^{-3}	1209	N/A
Roses and ornamental plants outdoor (0.525 kg a.i./ha)					
All activities (excludes cut flowers)	400	0.0042	4.78×10^{-35}	209 287	N/A
Cut roses	7000		8.36×10^{-4}	11 959	N/A

Activity	Transfer Coefficient (cm^2/h)[a]	15% of the DFR/TTR Value at the Proposed REI[b]	Absorbed Daily Dermal Dose[c] (mg/kg/day)	Short/Intermediate-Term MOE[d] (target = 1000)	Long-Term MOE[d] (target = 1000)
Greenhouse potted ornamentals (0.595 kg a.i./ha) DFR based on highest reported value from cut flower study (0.35 µg/cm^2) corrected for rate					
All activities (excludes cut flowers)	400	0.35	4.00×10^{-3}	N/A	2250
Hand harvest, hand prune, pinch, thin	7000	0.35	7.00×10^{-2}	N/A	129
Turf					
Scout, irrigate, aerate (17.5 kg a.i./ha)	500	0.0641	9.16×10^{-4}	10 918	N/A
Mowing (17.5 kg a.i./ha)	6800		1.25×10^{-2}	803	N/A
Scout, irrigate, aerate (3 kg a.i./ha)	500	0.0041	5.84×10^{-5}	171 191	N/A
Mowing (3 kg a.i./ha)	6800		7.94×10^{-4}	12 588	N/A

a Transfer coefficients (TCs) are from the Science Advisory Council for Exposure Agricultural Transfer Coefficient document (revised, 7 August 2000) and any amendments thereof.

b The proposed REI in order reach a target MOE of 1000 for short-/intermediate-term postapplication exposure scenarios. except for greenhouse ornamentals, which is based on highest reported carbendazim values in a greenhouse study (USEPA 2001).

c Dermal exposure at proposed REI or when SRL reached = DFR × TC × 8 h × DAF (25%) / 70 kg.

d Safety factor of 1000 for intermediate-term based on the intermediate-term dermal NOAEL of 8 g/kg/day and dermal absorption factor of 25%.

e TC of 400 cm^2/h has not been finalized and is subject to change once a full review of the ARTF data has been completed.

Shaded cells have values lower than the target MOE.

Appendix Vc Occupational Postapplication Cancer Risk Estimates for Thiophanate-Methyl and Carbendazim

Activity	Transfer Coefficient (cm^2/h)	Exposure Frequency[a] (days/year)	DFR/TTR[b] (average residues for TPM)	Thiophanate-Methyl			Carbendazim		
				Absorbed Daily Dermal Dose (mg/kg/day)	LADD[c] (mg/kg/day)	Cancer Risk[d]	Absorbed Daily Dermal Dose[e] (mg/kg/day)	LADD[c] (mg/kg/day)	Cancer Risk[f]
Lowbush blueberries (0.77 kg a.i./ha)									
Irrigate, scout, thin, prune	400	180	0.0718	0.0008	2.02×10^{-4}	2.67×10^{-6}	1.23×10^{-4}	3.04×10^{-5}	4.86×10^{-7}
Hand harvest, prune	1500	180		0.0031	7.59×10^{-34}	1.00×10^{-5}	4.62×10^{-4}	1.14×10^{-4}	1.82×10^{-6}
Raspberries (0.77 kg a.i./ha)									
Weed, irrigate, scout	500	180	0.3965	0.0057	1.40×10^{-3}	1.84×10^{-5}	8.50×10^{-34}	2.10×10^{-4}	3.35×10^{-6}
Hand harvest, prune, thin, train, tie	1500	180		0.017	4.19×10^{-23}	5.53×10^{-5}	2.55×10^{-3}	6.29×10^{-4}	1.01×10^{-5}
Strawberries (0.77 kg a.i./ha)									
Irrigate, mulch, weed, scout, thin	400	180	0.3965	0.0045	1.12×10^{-3}	1.47×10^{-5}	6.80×10^{-4}	1.68×10^{-4}	2.68×10^{-6}
Hand harvest, pinch, prune, train	1500	180		0.017	4.19×10^{-3}	5.53×10^{-5}	2.55×10^{-3}	6.29×10^{-4}	1.00×10^{-5}
White beans (1.59 kg a.i./ha)									
Weed	500	45	0.2559	0.0037	2.25×10^{-4}	2.97×10^{-6}	5.48×10^{-4}	3.38×10^{-5}	5.41×10^{-7}
Irrigate, scout	1500	45		0.011	6.76×10^{-4}	8.92×10^{-6}	1.64×10^{-3}	1.01×10^{-4}	1.62×10^{-6}
Hand harvest	2500	45		0.0183	1.13×10^{-3}	1.49×10^{-5}	2.74×10^{-3}	1.69×10^{-4}	2.70×10^{-6}
Sugar beets (0.39 kg a.i./ha)									
Thin, weed	100	30	0.37	0.0011	4.34×10^{-5}	5.73×10^{-7}	1.58×10^{-4}	6.51×10^{-6}	1.04×10^{-7}
Irrigate, scout	1500	30		0.0158	6.51×10^{-4}	8.59×10^{-6}	2.37×10^{-3}	9.76×10^{-5}	1.56×10^{-6}

Activity	Transfer Coefficient (cm^2/h)	Exposure Frequency[a] (days/year)	DFR/TTR[b] (average residues for TPM)	Thiophanate-Methyl			Carbendazim		
				Absorbed Daily Dermal Dose (mg/kg/day)	LADD[c] (mg/kg/day)	Cancer Risk[d]	Absorbed Daily Dermal Dose[e] (mg/kg/day)	LADD[c] (mg/kg/day)	Cancer Risk[f]
Apples and pears (1.58 kg a.i./ha)—Western (based on NY Data)									
Weed, prop	100	60	0.8432	0.0024	1.98×10^{-4}	2.61×10^{-6}	3.61×10^{-4}	2.97×10^{-5}	4.75×10^{-7}
Prune, scout, pinch, tie, train	500	60		0.012	9.90×10^{-4}	1.31×10^{-6}	1.81×10^{-3}	1.49×10^{-4}	2.38×10^{-6}
Hand harvest	1500	60		0.0361	2.97×10^{-3}	3.92×10^{-6}	5.42×10^{-3}	4.46×10^{-4}	7.13×10^{-6}
Thin	3000	60		0.0723	5.94×10^{-3}	7.84×10^{-6}	1.08×10^{-2}	8.91×10^{-4}	1.00×10^{-5}
Thin (WA data)	3000	60		0.2009	1.65×10^{-2}	2.18×10^{-4}	3.01×10^{-2}	2.48×10^{-3}	3.96×10^{-5}
Peaches, nectarines, plums, prunes and cherries (1.23 kg a.i./ha) (based on New York data)									
Weed, prop	100	45	0.6564	0.0019	1.16×10^{-4}	1.53×10^{-6}	2.81×10^{-4}	1.73×10^{-5}	2.77×10^{-7}
Prune, scout, pinch, tie, train	500	45		0.0094	5.78×10^{-4}	7.63×10^{-6}	1.41×10^{-3}	8.67×10^{-5}	1.39×10^{-6}
Hand harvest	1500	45		0.0281	1.73×10^{-3}	2.29×10^{-5}	4.22×10^{-3}	2.60×10^{-4}	4.16×10^{-6}
Thin	3000	45		0.0563	3.47×10^{-3}	4.58×10^{-5}	8.44×10^{-3}	5.20×10^{-4}	8.32×10^{-6}
Thin (WA data)	3000	45		0.1563	9.64×10^{-3}	1.27×10^{-4}	2.35×10^{-2}	1.45×10^{-3}	2.31×10^{-5}
Aspen and poplar (0.77 kg a.i./ha) (based on New York data)									
Hand prune, scout, pinch, tie, train	500	30	0.7026	0.01	4.12×10^{-4}	5.44×10^{-6}	1.51×10^{-3}	6.19×10^{-5}	9.90×10^{-7}
Hand-line irrigate	1100	30	0.7026	0.0221	9.07×10^{-4}	1.20×10^{-5}	3.31×10^{-3}	1.36×10^{-4}	2.18×10^{-6}
Hand-line irrigate (WA data)	1100	30	0.7026	0.0383	1.58×10^{-3}	1.10×10^{-3}	5.75×10^{-3}	2.36×10^{-4}	3.78×10^{-6}
Roses and ornamental plants—Outdoor (0.525 kg a.i./ha)									
All activities (potted ornamen-tals)	400[g]	90	0.169	0.0019	7.96×10^{-5}	1.05×10^{-6}	2.91×10^{-4}	3.58×10^{-5}	5.73×10^{-7}
All activities (cut flowers)	7000	90		0.0339	1.39×10^{-3}	1.84×10^{-5}	5.08×10^{-3}	6.27×10^{-4}	1.00×10^{-5}

Activity	Transfer Coefficient (cm^2/h)	Exposure Frequency[a] (days/year)	DFR/TTR[b] (average residues for TPM)	Thiophanate-Methyl			Carbendazim		
				Absorbed Daily Dermal Dose (mg/kg/day)	LADD[c] (mg/kg/day)	Cancer Risk[d]	Absorbed Daily Dermal Dose[e] (mg/kg/day)	LADD[c] (mg/kg/day)	Cancer Risk[f]
Greenhouse potted ornamentals (0.595 kg a.i./ha)									
All activities (cut flowers)	7000	90	1.347	0.0154	1.90×10^{-3}	2.51×10^{-5}	2.31×10^{-3}	2.85×10^{-4}	4.56×10^{-6}
All activities (potted ornamen-tals)	400[g]	90		0.2695	3.32×10^{-2}	4.39×10^{-4}	4.04×10^{-2}	4.98×10^{-3}	8.00×10^{-5}
Turf (3 kg a.i./ha) (based on California residue study)									
Scout, irrigate, aerate	500	90	0.0619	0.0009	1.09×10^{-4}	1.44×10^{-6}	1.33×10^{-4}	1.64×10^{-5}	2.62×10^{-7}
Mowing	6800	90		0.012	1.48×10^{-3}	1.96×10^{-5}	1.80×10^{-3}	2.22×10^{-4}	3.56e-06
Turf (17 kg a.i./ha) (based on California residue study)									
Scout, irrigate, aerate	500	90	0.3611	0.0052	6.36×10^{-4}	8.40×10^{-6}	7.74×10^{-4}	9.54×10^{-5}	1.53×10^{-6}
Mowing	6800	90		0.0702	8.65×10^{-3}	1.14×10^{-4}	1.05×10^{-2}	1.30×10^{-3}	2.08×10^{-5}

a Based on information from the USEPA RED for thiophanate-methyl (USEPA 2004).

b Based on the average DFR/TTR data for 14 days (or until residue were less than the LOQ) starting on the proposed day of re-entry; for crops where proposed REI is not considered feasible, agronomically feasible REIs were used as the proposed REI.

c Lifetime average daily dose, amortizing 35 years of occupational exposure over a 70-year lifetime for workers.

d Cancer risk = LADD (mg/kg/day) × Q_1^* (0.0132)

e Based on 15% of the average estimated residues of thiophanate-methyl includes incorporating a dermal absorption factor of 25%.

g Cancer risk = LADD (mg/kg/day) × Q_1^* (0.016)

g Transfer coefficients of 400 m^2/h have not been finalized and are subject to change once a full review of ARTF data has been completed.

Shaded cells are unacceptable values.

Appendix Vd Residential Exposure Risk Estimates

Table 1 Residential M/L/A Exposure Risk Estimates

Equipment Type	Application Rate (a.i./ha)	Short-Term MOE (target MOE = 300)			Intermediate-Term MOE (target MOE = 1000)			LADD	Cancer Risk[f]
		Dermal[a]	Inhalation[b]	Combined[c]	Dermal[d]	Inhalation[e]	Combined		
Shaker can / squeeze container	1 kg	10 972	143449	10192	3511	114 759	3407	2.25×10^{-5}	4.95×10^{-7}

a Dermal MOE = NOAEL (100 mg/kg/day) / daily dermal dose (mg/kg/day). Dermal NOAEL from a dermal study; therefore, no adjustment for dermal absorption.

b Inhalation MOE = NOAEL (10 mg/kg/day) / daily inhalation dose (mg/kg/day).

c Combined MOE = 1/(1/MOE dermal + 1/MOE inhalation.

d A dermal absorption factor of 25% was used for intermediate-term based on available data for dermal exposure estimates and a NOAEL of 8 mg/kg/day was used.

e Inhalation MOE = NOAEL (8 mg/kg/day) / daily inhalation dose (mg/kg/day).

f Cancer risk = LADD (mg/kg/day) × Q_1^* (0.0132).

Table 2 Residential Postapplication Exposure Risk Estimate of Thiophanate-Methyl (TPM)

Scenario	Transfer Coefficient (cm^2/h)	Duration (h)	DFR/TTR[a] (day 0)	DFR / TTR (day 0–7 average)[b]	Dermal Exposure (µg/kg bw/day)	Dermal MOE[c] (day 0)	LADD (mg/kg/day)	Cancer Risk[d] (TPM)
Gardeners (1.0 kg a.i./ha) (target = 300)								
Youth (39 kg)	4821	0.67	3.97	0.947	328.8	304	1.38×10^{-5}	1.82×10^{-7}
Adult (70 kg)	7000				265.99	376	9.31×10^{-5}	1.23×10^{-6}
Golfers (3.0 kg a.i./ha)								
Youths (39 kg)	344	4	0.764	0.119	26.96	3709	1.23×10^{-6}	1.63×10^{-8}
Adult (70 kg)	500				21.83	4581	8.32×10^{-6}	1.10×10^{-7}
Golfers (17.5 kg a.i./ha)								
Youths (39 kg)	344	4	4.458	0.697	157.29	636	7.22×10^{-6}	9.53×10^{-8}
Adult (70 kg)	500				127.37	785	4.87×10^{-5}	6.43×10^{-7}

a DFR value is based on predicted day 0 value from a strawberry DFR study (North Carolina site). TTR value based on highest reported TTR day 0 value (Philadelphia study site day 0.5 value).

b DFR value is based on the average predicted (day 0–7) value from strawberry DFR study (North Carolina site). TTR value is based on the average predicted TTR (day 0.5– 7) value from the Georgia study site.

c Dermal MOE = NOAEL (100 mg/kg bw/day) / daily dermal dose (mg/kg/day); target = 300.

d Cancer risk = LADD (mg/kg/day) × Q_1^* (0.0132); based on 50 years of exposure over a 70-year lifetime; exposure frequency of 3 days per year for gardeners and 5 days per year for golfers.

Table 3 Residential Postapplication Exposure Risk Estimates of Carbendazim

Activity	Transfer Coefficient (cm^2/h)	15% of DFR/TTR Values of TPM at Day 0[a] (μg/cm^2)	15% of Average Day 0–7 DFR/TTR of TPM (μg/cm^2)	Absorbed Daily Dermal Dose[b] (mg/kg/day)	Short-/ Intermediate-Term MOE[c]	Exposure Frequency (days/year)	LADD[d] (mg/kg/day)	Cancer Risk[e]
Turf (target = 1000)								
Golfing—youth 3 kg a.i./ha	344	0.1146	0.0179	1.57×10^{-34}	9890	5	1.85×10^{-7}	2.69×10^{-9}
Golfing—adult 3 kg a.i./ha	500			8.19×10^{-4}	12213	5	1.25×10^{-6}	2.00×10^{-8}
Golfing—youth 17.5 kg a.i./ha	344	0.6687	0.1046	8.57×10^{-3}	1695	5	1.08×10^{-6}	1.73×10^{-8}
Golfing—adult 17.5 kg a.i./ha	500			4.78×10^{-3}	2094	5	7.31×10^{-6}	1.17×10^{-7}
Roses, Flowers and Evergreens Residential (5 kg a.i./ha)								
Gardening activities—Youth	4821	0.5955	0.1421	1.23×10^{-2}	810	3	2.07×10^{-6}	3.32×10^{-8}
Gardening activities—Adult	7000			9.97×10^{-3}	1002	3	1.40×10^{-5}	2.24×10^{-7}

[a] The highest percentage of thiophanate-methyl residues that degraded to carbendazim is 15%. For this reason, 15% of the DFR/TTR value of thiophanate-methyl at day 0 was applied to obtain the carbendazim DFRs/TTRs values.

[b] Non-cancer dermal exposure = DFR/TTR × TC × 4 h (golfing) or 0.67 h (gardening) × dermal absorption factor of 25% / 70 kg for adults or 39 kg for youths.

[c] Safety factor of 1000 for short- and intermediate-term based on the short/intermediate-term dermal NOAEL of 10 mg/kg/day.

[d] LADD, amortizing 50 years of non-occupational exposure over a 70-year lifetime for adults and 6 years over a 70-year lifetime for youth.

[e] Cancer risk = LADD (mg/kg/day) × Q_1^*(0.016).

Shaded cells have values lower than the target MOE.

Appendix VI Dietary and Drinking Water Exposure Estimates

Table 1 Dietary Exposure and Risk Estimates of Thiophanate-Methyl

Population	Thiophanate-Methyl Exposure (mg/kg bw/day)		Risk Estimates		
	Acute	Chronic	% ARfD	% ADI	Cancer
Total population	0.00063	0.000020	0.48%	0.2%	2.64×10^{-7}
All infants (< 1 year)	0.00399	0.000047	3.07%	0.5%	
Children 1–2 years	0.00207	0.000072	1.60%	0.8%	
Children 3–5 years	0.00116	0.000051	0.89%	0.6%	
Children 6–12 years	0.00066	0.000026	0.51%	0.3%	
Youth 13–19 years	0.00041	0.000012	0.32%	0.1%	
Adults 20–49 years	0.00029	0.000012	0.22%	0.1%	
Adults 50+ years	0.00041	0.00002	0.32%	0.2%	
Females 13–49 years	0.00034	0.00001	0.50%	0.1%	
Reference doses	ARfD	0.13	(mg/kg bw)		
	ARfD ♀13–50	0.067			
	ADI	0.009			
	Q_1*	0.0132	$(mg/kg\ bw)^{-1}$		

Table 2 Dietary Exposure and Risk Estimates of Carbendazim

Population	Carbendazim Exposure (mg/kg bw/day)		Risk Estimates		
	Acute	Chronic	% ARfD	% ADI	Cancer
Total population	0.00066	0.000018	1.32%	0.2%	2.88×10^{-7}
All infants (< 1 year)	0.00316	0.000039	6.33%	0.4%	
Children 1–2 years	0.00163	0.000064	3.27%	0.7%	
Children 3–5 years	0.00120	0.000048	2.39%	0.5%	
Children 6–12 years	0.00064	0.000026	1.28%	0.3%	
Youth 13–19 years	0.00049	0.000013	0.98%	0.1%	
Adults 20–49 years	0.00034	0.000013	0.69%	0.1%	
Adults 50+ years	0.00034	0.000015	0.68%	0.2%	
Females 13–49 years	0.00036	0.000013	3.57%	0.1%	
Reference doses	ARfD	0.05	(mg/kg bw)		
	ARfD ♀13–50	0.01			
	ADI	0.009			
	Q_1*	0.016	$(mg/kg\ bw)^{-1}$		

Table 3 Acute and Chronic Dietary Drinking Water Levels of Comparison for Thiophanate-Methyl and Carbendazim

Population	Thiophanate-Methyl			Carbendazim		
	DWLOC[a] (µg/L)					
	Acute	Chronic	Cancer	Acute	Chronic	Cancer
DWEC[b], based on highest model EEC[c]	*56*	*3.4*	*3.4*	*181*	*162*	*162*
Total population	4528	279	1.99	1727	314	1.56
Northeast region	4527	279		1727	314	
Midwest region	4527	279		1727	314	
Western region	4528	279		1727	314	
All infants (< 1 year)	1260	80		468	90	
Nursing infants	1275	80		480	90	
Non-nursing infants	1256	79		465	90	
Children 1–2 years	1919	119		725	134	
Children 3–5 years	1933	119		732	134	
Children 6–12 years	2522	155		962	175	
Youth 13–19 years	4536	280		1733	315	
Adults 20–49 years	4540	280		1738	315	
Adults 50+ years	4536	279		1738	314	
Females 13–49 years	2067	248		299	279	

[a] DWLOC = (ARfD − dietary exposure mg/kg) × 1000 µg/mg × bw kg/water consumption L
Body weight =70, 62, 39, 15, 10 kg for adults, females, youth 6–13 years, children 1–6 years and infants, respectively.
Water consumption = 1 L/day for infants and children, 2 L/day all other populations.
[b] DWEC = Drinking water estimated concentration.
[c] EEC = estimated environmental concentarion. DWLOC values larger than the corresponding EEC indicate acceptable exposure.

The combined DWEC used for the cancer assessment converted thiophanate-methyl residues to carbendazim equivalents based on the ratio of molecular weights:

[3.4 µg thiophanate-methyl/L] × [191.2 g/mol carbendazim] / [342.4 g/mol thiophanate-methyl] + [162 µg/L carbendazim] = 163.9 µg/L

Shaded cells indicate values lower than the acceptable values.

Appendix VII Use Scenarios for Exposure Assessment of Thiophanate-Methyl on Mushrooms[a]

Thiophanate-methyl (Senator 70WP) is registered as an emergency use on mushrooms for the control of Trichoderma green mould. Senator 70WP is formulated as a wettable powder with an active ingredient guarantee of 70% thiophanate-methyl. It is applied at spawning at an application rate of 1.25 g of the product with 50–62 g of gypsum, limestone or chalk per 1 kg of spawn. The label specifies that 100 kg of spawn is to be applied to 100 m^2 of bed surface. This is equivalent to 87.5 g of active ingredient per 100 kg of spawn or 87.5 g of thiophanate-methyl per 100 m^2 of bed surface. Only one application of Senator 70WP is made to each crop of mushrooms.

The following information was provided by Engage Agro with S2004-1633, in the document *Use Description and Scenario* (Application and Postapplication) for Senator 70WP Fungicide (Thiophanate-Methyl) when used as a Spawn Treatment for Mushroom Production. Nailor et al., 14 July 2004. A video of mushroom operations in Ontario (specifically how Senator is applied to mushroom spawn and ‘mechanically’ applied to compost) was also submitted. Additional use information was provided by the British Columbia Ministry of Agriculture, Food and Fisheries (B.C. MAFF 2004) and through communication with British Columbia growers during a British Columbia Mushroom Farm tour in November 2005.

1.0 Use Scenario

The size of the mushroom crop in Canada is approximately 190 million pounds per year. Production is concentrated in Ontario and British Columbia. Ontario is the largest producer, accounting for almost 50% of the national total. British Columbia produces 32% of Canadian mushrooms. Approximately 703 000 m^2 of mushroom beds are available per cycle for mushroom cultivation in Canada. Up to 12 production cycles per year are possible, depending on the technology and economics of production. However, the national average for cycles per year was 5.76 in 2001 with approximately 4 million m^2 of production surface harvested.

Less than 10% of the production surface area in Ontario was being treated and usage estimates in British Columbia and Alberta range between 30 to 75%. It is expected that British Columbia will have higher use because of technology differences (many single zone facilities). Rigorous sanitation and hygiene coupled with fly control will lower the usage in all mushroom growing regions. Product use could also change with disease severity.

[a] These use scenarios obtained from the registrant, as well as other sources of information (e.g. Statistics Canada), were considered in this preliminary risk assessment.

2.0 Maximum Number of Applications and Timing

The maximum number of applications per crop is one, at spawning. Therefore, the maximum number of applications would be dependent on the number of crop cycles on a farm and the number of rooms per farm. Mushroom growers may produce up to 12 crops per year; however, in British Columbia, there are about five production cycles per year. Based on correspondence with British Columbia growers (in November 2005), thiophanate-methyl is used weekly and year-round because growing cycles (for each room) are staggered for continuous production. Mushroom farms can have anywhere from 16 to 32 rooms per farm.

Generally, on mushrooms farms where there are six or more crops per year (multi-zone systems), the sanitation and hygiene practices are very high and the occurrence of green mould is rare; thus, Senator is rarely used to coat the spawn grains on these farms. However, on farms with low technology (fewer production cycles - single zone systems) the need for Senator is higher because the risk of disease outbreak is greater.

3.0 Exposure Duration

Mushroom farms have continuous production; therefore, they are setting up one to three new crops per week. A team of two to three workers is required to apply spawn 1–3 times per week, depending on farm size. The spawning operation takes the majority of the day; therefore, one individual is spending 1–3 days per week (or 50–150 days per year) inoculating compost with spawn. Therefore, the duration of exposure is considered to be intermittent chronic in nature.

Worker exposure principally is restricted to weighing and premixing chemicals, coating of the spawn grains and application of treated spawn to the mushroom substrate. There may be one to three days of spawning per week. Therefore, a single individual if involved in weighing, mixing and transfering would be exposed to a maximum of 2 hours per day (up to 1600 m^2 of compost), up to 3 days per week. It is estimated (based on input from British Columbia growers) that hand spreading of treated spawn may take 2–3 hours per room, depending on room size (growing surface area ranges from 250 m^2 to 900 m^2 per room and broadcasting requires about 20 minutes for each 100 m^2).

4.0 Coating the Spawn Grains

Spawning is the process of seeding the compost (in mushrooms, the seed is referred to as the spawn). Spawn is prepared by special laboratories under sterile conditions. Mycelia (vegetative growth) are produced from a piece of mushroom tissue, and the mycelia are transferred to grain kernels. When the kernels are completely covered with mycelia, the spawn is considered to be ready for use as seed.

The coating of the spawn grains with Senator is performed mechanically, typically in a cement mixer. Thiophanate-methyl (wettable powder) and the lime, gypsum or chalk are mixed prior to the spawn being added. This premixing without the spawn is to assure a uniform mix for coverage of the fungicide on the spawn grains. In some cases, a bag is placed over the opening of the cement mixer and held in place by a rope or cord to minimize dust. However, the current label does not include directions or specify to cover the cement mixer to prevent exposure when mixing Senator with gypsum, lime or chalk.

Next, spawn is emptied from a polyethylene production bag into the mixer and the machine is rotated for less than a minute, which is just enough time to get adequate coverage, without damaging the spawn. Spawn is carefully handled throughout this process. Overmixing of the spawn in the mixer rubs the mycelia off of the surface of the grain. Again, in some cases, a bag is placed over the opening of the cement mixer during the coating of the spawn.

5.0 Application to the Substrate

After coating the spawn grains, they are empted into a tote, pail or garbage can for transfer. The treated spawn is then transferred again onto the compost medium in one of several methods, depending on the farm’s technology (single-zone or multizone):

Single-Zone System

A single-zone system occurs where the substrate is spawned in the same room as where the compost (growing medium) was pasteurized (completed on growing shelves). On farms where the pasteurization of the substrate takes place in the same room as the production room (single-zone system) the treated spawn is carefully spread by hand. Spawn is applied by hand (using a scoop) at most (95%) operations in British Columbia.

Following the application of the treated-spawn, the spawn is mixed into the compost mechanically by a machine the width of the shelf. This mixer machine automatically moves along the shelf, through the substrate, incoporating the treated spawn. A worker is required to monitor the mixing machine and in some cases adjust the placement over the bed. After mixing, it is pressed mechanically and/or with a hand-held float. In a single-zone system, plastic is often placed on top of the spawned and pressed compost.

Multizone System

In a multizone system, the substrate is spawned in a room separate from where the compost was pasteurized (i.e. trays or bulk tunnel) and transferred either to a bulk tunnel, trays or shelves for the spawn run. Spawn is “mechanically” applied to the compost in the majority of mushroom operations in Quebec, Ontario, Manitoba and Alberta (Engage Agro 2004).

Treated spawn is either poured directly on top of the bulk pile of compost or into a hopper where it is mechanically dispensed onto the mushroom substrate. However, the treated spawn must be transferred from the cement mixer into a container and again from the container into a distribution hopper or other type of distribution system.

Following the application of the treated-spawn, the spawn may be mixed into the compost mechanically by a machine. After mixing, it is pressed mechanically and/or with a hand-held float. If it is placed into shelves or trays, the substrate is often covered with plastic. If it is placed into a bulk-spawn run tunnel, a single worker manages the height and level of the spawned substrate inside the tunnel.

6.0 Clean-up Procedure

The cement mixer and totes to carry the treated spawn are dedicated solely for that purpose. Thus, after the mixer and totes are used, they need not be cleaned, only covered. Boxes and plastic are discarded. Any loose spawn grains on the floor of the mixing area are swept up. The floor is then washed. Two weeks after spawning, the plastic cover is removed from the trays or beds.

7.0 Postapplication Exposure

Approximately 12–16 days after spawning, a casing layer is added to the beds. The casing layer is a 3–5 cm layer of a suitable material on the surface of the spawning compost used to convert the mushroom mycelia from the vegetative phase to the reproductive phase. Mature mushrooms are ready for harvest approximately 15–18 days after the casing layer is applied. Mushrooms are typically hand harvested. There are at least 27 days between spawning and harvesting of mushrooms. Besides applying the casing layer and hand harvesting, re-entry activities with mushrooms are limited to checking the moisture content and temperature of the compost and casing layer.

No detectable residues were found for thiophanate-methyl or carbendazim (with an LOQ of 0.01 ppm), based on a GLP magnitude of residue study on agaricus mushrooms (Engage Agro 2004). Residues were measured at the time of harvest of the first flush of mushrooms; however, the rate applied in the study (7.84 kg a.i./ha) was lower than the currently registered rate (8.75 kg a.i./ha).

8.0 Exposure Data

There are no occupational exposure studies on file estimating potential exposure from application of a pesticide at mushroom spawning that can be used as a surrogate for the proposed use of Senator 70WP on mushrooms. Significant exposure is expected to occur from the mixing of Senator 70WP with the spawn, transfer of treated spawn from the cement mixer to containers (and distribution hopper) and from manual application to compost beds. The registrant submitted data which consisted of a use description and a 2002 USEPA exposure and risk assessment for this use. The rate in the United States was similar to the rate proposed in Canada.

The USEPA assessment for workers treating the spawn and spreading the compost containing treated spawn was based on the PHED data. Open M/L wettable powder data and hand distribution of treated granules were used to approximate the mushroom spawn treatment. The USEPA acknowledged that there was uncertainty in the use of this PHED data as it is not an exact match for this scenario, but it was believed that the exposure and risk estimates were sufficiently conservative to be protective.

The MOEs calculated by the USEPA ranged from 110–8200 based on a short- to intermediate-term NOAEL of 100 from a 21-day dermal study and a NOAEL of 10 for inhalation (target MOE of 100). The lifetime cancer risk calculated by the USEPA was 4.26×10^{-6}. The use of thiophanate-methyl on mushroom spawn was considered acceptable provided that mixer/loader/applicators wear coveralls over a long-sleeved shirt and long pants, shoes plus socks as well as chemical-resistant gloves. It is unclear from the review, if a respirator, was required.

It should be noted that the PHED M/L for a wettable powder formulation is based on mixing and loading into spray tank with water. These data are not considered representative of the current scenario (mixing and loading thiophanate-methyl into a cement mixer with gypsum (or chalk), followed by the coating of spawn and then transfer of the coated spawn into containers).

The PHED granular bait dispersed by hand surrogate study examined dermal and inhalation exposure to three commercial applicators during hand application of a granular bait insecticide around foundations, driveways and sidewalks. The insecticide used in the study was a ready-to-use product (mixing and loading not required) and was applied by scattering the product in a 2-foot wide band on the treated area. Sixteen replicates (16 residences) were monitored. Each applicator carried the insecticide in a 5-lb container in the left hand. While walking, the applicator periodically reached into the container with the right hand and scattered the product in a 2-foot wide band in the treatment area. The application rate ranged from 10 to 190 g a.i. for 32–97 m^2 of area treated (0.1–3.75 kg a.i./ha). An average of 3.6 g was handled per replicate (from 0.05–0.25 hours/replicate). The data were considered to be mostly C grade and occasionally A or E grade.

There is uncertainty as to whether exposure from adding thiophanate-methyl into a cement mixer, subsequent transfer from the cement mixer into containers or totes; application by hand (scoop) or transfer into a hopper; incorporation into compost (by machine); levelling; covering with plastic; and clean-up are captured with the PHED open M/L with wettable powder and granular bait dispersed by hand.

In the use description provided by the British Columbia Ministry of Agriculture, Food and Fisheries (B.C. MAFF 2004), thiophanate-methyl application to mushroom spawn is said to be equivalent to seed treatment in other horticultural crops (“...apply to spawn in the same fashion as a seed treatment...”).

The only surrogate seed treatment data comparable to wettable powder applied to spawn were:

a) Stevens and Davis (1981) (potato seed treatment with dust); and
b) Fenske et al. (1990) (wheat seed treatment with dust).

The Stevens and Davis (1981) study monitored exposure (using gauze pads) for the following three types of activities:

- cutting potatoes into pieces;
- filling the hopper of the seed dusting machine with product; and
- planting treated potato seed pieces.

The most comparable exposure scenario would be the filling of the hopper of the seed dusting machine. However, the study is considered limited study for a number of reasons such as follows:

- low number of replicates (3–18 for various job functions);
- exposure to head and legs were not considered;
- only summary data is presented;
- monitoring periods were short (maximum of 2 h);
- no QA/QC; and
- amount of product handled and PPE were not detailed.

The Fenske et al. (1990) wheat seed treatment study involved the addition of wheat seed to a 4-compartment, 12-bushel grain drill. The drill box is filled half full of seed and half of the formulation is then added. A plastic scoop was used to remove pesticide (dust formulation) from a bag and spread over the seed. The seed and formulation are mixed with a stick, and the rest of the grain is added and the procedure repeated. After thorough mixing, the seed was removed by a vacuum (workers were not monitored during the vacuuming procedure). Each replicate consisted of 5 mixings conducted by each of the 4 workers. Mixing times ranged from 19 to 33 minutes.

9.0 Risk Assessment

Table 1 and Table 2 of Appendix VII summarize exposure risk estimates based on the above information and all available surrogate exposure data (PHED; Stevens and Davis 1981; and Fenske et al. 1990).

Table 1 Summary of Non-Cancer Risk Estimates for Thiophanate-Methyl on Mushrooms With Maximum PPE[a]

Scenario	Unit Exposure (µg/kg a.i. handled)		Amount (a.i. handled/day)	MOE[b] (target = 1000)		
	Dermal	Inhalation (with respirator)		Dermal	Inhalation	Combined
PHED—Open M/L with wettable powder; granular bait dispersed by hand						
M/L	339.1	5.62	1.4 kg (1600 m^2)	4718	71 174	4425
A	34191.8	60.5	1.4 kg (1600 m^2)	47	6612	46
M/L/A	34530.9	66.12	1.4 kg (1600 m^2)	46	6050	46
			0.7 kg (800 m^2)	93	12 099	92
Stevens and Davis (1981)—Potato Seed Treatment						
M/L/A	2596	169	1.4 kg (1600 m^2)	616	2367	489
			0.7 kg (800 m^2)	1223	4734	978
Fenske et al. (1990)—Wheat Seed Treatment						
M/L/A	5541	0.34	1.4 kg (1600 m^2)	289	1176471	289
			0.7 kg (800 m^2)	578	2352941	578
			0.4 kg (460 m^2)	1011	4 117 647	1010

a Maximum PPE refers to chemical-resistant coveralls over a single layer of clothing, respirator and chemical-resistant gloves for PHED scenarios; for the Stevens and Davis study, the PPE was not specified; therefore, a 75% protection factor was used for coveralls over a single layer of clothing with a 50% protection factor for a respirator. For the Fenske study, a 75% protection factor was used for coveralls over a single layer of clothing with a 90% protection factor for a respirator.

b MOEs are based on the intermediate- and long-term dermal and inhalation NOAEL of 8 mg/kg bw/day and a dermal absorption factor of 25%.

Shaded cells have values lower than the target MOE.

Table 2 Summary of Cancer Risk Estimates for Thiophanate-Methyl on Mushrooms With Maximum PPE[a]

Scenario	Amount (a.i. handled/day)	Days of Exposure/Year	LADD[b] (mg/kg/day)	Cancer Risk[c]
PHED —Open M/L with wettable powder; granular bait dispersed by hand				
M/L/A	1.4 kg (1600 m^2)	90	2.14×10^{-2}	2.83×10^{-4}
	0.7 kg (800 m^2)	50	5.96×10^{-3}	7.86×10^{-5}
Stevens and Davis (1981)—Potato seed treatment				
M/L/A	1.4 kg (1600 m^2)	90	2.02×10^{-4}	2.66×10^{-5}
	0.7 kg (800 m^2)	50	5.60×10^{-4}	7.60×10^{-6}
Fenske et al. (1990)—Wheat seed treatment				
M/L/A	1.4 kg (1600 m^2)	90	3.42×10^{-3}	4.51×10^{-5}
	0.7 kg (800 m^2)	50	9.49×10^{-4}	1.25×10^{-5}

[a] Maximum PPE refers to chemical-resistant coveralls over a single layer of clothing, respirator and chemical-resistant gloves.

[b] LADD = dermal exposure × 25% dermal absorption factor × (days of exposure / 365 days) × 50 years of occupational exposure / 70-year lifetime.

[c] Cancer risk = LADD × Q_1* (0.0132 mg/kg bw/day).

Shaded cells have values lower than the target MOE.

In British Columbia, where spawn is mostly spread by hand, the use of thiophanate-methyl is reported to be the highest (Engage Agro 2004). In some cases, British Columbia farmers have reported that 100% of crops were being treated (once/week, year-round) with thiophanate-methyl. Using a thorough sanitation and hygiene program coupled with integrated pest management practices are critical for green mould management. In an effort to mitigate and reduce the potential for resistance to thiophanate-methyl, extension specialists have recommended that not all crops should be treated (limiting to ~30% of crops) with thiophanate-methyl. This would also reduce the exposure duration to “short-term” as opposed to year-round (chronic) use. A short-term exposure duration would be defined as 1–30 days.

Table 3 summarizes non-cancer risk estimates for operations using hand spreading of spawn, based on a short-term exposure duration.

Table 3 Summary of Short-Term Non-Cancer Risk Estimates With Maximum PPE[a]

Scenario	Unit Exposure (μg/kg a.i. handled)		Amount a.i. handled/day	MOE [b] (target = 300)		
	Dermal	Inhalation (with respirator)		Dermal	Inhalation	Combined
PHED—Open M/L with wettable powder; granular bait dispersed by hand						
M/L	339.1	5.62	1.4 kg (1600 m^2)	14745	88 968	12 649
A	34 191.8	60.5	1.4 kg (1600 m^2)	146	8264	144
M/L/A	34 530.9	66.12	1.4 kg (1600 m^2)	145	7562	142
			0.7 kg (800 m^2)	290	15 124	284

[a] Maximum PPE refers to chemical-resistant coveralls over a single layer of clothing, respirator and chemical-resistant gloves.

[b] MOEs are based on the short-term dermal NOAEL of 100 mg/kg bw day and inhalation NOAEL of 10 mg/kg bw/day.

The assumptions for this risk assessment include the following:

1. The assessment is based on the same person doing the mixing/loading and application. This is based on the use pattern information provided by Engage Agro.

2. The area treated per day value of 1600 m^2 was provided by the registrant, Engage Agro. This is equivalent to 2 kg of Senator (product), 100 kg of gypsum, limestone or chalk and 1600 kg of spawn handled per day.

3. The duration of exposure is considered to be intermittent chronic in nature. The exposure pattern was provided by Engage Agro. Mushroom farms have continuous production; therefore, they are setting up 1–3 new crops per week. A team of 2–3 workers is required to apply spawn 1–3 times per week, depending on farm size. The spawning operation takes the majority of the day; therefore, one individual is spending 1–3 days per week (or 50–150 days per year) inoculating compost with spawn. The cancer assessment included 90 days of exposure per year. However, this was also refined (to 50 days/year) for those operations that only treat once per week, year-round.

4. The rate is based on the label rate of 1.25 g of Senator 70WP Fungicide with 50–62 g of gypsum, limestone or chalk per 1 kg of spawn. The label specifies that 100 kg of spawn is to be applied to 100 m^2 of bed surface. This is equivalent to 8.75 kg of thiophanate-methyl per hectare of bed surface.

5. The PHED data may not be representative of the scenario as the M/L data is based on mixing and loading into a spray tank where water is added. The scenario being assessed may be more similar to on-farm seed treatment. The PHED granular bait dispersed by hand data was used to estimate exposure. Again, this data may not be representative of the proposed use.

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