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Re-evaluation Note REV2007-13

Preliminary Risk and Value Assessments of Endosulfan

(publié aussi en français)

16 October 2007

This document is published by the Health Canada Pest Management Regulatory Agency. For further information, please contact:

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ISBN: 978-0-662-47017-5 (978-0-662-47018-2)
Catalogue number: H113-5/2007-13E (H113-5/2007-13E-PDF)

Foreword

The purpose of this document is to inform registrants, pesticide regulatory officials and the Canadian public that Health Canada's Pest Management Regulatory Agency (PMRA) has completed a preliminary risk assessment of endosulfan. This Re-evaluation Note provides a summary of this preliminary assessment based on data and information reviewed.

The PMRA has previously proposed certain mitigation measures as outlined in a Proposed Acceptability for Continued Registration (PACR)document PACR2004-21, *Re-evaluation of Endosulfan – Interim Mitigation Measures*, including reduction of the registered use pattern for endosulfan. The remaining use pattern serves as the basis for this preliminary risk assessment.

The preliminary risk assessment indicates a level of concern for workers and the environment, and proposes endosulfan as a Track 1 substance under the federal government's Toxic Substances Management Policy (TSMP). The TSMP calls for the virtual elimination of Track 1 substances. The PMRA is requesting further data/information to refine the risk assessment prior to proposing regulatory action. Should endosulfan be confirmed as a Track 1 substance after consultation with stakeholders and finalization of the risk assessment additional consultation with stakeholders will take place to develop an appropriate management strategy in accordance with the long-term goal of virtual elimination.

The PMRA is soliciting information that may be used to refine this preliminary assessment and/or mitigate risks. The PMRA will accept information up to 60 days from the date of publication of this document. All comments should be forwarded to Publications at the address 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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1.0 Purpose

This document describes the PMRA's preliminary risk assessment of the insecticide endosulfan and its end-use products. It includes a human health assessment, an environmental assessment and information on the value of endosulfan to pest management in Canada. By way of this document, the PMRA is soliciting comments and input to the risk and value assessment of endosulfan from interested parties. Such comments and input could include, for example, additional data or information to further refine the risk assessment, such as typical use pattern information, percent crop treated, areas treated per day, number of applications, rates, etc., or could address the PMRA's risk assessment approaches and assumptions as applied to endosulfan. Further information on alternatives could refine the value assessment.

2.0 Re-evaluation of Endosulfan

Endosulfan is a cyclodiene organochlorine insecticide. Its mode of action involves antagonism of the γ-amino butyric acid (GABA) neurotransmitter receptor in the central nervous system, via contact or stomach action.

Upon commencement of the re-evaluation of endosulfan, Bayer Cropscience Inc. and Makhteshim Agan of North America Inc., registrants of endosulfan technical in Canada and primary data providers, indicated that they would phase out certain uses of endosulfan. The uses not supported by the registrant are as follows:

- alfalfa;
- clover;
- field corn;
- sunflower;
- spinach;
- greenhouse ornamentals;
- residential uses;
- succulent beans;
- succulent peas; and
- wettable powder uses on field tomatoes, sweet corn, dry beans and dry peas.

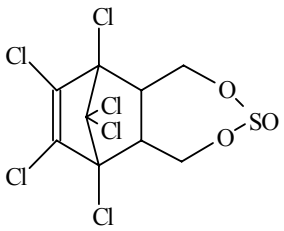
2.1 Chemical Identification

Chemical names:	Endosulfan exists in two stereoisomeric forms, as α and β endosulfan. The active ingredient has a ratio of 2:1 (α:β)
IUPAC:	(1,4,5,6,7,7-hexachloro-8,9,10-trinorborn-5-en-2,3-ylenebismethylene) sulfite
CAS:	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepine 3-oxide

CAS number: 115-29-7 for endosulfan
959-98-8 for alpha-endosulfan
33213-65-9 for beta-endosulfan

Molecular formula: $C_9H_6Cl_6O_3S$

Structural formula:



2.2 Description of Registered Endosulfan Uses

Type of Pesticide

Endosulfan is a organochlorine insecticide.

2.2.1 Description of Uses Considered in the Risk Assessment

Appendix IV lists all endosulfan products registered in Canada. Appendix V lists all the Commercial Class product uses for which endosulfan is presently registered. Appendix V shows which uses the registrant will continue to support, will no longer support or will partially support. Also presented is whether the use was added through the PMRA Minor Use Program. While currently supported by the registrant, the data supporting the minor uses were originally generated by a user group.

Uses of endosulfan belong to the following use-site categories: greenhouse non-food crops, greenhouse food crops, terrestrial feed crops, terrestrial food crops, outdoor ornamentals, outdoor structural industrial sites (food processing plants).

3.0 Effects Having Relevance to Human Health

3.1 Toxicology Summary

The toxicology database for endosulfan comprises studies provided by the registrant as well as published studies. Endosulfan is highly acutely toxic via the oral and inhalation routes in rats. It was also highly toxic via the dermal route in rabbits. Endosulfan was moderately irritating to the eyes but was not a dermal irritant in rabbits, nor was it a skin sensitizer in Guinea pigs. Female rats were much more sensitive to the acute oral and dermal effects of endosulfan than males. This increased sensitivity to females was also noted in studies of longer duration. Technical endosulfan was incompletely absorbed following oral administration in the rat. Metabolism followed one of two pathways to form either sulfur conjugates or sulfur-free and polar

conjugates, which were excreted primarily in the feces and to a lesser extent in the urine. The primary effect of endosulfan, via oral and dermal routes, is on the central nervous system (CNS). Effects in laboratory animals as a result of acute, subchronic, developmental toxicity and chronic toxicity studies indicate that endosulfan causes neurotoxic effects, particularly convulsions, which may result from overstimulation of the CNS. Additional effects were noted in the liver, kidney, blood vessels and hematological parameters following repeated exposure to endosulfan. Endosulfan was not carcinogenic in mice or rats and was not genotoxic. It was negative for birth defects in rats and rabbits, and there were no effects on reproductive performance in the rat. However, published reports did provide some indication of diminished sperm production in young rats that had been treated during development (Sinha et al.1995, Dalsenter et al. 1999).

Guideline studies showed no evidence of increased susceptibility in rat and rabbit fetuses following exposure to endosulfan during pregnancy, or following prenatal/post natal exposure in the two-generation reproduction study in rats. In the rat teratology study, fetal toxicity, which included a slight decrease in pup body weights and an increased incidence of fragmented thoracic vertebral centra, occurred at a maternally toxic dose. Nevertheless, some data from the open literature suggest that young rats may be more susceptible to toxic effects of endosulfan on neurological and reproductive parameters than older rats. Endosulfan produced negative or equivocal findings in endocrine-specific assays; however, the potential association with neuroendocrine effects or androgenic effects has not been fully examined and cannot be ruled out.

Several human cases of endosulfan poisoning have been reported in the open literature, some of which resulted in death. Clinical signs of toxicity in accidental poisoning in humans indicate involvement of the CNS. Reported symptoms include seizures, irritability, disorientation, dizziness, tremors, convulsions, cognitive deterioration and impairment of memory. In an epidemiology study, 117 boys (10–19 years) from an Indian village at the foothills of cashew plantations where endosulfan had been aerially applied for more than 20 years were compared to a group of 90 control children with no exposure history (Saiyed et al. 2003). Mean serum endosulfan levels were 5.5 times higher in the study group and the sexual maturity rating was negatively related to endosulfan exposure. The authors suggested that endosulfan exposure in male children may delay sexual maturity and interfere with sex hormone synthesis, although study limitations due to small sample size and non-participation were also cited.

Reference doses for endosulfan were based on the no observed adverse effect levels (NOAELs) for the most relevant endpoints; namely clinical signs of neurotoxic effects for shorter exposures as well as effects on body-weight gain, kidneys, blood parameters and blood vessels for longer exposures. These reference doses incorporate uncertainty factors to account for extrapolation between laboratory animals and humans as well as for variability within human populations and for data uncertainties (Appendix I, Table 1). Consistent with past PMRA policy and now formalized under the new *Pest Control Products Act* that came into force in 2006, additional safety factors have also been applied, where warranted, to protect children and pregnant females from relevant endpoints of concern or any database uncertainty regarding a potential for increased sensitivity in these population subgroups.

3.2 Dermal Absorption

As the toxicological endpoint for short- and intermediate-term dermal exposure scenarios is based on a NOAEL from a dermal toxicity study, no dermal absorption factor was necessary. Where a dermal absorption factor is required (such as for acute exposure scenarios for which a NOAEL derived from an oral study was used), a dermal absorption factor of 47% was applied, based on a rat in vivo study.

3.3 Occupational Exposure and Risk Assessment

Workers can be exposed to endosulfan through mixing, loading or applying the pesticide or through postapplication activities.

For short- and intermediate-term dermal exposure, an overall NOAEL of 3 mg/kg bw/day from several repeat-dose (21–28-day) dermal toxicity study in rats was selected, based on spasms and tremors at 4 mg/kg bw/day and mortality in female rats at 12 mg/kg bw/day. The target margin of exposure (MOE) is 300; 10-fold for interspecies and 10-fold for intraspecies variations, with an additional safety factor of 3-fold for potential sensitivity in the young and the lack of a developmental neurotoxicity study in rats. Because a dermal NOAEL was selected, a dermal absorption factor is not required for route-to-route extrapolation.

For long-term dermal exposure scenarios, the oral NOAEL of 0.6 mg/kg bw/day from a 2-year chronic/carcinogenicity study in rats was selected, based on reduced body-weight gain and increased incidences of blood vessel aneurysm as well as marked progressive glomerulonephrosis in male rats at a lowest observed adverse effect level (LOAEL) of 2.9 mg/kg bw/day. The selected NOAEL is also supported by a NOAEL of 0.57 mg/kg bw/day from the one-year dietary study in dogs in which decreased weight gain and neurological symptoms were observed at 1.75 mg/kg bw/day. The target MOE is 300, 10-fold for interspecies variation, 10-fold for intraspecies variation and 3-fold for potential sensitivity of the young and the lack of a developmental neurotoxicity study in rats. The selected endpoint and uncertainty factor is inherently protective of findings noted in pregnant rabbits.

The NOAEL of 0.2 mg/kg bw/day from a 21-day rat inhalation study was chosen for all inhalation exposure scenarios, based on decreased body-weight gain and reduced leucocyte counts at 0.4 mg/kg bw/day. The target MOE is 300, 10-fold for interspecies and 10-fold for intraspecies variations and an additional 3-fold for potential sensitivity in the young and the lack of a developmental neurotoxicity study in rats. There was no apparent increase in toxicity with duration; therefore, an additional safety factor to account for use of a short-term study to extrapolate to a longer term scenario was not required.

3.3.1 Mixer/Loader/Applicator Exposure and Risk Assessment

There are potential exposures to mixers, loaders, applicators and other handlers. The following supported uses were assessed:

- mixing/loading wettable powder (WP);
- mixing/loading emulsifiable concentrate (EC);
- groundboom application to beans, broccoli, Brussels sprouts, cabbage, cauliflower, celery, field and head lettuce, sweet corn, cucumber, squash, melon, pumpkin, eggplant, field tomato, pepper, peas (canning, seed), potato, rutabaga, sugar beet, turnip, strawberry, ornamental flowers and shrubs;
- airblast application to apple, pear, apricot, cherry, peach, plum, grape;
- handheld application to greenhouse vegetable crops (pepper, cucumber, lettuce and tomato), strawberries, bark treatment of orchard crops, ornamental crops;
- low-volume sprayer for greenhouse lettuce;
- bait application around food processing plants; and
- root dip for peach seedlings.

Based on the number of applications, workers applying endosulfan would generally have a short-term (up to 30 days) duration of exposure. The PMRA estimated handler exposure based on different levels of personal protective equipment (PPE) and engineering controls as follows:

- Baseline PPE: a long-sleeved shirt and long pants, chemical-resistant gloves (unless specified otherwise), with open mixing and open cab. When specified, respirator worn during mixing/loading activities.

- Mid-level PPE: coveralls over a long-sleeved shirt and long pants, chemical-resistant gloves, with open mixing and open cab. When specified, respirator worn during mixing/loading activities.

- Maximum PPE: chemical-resistant coveralls over a long-sleeved shirt and long pants, chemical-resistant gloves, with open mixing and open cab. When specified, respirator worn during mixing/loading activities.

- Engineering controls: closed mixing/loading systems and/or closed cab application.

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 endosulfan; therefore, dermal and inhalation exposures were estimated using 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 which facilitates the generation of scenario-specific exposure estimates based on formulation type, application equipment,

mixing/loading 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. Data were also not available to assess exposure to workers wearing chemical-resistant headgear. In this case, a 90% clothing protection factor was applied to the head and neck unit exposure data for open cab airblast scenarios.

Occupational risk is estimated by comparing a calculated MOE to a target MOE incorporating safety factors protective of the most sensitive subpopulation. If the calculated MOE exceeds the target MOE, the risk is considered acceptable. Calculated MOEs that do not reach target MOEs indicate that mitigation measures are required. For endosulfan, the adverse toxicological endpoints of concern are different depending on the exposure route, thus it is not appropriate to combine the exposures from different routes.

Bait application is permitted on some endosulfan labels. This use involves mixing wettable powder product with corn or bananas and dispensing the mixture onto pie plates. As there are no data sets in the PHED to estimate exposure, surrogate scenarios were used; however, due to the requirement of water-soluble packaging, this use may not be feasible, as the packages would need to be broken to follow use instructions.

No scenario-specific data exist for root dipping. PHED data were used to estimate exposure to individuals mixing/loading the dipping solution; however, there are no scenarios in the PHED that are appropriate to model exposure during root-dip treatment. In the absence of generic and specific exposure data, a draft model developed by the California Department of Pesticide Regulation was used to estimate potential exposure. The model incorporates equations from the *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (RAGS-E, USEPA 2004) to estimate applicator exposure. The RAGS-E model is adapted from equations derived from Potts and Guy (1992) in which human in vitro dermal absorption data is used to estimate the skin permeability coefficient (K_p) for chemicals based on physical-chemical properties. K_p values based on experimentally derived in vitro dermal absorption value for rats (in vivo and in vitro) and humans (in vitro) were also used in the exposure model. Although this model has a number of limitations, it was used to give an estimation of the potential exposure to workers dipping peach seedling roots.

As detailed in Appendix II, Tables 1 to 5, calculated MOEs exceed the target MOEs, with the exception of the following (for both WP and EC formulations):

- airblast application to apple, peach, pear, ornamental trees, grape;
- groundboom application to bean, corn, eggplant, pepper, field tomato, peas, potato, sugar beet;
- high-pressure handwand application to greenhouse crops (tomato, cucumber, pepper, lettuce), bark treatment, ornamentals, strawberry
- bait application; and
- peach root dipping.

For those scenarios that did not exceed the target MOE, even with the maximum PPE or engineering controls, the amount of active ingredient (kg a.i.) that can be safely handled per day for each application equipment and formulation was calculated using the following equation:

$$\text{kg a.i. handled/day to reach target MOE} = \frac{\text{AR} \times \text{ATPD} \times \text{MOE}}{\text{target MOE}}$$

Where:

AR:	Application rate (kg a.i./ha or kg a.i./L)
ATPD:	Area treated per day (ha/day or L/day)

Proposed mitigation measures are detailed in Appendix II, Table 10 and Table 11, and information needed to refine the risk assessment is outlined in Section 7.0.

3.3.2 Occupational Postapplication Exposure Risk Assessment

The postapplication occupational risk assessment considered exposures to workers who re-enter treated sites to conduct agronomic activities involving foliar contact (e.g. pruning, thinning, harvesting or scouting). Based on the endosulfan use pattern, there is potential for short- to intermediate-term (> 1 day–6 months) postapplication exposure.

Potential exposure to re-entry workers was estimated using activity specific transfer coefficients (TCs) and default dislodgeable foliar residue (DFR) values. The TC is a measure of the relationship between exposure and DFRs for individuals engaged in a specific activity, and is calculated from data generated in field exposure studies.

A study of dislodgeable residue dissipation, for endosulfan applied to peaches, grapes and melons, was used to determine postapplication exposure for outdoor crops. DFR data for both the EC and WP formulations were presented. Due to differences in initial residues, EC and WP DFR data were considered and applied separately in the assessment. For greenhouse crops, no acceptable DFR studies were submitted. A default assumption of 20% of the application rate was used to estimate initial DFR values; however, because there is no default rate for dissipation inside greenhouses, restricted-entry intervals (REIs) could not be established.

Endosulfan is a mixture of two stereoisomers (β, α) with an oxidation product (endosulfan sulfate) that must be considered as part of the postapplication exposure assessment. It has been noted that the β-isomer can take longer to dissipate than the α-isomer, while the sulfate degrades slowly with an increase in the rate of degradation with increasing temperature. Due to this, the degradation curve of endosulfan is unique and is not predicted well using the standard *ln*-linear DFR model. Instead, log-linear and log-quadratic models were used to generate regression curves, based on goodness-of-fit.

Postapplication risk is managed by establishing an REI for specific tasks. Pesticide residues dissipate and/or breakdown over time and an REI is the length of time required for the dislodgeable pesticide residues to dissipate to such a level that entry into a treated area results in acceptable MOEs.

Postapplication exposure and risk estimates, based on the currently available data, are presented in Appendix II, Table 6 and Table 7. In general, the required REIs are lengthy and may not be agronomically feasible for growers, even when the minimum rate is considered. Feasibility of REIs, and proposed mitigation measures are detailed in Appendix II, Table 10 and Table 11; information needed to refine the risk assessment is outlined in Section 7.0.

3.3.3 Non-Occupational Exposure and Risk Assessment

Residental uses of endosulfan are not supported by the registrant and will be phased out. Therefore, residential uses were not examined in this assessment.

Potential acute dermal exposure from individuals performing pick-your-own activities on commercial strawberry farms was assessed for both adults and youth.

For acute dermal exposure, the NOAEL of 1.5 mg/kg bw/day from an acute neurotoxicity study in rats was chosen based on clinical signs (stilted gait, squatting posture, irregular respiration and decreased spontaneous activity) in female rats at 3 mg/kg bw. The target MOE was 1000 (10-fold for interspecies extrapolation, 10-fold for intraspecies variability and 10-fold to account for potentially higher sensitivity among the young compared to adults, the lack of a developmental neurotoxicity (DNT) study in rats, and uncertainty in the NOAEL from the acute neurotoxicity study in rats, as animals were examined prior to attainment of peak plasma concentrations in female rats). This additional factor also provides protection for severity of the endpoint (mortality) noted at the LOAEL of 2 and 6 mg/kg bw/day in rabbit and rat developmental toxicity studies, respectively.

MOEs were acceptable when the REI was increased to 10 and 14 days for the EC and WP formulations, respectively (Appendix II, Table 8).

Potential exposure to bystanders from spray drift was assessed using a conservative semi-quantitative approach. Although the MOE was considered to be adequate, a label statement to reduce drift to areas of human habitation and areas of human activity will minimize potential exposure.

3.4 Dietary Exposure and Risk Assessment

In a dietary exposure assessment, the PMRA determines how much of a pesticide residue, including residues in milk and meat, may be ingested with the daily diet. Exposure to endosulfan from potentially treated imports is included in the assessment. These dietary assessments are age-specific and incorporate the different eating habits of the population at various stages of life. For example, the assessments take into account differences in children's eating patterns, such as food preferences, and the greater consumption of food relative to their body weight when compared to adults. Dietary risk is then determined by comparing the dietary intake to the reference doses established in the toxicity assessments.

Residue estimates used in the dietary risk assessment may be conservatively based on the maximum residue limits (MRL) or on field trial data, which is representative of the residues that may remain on food after treatment at the maximum label rate. Surveillance data representative of the national food supply may be used to derive a more accurate estimate of residues that may remain on food when it is purchased. These include the Canadian Food Inspection Agency's National Chemical Residue Monitoring Program as well as the United States Department of Agriculture's Pesticide Data Program.

Acute and chronic dietary exposure and risk estimates were generated using Dietary Exposure Evaluation Model (DEEM) software and updated consumption data from the United States Department of Agriculture's Continuing Survey of Food Intakes by Individuals (1994–1998).

3.4.1 Acute Dietary Exposure and Risk Assessment

Acute dietary risk is calculated considering the highest ingestion of endosulfan that would be likely on any one day. It is calculated from known food consumption habits and pesticide residues measured in food. A probabilistic analysis generates all possible combinations of consumption and residue levels to estimate a distribution of endosulfan residues that might be consumed in a day. A value representing the high end (99.9^{th} percentile) of this distribution is compared to the acute reference dose (ARfD), which is the dose at which an individual could be exposed on a single day and expect no adverse health effects. When the expected intake from residues is less than the ARfD, the expected intake is not considered to be of concern.

The acute dietary reference dose for all population subgroups, including females 13–50 years, infants and children, was derived from a NOAEL of 1.5 mg/kg bw/day from an acute neurotoxicity study in rats based on clinical signs (stilted gait, squatting posture, irregular respiration and decreased spontaneous activity) in female rats at 3 mg/kg bw. An overall factor of 1000 (10-fold for interspecies extrapolation and 10-fold for intraspecies variability and an additional 10-fold safety factor) was applied to the selected NOAEL. The additional 10-fold is to account for potentially higher sensitivity among the young compared to adults, the lack of a DNT study in rats and uncertainty in the NOAEL from the acute neurotoxicity study in the rats, as animals were examined prior to attainment of peak plasma concentrations in female rats. This additional factor also provides protection for severity of the endpoint (mortality) noted at the LOAEL of 2 and 6 mg/kg bw/day in rabbit and rat developmental toxicity studies, respectively. This results in an ARfD of 0.0015 mg/kg bw/day (1.5 mg/kg bw ÷ 1000 = 0.0015)

The dietary exposure estimates due to all potentially treated domestic and imported commodities exceeded the ARfD, even when all available data were applied to refine the assessment. Table 1 of Appendix III shows that the overall burden arising from all registered usage is driven by American imports, leaving little room for domestic applications. Mitigation was applied by ranking commodities in order of decreasing agricultural importance and selectively adding them to existing imported commodities, until the dietary risk estimate exceeded levels of concern. Agricultural importance was highest when the commodity had no alternative to endosulfan and when it affected a major production. This approach took into consideration uncertainty of estimation arising from setting all below-detection values at ½ limit of detection (LOD). This was done by artificially forcing a zero value to all below-detection values and noting the

difference in risk estimate. Dietary exposure from domestic grapes and the cole group (broccoli, Brussels sprout, cabbage, cauliflower) were not considered due to occupational exposure concerns.

The final selection (Appendix III, Table 1) returned an exposure estimate at 115% of ARfD and included apple, celery, cucumber, eggplant, pepper, pumpkin, rutabaga, sugar beet and turnip. The risk exceeded the 100% threshold mostly due to imports from the United States (94% ARfD), but was deemed acceptable because imputation of ½ LOD accounted for 24% of its value. Milk and juices of apple and, to a lesser extent, imported grape were major contributors to acute risk for all population subgroups.

3.4.2 Chronic Dietary Exposure and Risk Assessment

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

The chronic (lifetime) dietary reference dose or an ADI for all populations is 0.002 mg/kg bw/day. This was derived from an NOAEL of 0.6 mg/kg bw/day from a 2-year feeding study in rats, which was based on reduced body-weight gain and increased incidences of progressive glomerulonephritis and blood vessel aneurysm in male rats at the next dose (2.9 mg/kg bw/day). An uncertainty factor of 100 (10-fold for interspecies extrapolation and 10-fold for intraspecies variability) and an additional safety factor of 3-fold to account for potential sensitivity of the young and lack of developmental neurotoxicity, was applied to the NOAEL (ADI = 0.6 ÷ 300 = 0.002). The selected NOAEL was supported by a NOAEL of 0.57 mg/kg bw/day from the 1-year dietary study in dogs in which decreased weight gain and neurological symptoms were observed at 1.75 mg/kg bw/day. The ADI provides a margin of safety of 500/1000 to the NOAEL/LOAEL for mortality and clinical signs of neurotoxicity in pregnant rabbits, 750 to the NOAEL for sperm effects reported in a published study and 1000 to the NOAEL for mortalities noted in pregnant rats.

Chronic dietary exposure for the North American population was not a concern (Appendix III, Table 1).

3.4.3 Cancer Dietary Exposure and Risk Assessment

Endosulfan does not pose a cancer risk.

3.4.4 Drinking Water Exposure

The drinking water levels of comparison (DWLOC) is the maximum concentration of pesticide in water that would bring the total risk (dietary + water) to 100% of the reference dose. It can only be determined if all other sources of exposure are acceptable. This quantity is compared to model predictions of water concentrations, considering both acute and chronic exposure. Model predicted expected environmental concentrations (EECs) may raise concern when they exceed the DWLOC.

Chronic estimates of endosulfan in groundwater were below the DWLOC for all population subgroups. Acute estimates exceeded the DWLOC for most population subgroups (Appendix III, Table 2). While modelled estimates are conservative in nature, there are insufficient data to refine these values (Section 4.3). In addition, the lack of data to model the concentration of endosulfan sulfate in drinking water likely underestimates risk, because this species is more persistent than the parent.

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, this from all known or plausible exposure routes (oral, dermal and inhalation). As the estimates for endosulfan acute risk associated with drinking water and dietary exposure exceed the ARfD independently of each other, mitigation or additional data to refine these estimates are required and are discussed in Section 7.0.

3.5.1 Pick-Your-Own Activities

Acute dermal exposure from pick-your-own activities in commercial strawberry fields may co-occur with acute dietary exposure for youths and adults eating picked berries. No inhalation exposure is expected.

As seen in Appendix II, Table 9, MOEs were above the target when the REI was increased to 10 and 14 days for the EC and WP formulations, respectively. Under these conditions the aggregate exposure due to pick-your-own activities is not of concern.

3.5.2 Dietary and Drinking Water

Registrants do not support residential uses of endosulfan and these uses will be phased out; therefore, aggregate exposure will be covered by the dietary and drinking water assessment. Acute aggregate risk exceeds the level of concern, but could possibly be mitigated with a better estimate of drinking water concentrations (Section 4.3). Aggregate chronic risk is acceptable.

4.0 Environmental Assessment

4.1 Summary of Physical Chemical Properties and Environmental Fate

Endosulfan α and β isomers as well as the major transformation product endosulfan sulfate are classified as sparingly soluble in water. Based on vapour pressures for the α and β isomers, calculated Henry's law constants and available monitoring data, both endosulfan isomers have an intermediate to high volatility under field conditions and can be subject to long-range transport. Endosulfan sulfate is considered relatively non-volatile under field conditions based on vapour pressure and Henry's law constant. The ultraviolet/visible absorption spectrum indicated there are no significant absorption peaks in the natural sunlight region (290–800 nm) of the spectrum for either α or β isomers, for endosulfan sulfate and endosulfan diol; therefore, phototransformation is not expected to be an important route of transformation.

In soil, both aerobic and anaerobic processes contribute to the biotransformation of endosulfan. The major transformation product identified in all aerobic biotransformation studies was endosulfan sulfate. There was no information on the aerobic biotransformation of endosulfan sulfate; however, the combined half-life of endosulfan isomers plus endosulfan sulfate residues was greater than just the parent isomers, which indicates that endosulfan sulfate is more persistent than the parent isomers. Under anaerobic conditions, α endosulfan and β endosulfan are moderately persistent to persistent in soils according to the classification of Goring et al. (1975). Endosulfan sulfate appears to be persistent in soils under anaerobic conditions. Under field conditions, the α isomer dissipates fairly rapidly (50% loss in 40–60 days), but the β isomer was more persistent (50% loss in 800 days) in a bare sandy loam soil in a field dissipation study conducted in Canada. The α isomer would be considered moderately persistent and the β isomer persistent under these conditions according to the classification of Goring et al. (1975). Endosulfan sulfate was the major transformation product, which persisted throughout the study.

Information on soil organic carbon partition coefficients (K_{oc}s) from four soils and a sediment as well as fate modelling, laboratory and field studies show that α and β endosulfan and endosulfan sulfate are strongly adsorbed and generally considered immobile in soils. There is however some difference between the isomers. Research has shown that the β isomer remained strongly adsorbed to sediment while the α isomer desorbed, resulting in the formation of endosulfan sulfate in the water column. While leaching into groundwater is not a concern, endosulfan and its major transformation product endosulfan sulfate are still subject to surface water runoff. Surface water runoff occurs both in the dissolved phase, due to equilibrium partitioning, and through movement of soil particles with adsorbed endosulfan.

Once in an aquatic ecosystem, α and β endosulfan are expected to dissipate rapidly from the water column due to a combination of alkaline hydrolysis and partitioning into sediment. Maximum concentrations of endosulfan isomers and endosulfan sulfate in the sediment can be one to two orders of magnitude greater than that of the water column due to the strong adsorption to sediment particles. Endosulfan sulfate is much more persistent in the water column (half-life of a few weeks) compared to parent compound.

Endosulfan is mobile in the environment due to its volatility. Significant amounts volatilize from soil and leaf surfaces, particularly soon after application. The α isomer is more volatile than the β isomer, which in turn is more volatile than the sulfate transformation product. Subsequent deposition of volatilized endosulfan to water is favoured by high water/air partition coefficients. Endosulfan has been detected in air, water, snow and biota samples in remote areas such as the Arctic, which resulted from long-range atmospheric transport.

Bioconcentration

Bioconcentration data for endosulfan are available for several species of freshwater fish and invertebrates. Estimates of a bioconcentration factor (BCF) vary by almost 4 orders of magnitude, ranging from 1.97 to 11 583 for the Yellow tetra (*Hyphessobrycon bifasciatus*). Endosulfan residues depurate rapidly in aquatic invertebrates and fish. Ernst (1977) reported a depuration half-life of 34 hours for the α isomer in marine mussels (*Mytilus edulis*). Toledo and Jonsson (1992) reported depuration half-lives of 2.9 and 5.1 days for the α and β isomers and 5.9 days for the sulfate transformation product in zebra fish (*Brachydanio rerio*).

Bioaccumulation

The endosulfan α and β isomers and endosulfan sulfate have log K_{ow} values of 4.74, 4.79 and 3.77, respectively, which indicate a high potential for bioaccumulation in biota. Environment Canada reports measures of bioaccumulation factor (BAF) values on a wet-weight basis for α-endosulfan for a variety of zooplankton and Arctic fish species ranging from 3400 to 670 000. These data are presented in Table 4.1.1.

Endosulfan sulfate has been reported in beluga whale blubber samples from the Canadian Arctic (Stern and Ikonomou 2003). Concentrations increased 3.2-times over the 20-year period from 1982 to 2002. There is, however, some uncertainty in the validity of the trend to increasing endosulfan sulfate concentrations in beluga blubber because none of the results for endosulfan sulfate data in beluga blubber have been confirmed by gas chromatography with mass spectrometry (GC-MS); therefore, there is the potential for false positives due to interference from chlordane and/or toxaphene components.

These data indicate that endosulfan residues are bioaccumulating in these biota. Laboratory studies have shown that endosulfan residues are metabolized in fish and mammals; therefore, they would not be expected to bioaccumulate. Temperature could be an important variable that has not been accounted for in the comparison of BCFs from lab studies with field studies. The effect could be to limit metabolism of endosulfan both by invertebrates and fish under arctic marine conditions (average temperature < 1 °C).

Table 4.1.1 Bioaccumulation Factors for Selected Species in Cold Water Food Webs

Organism	Barrow, Alaska	White Sea, Russia	Holman, North West Territories	Lake Superior, Ontario
[α-endosulfan]$_{water}$	1.7 ± 0.76 pg/L	3.1 ± 2.0 pg/L	3.0 ± 0.97 pg/L	2.3 ± 2.7 pg/L
BAF*				
Zooplankton	610000	660000	200000	670000
Herring		10000		270000
Cod	30000	56000	3400	
Arctic char	97000			
Salmon	18000			
Smelt				180 000
Navaga		200000		

* Values are wet-weight normalized, calculated as the average concentration of α-endosulfan in the organism divided by the average concentration in water (Borga et al. 2004)

Biomagnification

The trophic magnification factors (TMFs) for α-endosulfan were generally < 1 when the food web was restricted to algae, zooplankton, and various species of fish. This suggests that averaged over at least three trophic levels, endosulfan is not biomagnifying in aquatic food webs.

4.2 Environmental Toxicology

The 14-day lethal concentration 50% (LC_{50}) for the earthworm *Eisenia fetida* exposed to technical endosulfan in an artificial soil test was 14 mg a.i./kg. The LC_{50} for the earthworm *Lumbricus terrestris* in loamy sand soil is 9 mg a.i./kg. Lethal doses 50% (LD_{50}s) of 4.5 and 7.1 µg/honeybee were observed in two acute contact studies on the honeybee *Apis mellifera*. Endosulfan at 0.07%, was highly toxic to 1–2 day old gravid female phytoseiid mites (*Amblyzeius tetranychivorus*), was shown to have an immediate adverse impact on populations of soil micro-arthropods and persisted in Indian field soils at levels toxic to Collembola for 45 days after application.

The acute oral toxicity of endosulfan to various species of birds ranges from 28 mg a.i./kg bw for the mallard duck (*Anas platyrhynchos*) to > 320 mg a.i./kg bw for the pheasant (*Phasianus colchicus*). The acute dietary toxicity of endosulfan to various species of birds ranges from 805 mg a.i./kg diet for the bobwhite quail (*Colinus virginianus*) to 1275 mg a.i./kg diet for the pheasant (*Phasianus colchicus*). Chronic avian reproduction studies showed that there were

treatment related effects on reproduction (reduction in the number of eggs laid and hatchability), adult body weight and feed consumption of mallard ducks at levels of endosulfan as low as 60 mg a.i./kg diet. The acute oral toxicity of endosulfan to mammals estimates are 10 to 40 mg a.i./kg bw.

Some phytotoxic effects of endosulfan have been reported; however, these were very isolated. Endosulfan has not been shown to be significantly toxic to plants following most operational applications.

Acute 48-h LC_{50}s of endosulfan to freshwater invertebrates ranged from 1.2 µg a.i./L for the burrowing mayfly *Jappa kutera* to 180 µg a.i./L for the waterflea *Daphnia magna* The 96-h LC_{50} of the transformation product endosulfan sulfate to *Hyalella azteca* and the burrowing mayfly *Jappa kutera* was 5.7 and 1.2 µg a.i./L. The effect concentration 50% (EC_{50}) of the transformation product endosulfan diol to *Daphnia magna* was 580 µg a.i./L.

Acute 96-h LC_{50}s of endosulfan ranged from 0.1 µg a.i./L for the common carp (*Cyprinus carpio*) to 3.3 µg a.i./L for the bluegill sunfish (*Lepomis macrochirus*). The 96-h LC_{50} of the major transformation product endosulfan sulfate to rainbow trout (*Oncorhynchus mykiss*) was reported as 1.4 µg a.i./L. The estimated no observed effect concentration for survival (NOEC) for the fathead minnow (*Pimephales promelas*) to technical grade endosulfan (99% a.i.) was 0.2 µg a.i./L.

Little appears to be known regarding the algal toxicity of endosulfan. No information was available addressing the toxicity of endosulfan to aquatic vascular plants. Acute 96-h LC_{50}s of endosulfan to amphibians ranged from 1.8 µg a.i./L for the tiger frog (*Rana tigrina*) to 4700 µg a.i./L for the green frog (*Rana clamitans*).

Toxicity of endosulfan to marine organisms, is available for eastern oysters (*Crassostrea virginica*) EC_{50} = 0.45 µg a.i./L and for marine/estuarine fish, ranging from 0.1 µg a.i./L for the striped bass (*Morone saxatilis*) to 0.38 µg a.i./L for the striped mullet (*Mugil cephalis*).

Endosulfan has demonstrated both reproductive and developmental effects in a broad range of organisms and has been implicated in peer-reviewed literature as an endocrine disrupting agent. Based on the chronic effects of endosulfan and open literature, it is recommended that when appropriate screening and/or testing protocols being considered under the USEPA's Endocrine Disruptor Screening Program (EDSP) have been developed, endosulfan be subjected to more definitive testing to better characterize effects related to its potential to cause developmental and reproductive effects.

4.3 Drinking Water

The screening level 1 surface water EECs exceeded the DWLOCs. Refined level 2 EECs were calculated with theLeaching Estimation and Chemistry Model (LEACHM) for groundwater as well as Pesticide Root Zone Model /Exposure Analysis Modeling System (PRZM/EXAMS) for surface water using relevant scenarios where endosulfan is used in Canada. Given that endosulfan is used throughout Canada, three crops were selected that would represent the major

uses of endosulfan in different geographical regions of Canada. The British Columbia apples, Ontario corn and Manitoba potato scenarios were modelled. In addition to selecting relevant scenarios, the physicochemical properties used to run the models were refined. Insufficient data was available to model endosulfan sulfate in potential drinking water sources.

The LEACHM model results indicate that endosulfan is not likely to contaminate groundwater sources. However, detections of endosulfan were reported by Environment Canada in recent monitoring data from British Columbia. In this study, α and β endosulfan and endosulfan sulfate were detected in groundwater sources with maximum concentrations of 37 ng a.i./L; 32 ng a.i./L and 9.4 ng a.i./L, respectively.

Results from PRZM/EXAMS predicted that the acute (yearly peak) and chronic (yearly average) concentrations of endosulfan at the 90th percentile resulting from runoff from the Ontario corn scenario (1 application at 1700 g a.i./ha) to be 8.31 and 0.81 µg/L for reservoirs, respectively. The British Columbia apples acute and chronic reservoir concentrations are less than those predicted for Ontario corn. Estimated acute (yearly peak) and chronic (yearly average) concentrations of endosulfan at the 90th percentile resulting from runoff for the Manitoba potato scenario (4 applications at 550 g a.i./ha) were 27.81 and 2.19 µg/L for dugouts, respectively. The values resulting from the models are considered to be "upper bound" concentrations in surface water that potentially may be used as a drinking water source.

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 available monitoring data indicate that endosulfan has been detected in surface water samples in Canada; however, the quality of the data did not allow for the determination of values for use in the drinking water assessment. Very little data are available addressing concentrations of endosulfan sulfate in Canadian drinking water supplies. Additional groundwater and surface water monitoring data would be required to evaluate actual acute and chronic concentrations of endosulfan as well as the major transformation product endosulfan sulfate in Canadian drinking water sources.

4.4 Terrestrial Assessment

An initial deterministic terrestrial risk assessment was conducted for endosulfan. In this assessment, risk was characterized by the quotient method, calculated as the ratio of the EEC to the effects endpoints of concern. Risk quotient (RQ) values less than one are considered indicative of a low risk to non-target organisms, whereas values greater than one are considered to indicate that some degree of risk exists for non-target organisms. The endpoint used for both acute and chronic toxicity is the NOEC from the appropriate laboratory study or, if not available, 1/10th of the appropriate LD_{50} or LC_{50} value.

The risk to earthworms was determined by calculating the concentration in 15 cm of soil that they would be exposed to following a direct application at the different registered application rates. Earthworms are considered to be at low risk (RQ = 0.27–0.78) for all groundboom applications of endosulfan up to and including 1 application at 1100 g a.i./ha, and at moderate risk (RQ = 1.1–1.4) for 2 groundboom applications at 1100 g a.i./ha and 1 airblast application at 2800 g a.i./ha.

An application of 5.04 kg a.i./ha (5040 g a.i./ha) of endosulfan would be expected to kill 50% of the bees foraging in the treated field at the time of application or shortly afterwards. The maximum application rate for all of the registered uses is 2800 g a.i./ha; therefore, endosulfan should not be applied when bees are actively foraging in the field. This conclusion is confirmed by various field studies from around the world.

Standard exposure scenarios on vegetation and other food sources based on correlations in Hoerger and Kenaga (1972) and Kenaga (1973) and modified according to Fletcher et al. (1994) were used to determine the risk to birds and small wild mammals due to the consumption of contaminated food items.

Birds of similar size to the American robin and field sparrow may be at risk following all applications because it required only 0.2–1 hour consumption of food contaminated with endosulfan to reach the acute oral NOEL. Bird species in the size range of the bobwhite quail may be at risk at application rates of 1100 g a.i./ha and 2800 g a.i./ha because it required only 0.12–2.9 hours consumption of food contaminated with endosulfan to reach the acute oral NOEL. At the highest application rate of 2800 g a.i./ha, only 16% of the diet contaminated with endosulfan would be required to reach a RQ = 1, which indicates risk.

Based on the RQs, larger species of birds such as the mallard duck would be at low risk (RQ = 0.6–0.9) due to chronic exposure following applications of endosulfan up to and including single applications at 800 g a.i./ha, and at moderate risk (RQ = 1.2–3.2) due to chronic exposure following multiple applications at 800 g a.i./ha and all higher applications. Smaller species of birds may be at higher risk due to chronic exposure; however, no information is available to assess risk to these species.

The number of hours of continuous feeding on a contaminated diet by a small wild mammal to reach the NOEC ranges from only 0.05 to 0.24 for all the registered applications of endosulfan. The number of hours of continuous feeding on a contaminated diet to reach the LD_{50} ranges from only 0.5 to 2.4 for all the registered applications of endosulfan. Small wild mammals may, therefore, be at risk due to consumption of contaminated food following all applications of endosulfan. The risk to small mammals from exposure to endosulfan on an acute dietary basis would range from high to very high depending on the application rate. Only 0.7–4% of the diet contaminated with endosulfan would be required to reach a RQ = 1, indicating risk. The risk to small mammals from exposure to endosulfan on a chronic reproductive basis ranged from moderate to high depending on the application rate. Only 5.3–27% of the diet contaminated with endosulfan would be required to reach a RQ = 1, indicating risk.

4.5 Aquatic Assessment

Aquatic organisms may be exposed to residues of endosulfan initially from drift immediately following ground application and subsequently from runoff following rainfall events. The risk assessment for aquatic organisms was designed to characterize the risk from drift and runoff separately so that appropriate mitigative measures may be used to reduce risk from both sources of exposure. A refined aquatic risk assessment was conducted beginning with a screening level assessment and progressing to a probabilistic assessment.

4.5.1 Screening Level Assessment

The initial aquatic assessment conducted is a deterministic screening level risk assessment. This approach is conservative and primarily designed to identify the taxonomic groups that are not at risk and/or the use scenarios that do not pose an unacceptable risk. Environmental risk is characterized using the quotient method, which is the ratio of the EEC: toxicity endpoint. The EEC is the concentration resulting from a direct application to a 30-cm depth of water. The endpoint used for both acute and chronic toxicity is the NOEC from the appropriate laboratory study or, if not available, $1/10^{th}$ of the appropriate LC_{50} value. If the RQ from this analysis is < 1 then it can be concluded there is low risk and no further refinement is necessary.

Risk quotients for the range of application rates covering the registered uses of endosulfan in Canada are as follows: freshwater aquatic invertebrates acute (RQ = 316–1610), freshwater aquatic invertebrates chronic (RQ = 92–467), estuarine/marine aquatic invertebrates acute (RQ = 3660–18 700), freshwater fish acute (RQ = 2290–11 700), freshwater fish chronic (RQ = 915–4665), estuarine/marine fish acute (RQ = 18 300–93 300), amphibians acute (RQ = 1020–5180).

Risk was indicated (RQ > 1) to all of the freshwater and estuarine/marine taxa examined; therefore, further refinement was required to determine the risk resulting from both drift and runoff.

4.5.2 Refined Assessment Level 1

In the first step of a refined assessment, the same effects endpoints are considered; however, the summary exposure concentrations are determined for separate input sources and are estimated using more sophisticated models. Separate exposure concentrations in water are determined for inputs from drift and runoff.

Drift

The estimation of exposure from spray drift was refined as follows: EECs were calculated based on an 80-cm depth of water instead of a 30-cm depth. This depth was chosen to be consistent with the modelled body of water used to determine EECs from runoff. Instead of an assumption of 100% deposit as in the screening assessment, the EECs were calculated based on 10% deposit when groundboom spray equipment was used. The spray drift data of Wolfe and Caldwell (2001) indicated that the 90^{th} percentile deposit into an aquatic habitat adjacent to a field sprayed using groundboom equipment will not exceed 10% of the application rate. Similarly, the data of

Ganzelmeier et al. (1995) indicated that the 95th percentile deposit into an aquatic habitat adjacent to an orchard sprayed using airblast equipment will not exceed 77% of the applied application rate for early applications and 59% of the applied application rate for late applications. EECs were recalculated based on 77% and 59% deposit for airblast sprayers. The EECs from both groundboom and airblast sprayers at the reduced percentage deposit were calculated based on an 80-cm deep water body adjacent to the application.

The RQs for the range of application rates with groundboom sprayers covering the registered uses of endosulfan in Canada are as follows:

- freshwater aquatic invertebrates acute (RQ = 12–25);
- freshwater aquatic invertebrates chronic (RQ = 4–7);
- estuarine/marine aquatic invertebrates acute (RQ = 142–286);
- freshwater fish acute (RQ = 89–179);
- freshwater fish chronic (RQ = 36–72);
- estuarine/marine fish acute (RQ = 710–28 000); and
- amphibians acute (RQ = 40–79).

The RQs for the range of application rates with airblast sprayers covering the registered uses of endosulfan in Canada are as follows:

- freshwater aquatic invertebrates acute (RQ = 145–370);
- freshwater aquatic invertebrates chronic (RQ = 55–140);
- estuarine/marine aquatic invertebrates acute (RQ = 1686–5600);
- freshwater fish acute (RQ = 1054–3500);
- freshwater fish chronic (RQ = 422–1400);
- estuarine/marine fish acute (RQ = 1040–28 000); and
- amphibians acute (RQ = 468–1556).

Despite the refinement of potential exposure from drift, the RQs indicate that freshwater and estuarine/marine aquatic invertebrates, fish and amphibians inhabiting shallow water bodies next to the site of ground applications are still at risk from both acute and chronic exposure to residues in drift for all of the registered uses of endosulfan. Aquatic organisms, however, would not be chronically exposed to these concentrations in surface water from residues in drift following applications of endosulfan based on the dissipation time (DT_{50}) of one day observed in surface water in an aquatic mesocosm study. No further refinement of risk from drift following ground applications was conducted. Exposure in aquatic systems resulting from drift can be mitigated through buffer zones.

Runoff

The linked models PRZM and EXAMS were used to predict EECs resulting from runoff of endosulfan following application. The PRZM simulates runoff and erosion events from an agricultural field that are then input into EXAMS to simulate the fate in the receiving water ecosystem. As defined, this scenario was designed to represent concentrations that would occur in shallow bodies of water and/or headwater streams next to the site of application.

The PRZM/EXAMS models were run with the drift input parameter set to zero on a scenario designed to minimize runoff. The model water body used for this simulation was a one-hectare pond with an average depth of 80 centimetres and a drainage area of 10 hectares.

Surface water EECs for endosulfan sulfate, a major transformation product of endosulfan were estimated by a method that incorporated modelling and the USEPA STORET database. The USEPA STORET database was searched for incidences where α + β endosulfan as well as endosulfan sulfate were measured at the same time and at the same location (82 coincident measurements for surface water). The ratio of endosulfan sulfate to total endosulfan (α + β) was then calculated for each incidence. The median value for this ratio was 0.55 for surface water. This ratio was then multiplied by the surface water total (α + β) EECs, as determined by PRZM/EXAMS, to obtain the endosulfan sulfate EECs.

The RQs calculated for exposure to endosulfan are as follows:

- freshwater aquatic invertebrates acute (RQ = 8);
- benthic freshwater aquatic invertebrates (RQ = 4);
- freshwater aquatic invertebrates chronic (RQ = 0.4);
- estuarine/marine aquatic invertebrates acute (RQ = 93);
- freshwater fish acute (RQ = 58);
- freshwater fish chronic (RQ = 2.8);
- estuarine/marine fish acute (RQ = 466); and
- amphibians acute (RQ = 26).

The RQs calculated for exposure to endosulfan sulfate are as follows:

- freshwater aquatic invertebrates acute (RQ = 5); and
- freshwater fish acute (RQ =19).

The RQs calculated for exposure to endosulfan and the major transformation product endosulfan sulfate are all > 1 (with the exception of freshwater aquatic invertebrates chronic), indicating that freshwater and estuarine/marine aquatic invertebrates as well as fish and amphibians inhabiting shallow water bodies next to the site of ground applications are at risk from both acute and chronic exposure to endosulfan in runoff. Freshwater aquatic invertebrates and fish inhabiting shallow water bodies next to the site of ground applications are also at risk from acute exposure to endosulfan sulfate in runoff.

4.5.3 Refined Assessment Level 2a

In this step, the exposure was refined further by using exposure distributions instead of single exposure values. Modelled concentrations using PRZM/EXAMS for multiple years from different Canadian crop exposure scenarios were fit to distribution functions. The analysis only considered exposure resulting from runoff. These distribution functions were then used in a Monte Carlo simulation to determine the probability of exceeding various acute and chronic effects endpoints. Exceedence probabilities were determined using both peak and 96-h average concentrations for acute effects endpoints. This assessment allowed for the determination of the probability of exceeding effects thresholds for the most sensitive species tested.

Table 4.5.3.1 lists the probability of exceeding the acute LC_{50} values for freshwater and estuarine/marine taxa and of the chronic NOECs for freshwater fish and aquatic invertebrates due to residues of endosulfan in runoff for the different crop scenarios. Only the analysis of the 96-h EEC's is presented for the acute assessment. An analysis of peak EECs was also conducted.

Table 4.5.3.1 Probability of Exceeding the Acute and Chronic Endpoints for Freshwater and Estuarine/Marine Taxa Due to Residues in Runoff for the Different Crop Scenarios

Tested Species	British Columbia Apples 1 × 2800 g a.i./ha	Manitoba Potatoes 1 × 550 g a.i./ha	Manitoba Potatoes 4 × 550 g a.i./ha	Ontario Corn 1 × 1700 g a.i./ha	Ontario Grapes 2 × 1500 g a.i./ha	Prince Edward Island Potatoes 1 × 550 g a.i./ha	Prince Edward Island Potatoes 4 × 550 g a.i./ha	Nova Scotia Apples 1 × 2800 g a.i./ha
Acute Effects (LC_{50})								
Freshwater fish	3–9	49–99.9	99.9	71–99.9	74–98	45–99.9	97–99	99.8
Freshwater invertebrates	3	3	9–66	3–17	2–19	2	69	54
Benthic invertebrates	0.5	1.8	74	4	7	1.2	62	71
Estuarine/ Marine fish	9	99.9	99.9	99.9	98	99.9	99	99.8
Estuarine/ Marine invertebrates	3	85	99.9	92	89	86	99	99.9
Amphibians	3	6	83	28	33	5	83	72
Chronic Effects (NOEC)								
Freshwater fish	0.09	98	99.7	99	93	94	99.8	99.9
Freshwater invertebrates	1	1	38	3	3	2	26	18

The information in Table 4.5.3.1 indicates that there is a low probability (3–9%) of exceeding the acute LC_{50} for freshwater fish for the British Columbia apple scenario, but a high probability (45–99.9%) of exceeding the acute LC_{50} for freshwater fish for all of the remaining Canadian scenarios. Similarly, there is a low probability (9%) of exceeding the acute LC_{50} for estuarine/marine fish for the British Columbia apple scenario, but a high probability (98–99.9%) of exceeding the acute LC_{50} for estuarine/marine fish for all of the remaining Canadian scenarios. There is a low probability (0.09%) of exceeding the chronic NOEC for freshwater fish for the British Columbia apple scenario, but a high probability (93–99.9%) of exceeding the chronic NOEC for freshwater fish for all of the remaining Canadian scenarios. The reason for the low probability of exceeding the acute and chronic endpoints for freshwater and estuarine/marine fish for the British Columbia apple scenario is that the scenario is from the Okanagan Valley, which receives very little rainfall. Therefore, inputs of endosulfan from runoff into aquatic systems would be very limited. The probabilities of exceeding the acute and chronic endpoints of freshwater invertebrates (pelagic and benthic), estuarine/marine invertebrates and amphibians are also presented in Table 4.5.3.1.

4.5.4 Refined Assessment Level 2b

The next step in refinement uses the same distributions of exposures from runoff used in level 2a but alternate effects endpoints. For this assessment, species sensitivity distributions (SSDs) were determined for fish and aquatic invertebrates based on LC_{50}s from acute toxicity tests. The SSDs for freshwater aquatic invertebrates and freshwater fish were fit based on the log-logistic model. Using fitted SSDs, concentrations equivalent to affecting 5, 50 and 90% of species were determined and exceedence probabilities determined using the fitted distributions for modelled concentrations in water. This part of the assessment allows for the determination of the probability of exceeding effects thresholds for different proportions of two different taxonomic groups (aquatic invertebrates and fish).

The analysis for aquatic invertebrates using the 96-h EEC distribution data shows a very low probability (1.95%) of exceeding the HC_5 (concentration that does not exceed the LC_{50} of 95% of the species) for the British Columbia apple scenario, whereas the probability of exceeding the HC_5 for all of the other scenarios was very high (77.1–99.8%).

The analysis for freshwater fish using the 96-h EEC distribution data, shows that there is a very low probability (4.9 %) of exceeding the HC_5 for the British Columbia apple scenario, whereas the probability of exceeding the HC_5 for all of the other scenarios was very high (99.7–99.9%).

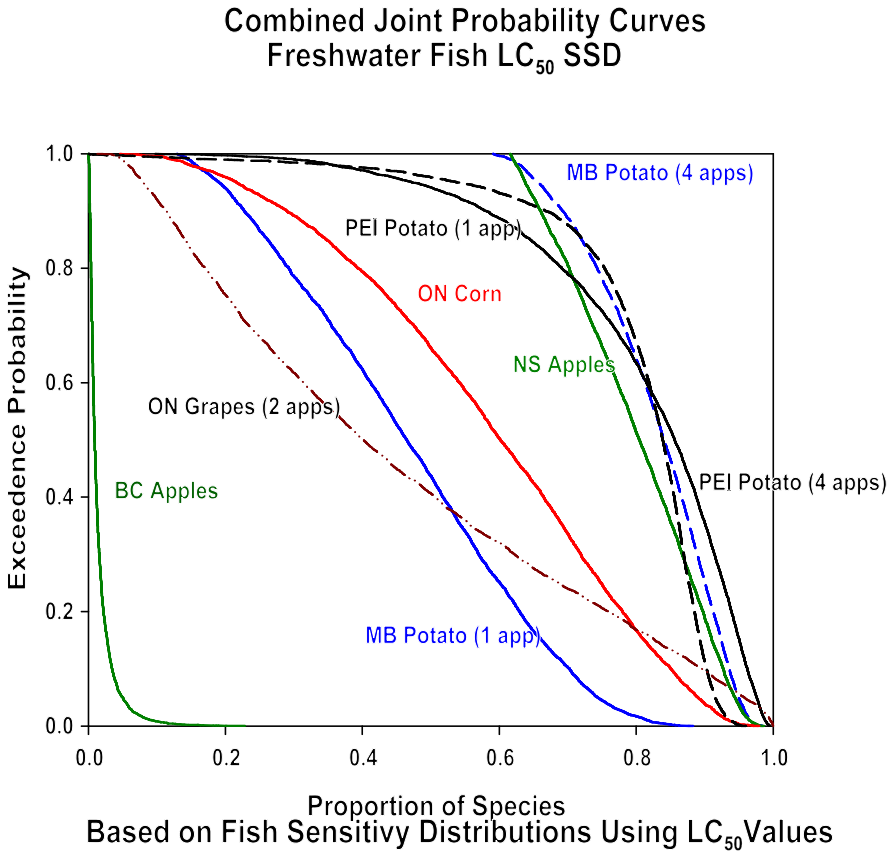
Freshwater fish and invertebrates inhabiting shallow water bodies adjacent to a British Columbia apple orchard would, therefore, be at low risk due to 96-h average concentrations of endosulfan in runoff following 1 application of endosulfan at 2800 g a.i./ha. Freshwater fish and invertebrates in shallow water bodies adjacent to the site of application would be at very high risk due to 96-h average concentrations of endosulfan in runoff from applications of endosulfan in all the remaining Canadian use scenarios, including Manitoba potatoes, Ontario corn, Ontario grapes, Prince Edward Island potatoes and Nova Scotia apples.

4.5.5 Refined Assessment Level 2c

An extension of this last approach is the use of a Monte Carlo simulation to combine the exposure distribution from runoff derived from a PRZM/EXAMS model run and the species sensitivity distribution. These are combined and subjected to Monte Carlo analysis to derive an exceedence profile plot, also known as a joint probability curve (JPC). This part of the assessment allows for the determination of the probability and corresponding magnitude of a potential effect (e.g. a 20% probability of exceeding the LC_{50} for 30% of fish species).

Figure 1 shows the JPCs for the distribution of maximum yearly 96-h concentrations of endosulfan in surface water for the different scenarios and the fish SSDs using LC_{50} values. The plots show a low probability of exceeding the LC_{50} in a low proportion of fish species for the British Columbia apple scenario (the curve is very close to the axes), whereas for all of the other scenarios there is a high probability of exceeding the LC_{50} in a high proportion of fish species (the curves are much farther away from the axes). For example, there is a 40% probability of exceeding the LC_{50} in approximately 3% of the fish species for the British Columbia apple scenario, whereas there is a 40% probability of exceeding the LC_{50} in approximately 90% of the fish species for the Prince Edward Island potato scenario (four (4) applications). The conclusion from this analysis is that freshwater fish inhabiting shallow water bodies adjacent to a British Columbia apple orchard are at low risk due to 96-h concentrations of endosulfan in runoff following one application at 2800 g a.i./ha. The reason is that the British Columbia scenario is from the Okanagan Valley, which receives very little rain; therefore, runoff would be minimal. Apple orchards in other locations in British Columbia would receive more rainfall; therefore, fish in shallow water bodies next to these sites are expected to be at higher risk. Freshwater fish inhabiting shallow water bodies adjacent to the site of application for all of the other scenarios are at high risk due to 96-h concentrations of endosulfan in runoff. Higher rainfall occurs in these scenarios, which would result in higher concentrations of endosulfan in runoff.

Figure 1 **Joint Probability Curves for Maximum Yearly 96-h Concentrations of Endosulfan in Surface Water for the Different Scenarios and the Fish Species Sensitivity Distributions Using LC_{50} Values**



4.5.7 Conclusions of Refined Aquatic Assessment

1) Freshwater and estuarine/marine aquatic invertebrates, fish and amphibians inhabiting shallow water bodies next to the site of groundboom and airblast applications of endosulfan are at risk from acute exposure to endosulfan inputs resulting from spray drift.

2) Amphibians and freshwater and estuarine/marine aquatic invertebrates inhabiting shallow water bodies next to the site of ground boom and airblast applications of endosulfan are at risk from acute exposure to endosulfan in runoff. The probabilities of exceeding the acute LC_{50} for amphibians are as follows:

- Manitoba and Prince Edward Island potatoes: four (4) applications (83%);
- Ontario corn (28%);
- Ontario grapes (33%); and
- Nova Scotia apples (72%).

3) Freshwater and estuarine/marine fish inhabiting shallow water bodies next to the site of groundboom or airblast applications of endosulfan are at risk from both acute and chronic exposure to endosulfan in runoff. There is a 40% probability of exceeding the acute LC_{50} in 50–90% of freshwater fish species for the Manitoba potato, Ontario grape, Ontario corn, Prince Edward Island potato and Nova Scotia apple scenarios. There is a 99 to 99.9% probability of exceeding the acute LC_{50} for estuarine/marine fish for the Prince Edward Island potatoes and Nova Scotia apple scenarios. There is a 98 to 99.9% probability of exceeding the chronic NOEC for freshwater fish for the Manitoba potato, Ontario corn, Ontario grape, Prince Edward Island potato and Nova Scotia apple scenarios.

4) Freshwater aquatic invertebrates and fish inhabiting shallow water bodies next to the site of groundboom or airblast applications of endosulfan are at risk from acute exposure to the major transformation product endosulfan sulfate in runoff for the Manitoba potato, Ontario corn, Ontario grape, Prince Edward Island potato and Nova Scotia apple scenarios.

4.6 Incident Reports

There have been 91 reported incidents involving endosulfan in the United States since 1971. The majority (96%) were associated with the aquatic environment; 82% involving fish, while 7% involved aquatic macroinvertebrates. Approximately 32% of the incidents were directly attributable to runoff from labeled uses of endosulfan. Endosulfan related incidents for fish averaged 5090 killed and ranged as high as 240 000 fish.

Endosulfan has also been linked to fish kills that occurred at various sites in Prince Edward Island in 1999. In each of the eight pesticide-related fish kills, a suspect field that showed evidence of a large amount of runoff and erosion was identified near the origin of the fish kill. Endosulfan concentrations in standing water samples collected between the field and Westmoreland River were higher than the LC_{50} value for fish. If these concentrations are somewhat representative of the endosulfan concentrations that are moving off the potato fields towards the end of the storm events, fish are at high risk.

4.7 Risk Mitigation

Effects in the terrestrial ecosystem are often difficult to mitigate due to the occurrence of non-target species in treated areas. Risk to bees may be reduced by restricting the application of endosulfan to periods when they are not actively foraging. For other terrestrial organisms, such as birds and small wild mammals, options are limited and include decreased application rates, numbers and/or frequencies of application, depending on the potential impact on efficacy.

Endosulfan can enter aquatic ecosystems through spray drift and surface runoff. The observance of buffer zones can effectively mitigate the entry of spray drift into aquatic systems. The spray drift data of Wolfe and Caldwell (2001) were used for predicting the spray drift from groundboom sprayers. The data of Ganzelmeier et al. (1995) were used to estimate spray drift from airblast sprayers used in orchards and vineyards. Based on these model predictions and the most sensitive freshwater and estuarine/marine aquatic organisms tested, rainbow trout (*Oncorhynchus mykiss*) and striped bass (*Morone saxatilis*), buffer zones were calculated for mitigating the entry of spray drift into aquatic systems. In addition, the buffer zone estimation was based on the maximum application rate, the number of applications per season and the interval between applications.

The buffer zones specified in Table 4.7.1 are required between the point of direct application and the closest downwind edge of sensitive aquatic habitats (such as lakes, rivers, sloughs, ponds, prairie potholes, creeks, marshes, streams, reservoirs, wetlands and estuarine/marine habitats).

Table 4.7.1 Buffer Zones Required for the Protection of Aquatic Habitats

Method of Application /Use	Buffer Zone (m) Required for the Protection of Aquatic Habitats at Water Depths:					
	Freshwater Habitat			Estuarine/Marine Habitat		
	< 1 m	1–3 m	> 3 m	< 1 m	1–3 m	> 3 m
Field sprayer	120	120	70	120	120	120
Airblast sprayer (early season)	80	70	60	100	90	80
Airblast sprayer (late season)	70	60	50	90	80	70

Approximately 32% of the fish kill incidents reported in the United States were directly attributable to runoff from labelled uses of endosulfan. Endosulfan has also been linked to fish kills that occurred at various sites in Prince Edward Island in 1999. Buffer zones will not mitigate runoff. Endosulfan and the major transformation product endosulfan sulfate are persistent in soil; therefore, numerous runoff events could occur following applications of endosulfan. Vegetative filter strips have been proposed in some countries, e.g. the United States to mitigate risk to aquatic organisms from pesticide runoff. Field research is required in Canada to examine the effectiveness of vegetative filter strips in reducing risk to aquatic organisms from surface runoff of pesticides. Parameters such as vegetation type (e.g. grasses, broadleaf plants), plant density and the width of the filter strip required should be examined.

5.0 Value

5.1 Description of Registered Endosulfan Uses

Appendix IV lists all endosulfan products registered in Canada. Appendix V lists all the Commercial Class product uses for which endosulfan is presently registered. Appendix V shows which uses the registrant will continue to support, will no longer support or will partially support. Also presented is whether the use was added through the PMRA Minor Use Program. While currently supported by the registrant, the data supporting the minor uses were originally generated by a user group.

Uses of endosulfan belong to the following use-site categories: greenhouse non-food crops, greenhouse food crops, terrestrial feed crops, terrestrial food crops, outdoor ornamentals, outdoor structural industrial sites (food processing plants).

5.2 Commercial and/or Restricted Class Products

5.2.1 Alternatives to Commercial and/or Restricted Class Endosulfan Use

Appendix VI lists the registered chemical alternatives for unsupported uses of endosulfan or for those uses of endosulfan that the registrant continues to support but that have risk concerns as a result of this re-evaluation. The PMRA has not commented on the availability and extent of use of these alternatives.

Most sources of non-chemical alternatives focus on general cultural practices (including weed control, crop rotation, resistant varieties, appropriate soil cultivation and natural enemies). The PMRA has searched for information on specific site-pest combinations and found a number of non-chemical measures of pest control.

Site-Pest Combination	Alternative
Potato, tomato to control Colorado potato beetle	Plastic trenches around the perimeter of potato fields to trap adult beetles as they walk into fields in early spring or out of crop fields to overwintering sites in the fall.
Potato to control Colorado potato beetle	Use of propane burners to control beetles on small potato plants early in the season.
Brussels sprouts to control diamondback moth	Use sprinkler irrigation to discourage the development of larvae.
Broccoli, Brussels sprouts, cabbage and cauliflower to control diamondback moth, imported cabbageworm, cabbage looper and other caterpillars	In small fields use row covers to prevent moths from laying eggs.

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 endosulfan listed in Appendix VI and further information regarding the availability, effectiveness and extent of use of non-chemical control methods for any of the site-pest combinations listed in this appendix. This information will allow the PMRA to refine sustainable pest management options for the listed site-pest combinations.

5.3 Domestic Class Products

The registrant does not support the continued registration of the Domestic Class product Wilson Borer and Weevil Killer Liquid Insecticide (Reg. No. 14009) containing endosulfan, and this product will be phased out. The product is used on terrestrial food crops and outdoor ornamentals.

5.3.1 Alternatives to Domestic Class Products

The PMRA has no information about the use of the endosulfan Domestic Class product other than there are alternative active ingredients registered for the Domestic Class uses of endosulfan, with the exception of borers on ornamental shrubs and trees.

5.4 Value of Endosulfan

5.4.1 Endosulfan Use to Control Grape Phylloxera

There are no registered alternatives to endosulfan to control the leaf form of grape phylloxera. Malathion is registered for use as a root dip to control the root form of grape phylloxera; however, this option is limited to use prior to planting new rootstock and will not control the leaf form of grape phylloxera.

5.4.2 Endosulfan Use to Control Mirids and Pentatomids (plant bugs and stink bugs)

Tarnished plant bug (also known as lygus, or cat-facing insect)
There are no registered alternatives to endosulfan for the control of tarnished plant bug on the following crops: greenhouse pepper, cherry, cucumber, melon, pumpkin and squash. Azinphos-methyl is registered to control tarnished plant bug on plum, but is proposed to be phased out for use on this crop in 2007. Additionally the control of tarnished plant bug was added to the endosulfan label through the User Requested Minor Use Label Expansion (URMULE) process for greenhouse pepper, cucumber, melon, pumpkin and squash.

Stink bugs (also known as cat-facing insect)
There are no registered alternatives to endosulfan for the control of stink bugs on apricot and cherry. Furthermore, there are no viable registered alternative active ingredients to control stink bugs on peach and plum. Although azinphos-methyl is registered to control stink bugs on peach and plum, it has been proposed to be phased out for use on these crops in 2007.

5.4.3 Endosulfan and Resistance Management in Selected Crops: Rotation With Group 1 Insecticides

For the majority of the pests identified on the registered endosulfan labels to be controlled on stone fruit, cucurbits, solanaceous crops, forage crops and legumes, the registered alternative active ingredients are carbamates (mode of action [MoA] group 1A) or organophosphates (MoA group 1B). Endosulfan (MoA group 2A) is used for rotation with MoA group 1 insecticides for the purpose of resistance management. Rotation between insecticides with different modes of action should delay the development of resistance in insect populations. **Note**: insecticidal soap is registered to control aphids and mites on stone fruits, cucurbits, solanaceous crops and legumes; however, due to the short residual activity and potential for phytotoxicity from repeated applications, it is not considered to be a viable alternative to endosulfan.

5.4.4 Availability of Registered (or viable) Alternative Active Ingredients in Selected Crops

Details of the limitations of the registered alternative active ingredients by crop are discussed below.

Stone fruit (apricot, cherry, peach, plum)
The limitations of the registered alternative active ingredients for the control of the stone fruit pests listed on the registered endosulfan labels are summarized in Table 5.4.4.1. The majority of the stone fruit pests listed on the registered endosulfan labels have one of the following limitations:

- no registered alternative active ingredients;
- no viable registered alternative active ingredients; or
- the registered alternative active ingredients (which are viable) are limited to MoA group 1 insecticides.

Table 5.4.4.1 Value of Endosulfan Use for Stone Fruit Pest Management

Limitations of the Registered Alternative Active Ingredient		Crop			
		Apricot	Cherry	Peach	Plum
Lack of viable alternatives	Pests with no registered alternatives	Leafhoppers	Plant bugs, stink bugs	—	—
	Pests with no viable alternatives	Plum rust mite	—	Stink bugs[a]	Tarnished plant bug[a], stink bugs[a], plum rust mite[b] peach silver mite[c]
Resistance management	Pests with viable alternatives limited to MoA group[a]	Lesser peachtree borer, peachtree borer[d], twig borer, plant bugs, stink bugs, black cherry aphid, green peach aphid, mealy plum aphid	Lesser peachtree borer, peachtree borer[d], twig borer, leafhoppers, plum rust mite[e] black cherry aphid, green peach aphid, mealy plum aphid	Lesser peachtree borer, peachtree borer[d], leafhoppers, black cherry aphid, mealy plum aphid, plum rust mite	Lesser peachtree borer, peachtree borer[d], twig borer, leafhoppers, black cherry aphid[e], green peach aphid[e],
Number of pests with value concerns due to lack of alternatives or for resistance management (total number of pests)		10 (12)	10 (12)	7 (12)	10 (12)

[a] There is no viable alternative to endosulfan to control this pest as use of azinphos-methyl is proposed to be phased out on this crop in 2007.

[b] There are no viable alternative active ingredients to control plum rust mite, as lime sulphur is limited to use on dormant trees.

[c] Only one other active ingredient (dicofol) is registered to control peach silver mite on plum. Endosulfan is used for rotation with dicofol for the purposes of resistance management.

[d] Peachtree borer (root borer) pheromone is registered to control this pest in peaches; however, pheromones are frequently used in conjunction with other insecticides, which unlike pheromones, kill the pest. Endosulfan is essential for rotation with diazinon (the only other registered insecticide for control of peachtree borer on peach with killing activity) for the purposes of resistance management.

[e] Lime sulphur is registered for dormant season control only.

— Not applicable, as no pests have been identified with this value concern.

Cucurbits (cucumber, melon, pumpkin, squash)

Endosulfan is registered to control five pests (aphids, cucumber beetles, potato flea beetle, squash vine borer and tarnished plant bug) on cucumber, melon, pumpkin and squash. Of the pests listed, one (tarnished plant bug) has no registered alternatives. With the exception of cucumber beetles, for which kaolin clay was recently registered for population suppression, and aphids, for which insecticidal soap is registered, only MoA group 1 insecticides (organophosphates or carbamates) are registered to control the other pests listed on the registered endosulfan labels. In addition, there is no registered alternative active ingredient to endosulfan for the control of squash vine borer in pumpkin crops.

Solanaceous Plants (eggplant, pepper, tomato)

Eggplant
There are no registered alternative active ingredients to control pepper maggot on eggplant. Only MoA group 1 insecticides (organophosphates or carbamates) are registered to control flea beetles, hornworms, leafhoppers and tomato fruitworm (i.e. corn earworm). The only viable alternative to control aphids on eggplant is malathion (organophosphate; MoA group 1B).

Pepper
Only MoA group 1 insecticides (organophosphates or carbamates) are registered to control the following pests on pepper: flea beetles, hornworms, pepper maggot, leafhoppers, tomato fruitworm (corn earworm). The only viable alternatives to control aphids on peppers are MoA group 1 insecticides.

Tomato
There are no registered alternative active ingredients to control pepper maggot on tomatoes. The registrant does not support the use of wettable powder formulations of endosulfan on field tomatoes. Emulsifiable concentrate uses are supported.

Forage Crops (alfalfa and clover)
The registrant does not support the use of endosulfan on alfalfa and clover. The only registered alternative active ingredient for control of meadow spittlebug is malathion (organophosphate; MoA group 1B insecticide), which is currently under re-evaluation.

Legumes (beans and peas)
The registrant does not support the use of wettable powder formulations of endosulfan on beans and peas and does not support any endosulfan use on succulent beans and succulent peas. Retention of the emulsifiable concentrate formulation of endosulfan is needed for rotation with the Group 1 insecticides for the following site-pest combinations:

- beans to control Mexican bean beetles, potato leafhopper and green cloverworm. In addition, the only registered alternative active ingredient for the control of green cloverworm is diazinon, which is currently under re-evaluation.
- peas to control weevils. In addition, the only registered alternative active ingredient to control weevils on peas is malathion, which is currently under re-evaluation.

5.4.5 Endosulfan Use on Sugar Beet

Endosulfan is registered to control green peach aphid and beet webworm on sugar beets. There are no viable registered alternative active ingredients for the control of these pests. Insecticidal soap is registered for the control of aphids on sugar beet; however, due to the short residual activity and potential for phytotoxicity from repeated applications, it is not considered to be a viable alternative. Trichlorfon is registered to control beet webworm on sugar beets. Trichlorfon is currently under re-evaluation.

5.4.6 Endosulfan Use on Corn (field)

Endosulfan is registered to control corn leaf aphid on field corn. The registrant does not support the use of endosulfan on field corn. There are no viable registered alternative active ingredients for the control of corn leaf aphid. Insecticidal soap is registered for the control of aphids on field corn; however, due to the short residual activity and potential for phytotoxicity from repeated applications, it is not considered to be a viable alternative.

5.4.7 Endosulfan Commercial Class Product Non-Food or Feed Uses for Which There Are No Registered Alternatives

The following sites have been identified for which there are no registered alternative active ingredients:

- Greenhouse ornamentals to control black vine weevil, rose chafer and elm leaf beetle (the registrant does not support the use of endosulfan on greenhouse ornamentals);
- Food processing plants to control sap beetle; and
- Japanese yew (outdoors) to control black vine weevil.

5.4.8 Endosulfan Commercial Class Product Non-Food or Feed Uses and Resistance Management

The following site-pest combination has been identified for which only MoA group 1 insecticides are registered and rotation with endosulfan is necessary for the purposes of resistance management:

- Outdoor ornamentals for the control of black vine weevil and rose chafer.

5.4.9 Endosulfan Use on Residential Fruit Trees to Control Wood Boring Insects

There are no registered alternatives to the endosulfan Domestic Class product for use on residential fruit trees (peach and plum) and ornamentals to control wood boring insects. These hosts (particularly peach and plum) may act as a source of pests to infest orchard trees, particularly where residential yards are adjacent to production areas. The registrant does not support residential uses of endosulfan, and these uses will be phased out.

6.0 Other Assessment Considerations

6.1 Toxic Substances Management Policy

The PMRA has taken into account the federal TSMP during the review of endosulfan. The four criteria against which endosulfan has been assessed are as follows:

- predominantly anthropogenic (source);
- *Canadian Environmental Protection Act* (CEPA)-toxic or equivalent;
- persistence; and
- bioaccumulation.

By definition, the majority of chemical pesticides are considered as arising from anthropogenic sources as they are manufactured and applied to the environment for pest control purposes. As such endosulfan is considered to have met the criteria of being predominately anthropogenic.

Based on a refined environmental risk assessment endosulfan is entering the environment at levels that pose a risk to aquatic organisms; therefore, it would be considered "CEPA-toxic equivalent" under the *Canadian Environmental Protection Act*.

Endosulfan (α and β isomers) has been detected in air, water, snow and biota samples in remote areas such as the Arctic which has resulted from long range atmospheric transport, and meets the criteria for persistence in air. The combined half-life of total endosulfan isomers and endosulfan sulfate residues in soil ranged from 288 to 2148 days, which meets the TSMP criteria for persistence in soil (≥ 6 months). Endosulfan, therefore, meets the TSMP criteria for persistence.

A BCF of 11 583 has been observed in one species of fish (yellow tetra) which exceeds the TSMP criteria for BCF of ≥ 5000. Measured BAF values on a wet-weight basis for α-endosulfan for a variety of zooplankton and Arctic fish species presented in Table 4.1.1 ranged from 3400 to 670 000. The majority of these values exceed the TSMP criteria for BAF of ≥ 5000.

It has therefore been determined that endosulfan meets all of the TSMP Track 1 criteria and that the continued use of products containing endosulfan will result in the entry of a Track 1 substance into the environment. The TSMP calls for the virtual elimination of Track 1 substances. Should endosulfan be confirmed as a Track 1 substance, after consultation with stakeholders and finalization of the risk assessment, additional consultation with stakeholders will take place to develop an appropriate management strategy in accordance with the long-term goal of virtual elimination.

Hexachlorobenzene (HCB) and polychlorinated biphenyls (PCBs) have been identified as microcontaminants in technical endosulfan. HCB and PCBs are considered TSMP Track 1 substances. As described in Regulatory Directive DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*, the PMRA will work with registrants to reduce/eliminate microcontaminants of concern in line with the best available technology from a manufacturing perspective and encourage the development of new technology.

6.2 Formulant Issues

Formulant issues are being addressed through PMRA formulant initiatives and Regulatory Directive DIR2006-02, *Formulants Policy and Implementation Guidance Document*, published on 31May 2006.

7.0 Summary of the Preliminary Risk Assessment and Consultation

The preliminary risk assessment for endosulfan, conducted with the information available to the PMRA at this time, indicates a level of concern for workers and the environment for the remaining uses of endosulfan. Additional use pattern information and any other relevant data will be considered to determine if the evaluations presented in this document can be refined. 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.

Bayer Cropscience Inc. and Makhteshim Agan of North America Inc., registrants of endosulfan technical in Canada and primary data providers, are no longer supporting the following uses:

- alfalfa;
- clover;
- field corn;
- sunflower;
- spinach;
- greenhouse ornamentals;
- residential uses;
- succulent beans;
- succulent peas; and
- wettable powder uses on field tomatoes, sweet corn, dry beans and dry peas.

These uses are not included in the present risk assessment and were proposed for discontinuation in PACR2004-21. In response to PACR2004-21, grower groups requested that use of endosulfan on grapes and sugar beets be maintained and assessed in PMRA's re-evaluation. Therefore, these uses were retained. Support for all methods of application on succulent peas and succulent beans was withdrawn by the registrant.

Based on information available to the PMRA, results of the preliminary exposure risk assessment indicate a level of concern for workers with respect to the following application scenarios (for both WP and EC formulations):

- airblast application to apple, peach, pear, ornamental trees, grape;
- groundboom application to bean, corn, eggplant, pepper, field tomato, peas, potato, sugar beet;
- high-pressure handwand application to greenhouse crops (tomato, cucumber, pepper, lettuce), bark treatment, ornamentals, strawberry;
- bait application; and
- peach root dipping.

For the above scenarios the amount of endosulfan (kg a.i.) that could be safely handled per day for each application was calculated. However, additional information is required regarding whether limiting applications to these amounts would be agronomically feasible. Similarly, REIs were calculated to determine acceptable timeframes for re-entry following different endosulfan application scenarios. In general, these calculations resulted in lengthy REIs even when minimum rates of are applied. Therefore, additional information is also required on whether these REIs are feasible.

The dietary exposure estimates due to all potentially treated domestic and imported commodities exceeded the ARfD. Therefore, the preliminary risk assessment ranked commodities in order of decreasing agricultural importance, to determine a proposed commodity grouping that would not be unacceptable for dietary exposure. The final selection included apple, celery, cucumber, eggplant, pepper, pumpkin, rutabaga, sugar beet and turnip.

Chronic estimates of endosulfan in groundwater were below the DWLOC for all population subgroups, whereas acute estimates exceeded the DWLOC for most population subgroups.

The environmental assessment has determined that endosulfan meets all of the TSMP Track 1 criteria and that the continued use of products containing endosulfan will result in the entry of a Track 1 substance into the environment. If endosulfan remains classified as a Track 1 substance, after consultation with stakeholders and finalization of the risk assessment, additional consultation with stakeholders will be required to develop an appropriate management strategy in accordance with the long-term goal of virtual elimination.

7.1 Information Needed to Refine the Preliminary Risk and Value Assessment for Endosulfan

At this time, the preliminary risk assessment has identified additional data that will be required as a result of re-evaluation. These may be revised in the future as part of the proposed decision.

7.1.1 Refinement of Toxicology Risk Assessment

DACO 4.5.14 Developmental neurotoxicity study

A DNT study is required based on the toxicological evidence of clinical signs of neurotoxicity following oral exposure in the rat, rabbit and dog. In addition, the postulated mechanism of action for endosulfan involves interference with γ-amino butyric acid (GABA) neurotransmitter receptor function the CNS. A potential for endosulfan to alter other CNS neurotransmitter levels, including noradrenaline, dopamine and serotonin has been demonstrated in published studies (Zaidi et al.1985, Lakshmana et al.,1994). The DNT study would provide critical data to assess the toxic effects of endosulfan on the developing nervous system.

7.1.2 Refinement of Occupational Risk Assessment

7.1.2.1 Specific Data Needed to Refine the Occupational Risk Assessment

Greenhouse Crops

- DACO 5.4/5.5 — Mixer/Loader/Applicator—passive dosimetry data or biological monitoring data for greenhouse application using non-automated low volume mist sprayers
- DACO 5.9 — Dislodgeable Residue—dislodgeable residue data for greenhouse vegetables following application with relevant equipment.

Sweet Corn

- DACO 5.9 — Dislodgeable Residue—data for dislodgeable residues on corn after 21 days or rationale for acceptable re-entry for hand harvesting at the PHI

Root Dipping

- DACO 5.4/5.5 — Mixer/loader/applicator—passive dosimetry data or biological monitoring data for root dipping.
- DACO 5.6/5.7 — Postpplication— passive dosimetry data or biological monitoring data for handling peach seedlings following root dipping

7.1.2.2 Additional Data to Refine Occupational Risk Assessment

The following data might refine the occupational risk assessment, thus possibly reducing some restrictions and/or personal protective equipment requirements. These data include, but are not limited to, the following:

- typical rate and number of applications per season;
- typical area treated per day;
- information to support the feasibility of limiting the amount of product that can be handled per day;
- critical worker activities and their timing with respect to the stage of growth of the crop and application of endosulfan;

- passive dosimetry or biological monitoring exposure data representative of modern spray equipment and engineering controls;
- additional DFR data;
- data to support rates of application lower than the registered rates;
- information to support the feasibility of longer re-entry intervals; and
- data supporting the feasibility of additional protective clothing and/or other mitigation measures selected for postapplication worker activities.

7.1.3 Refinement of Aggregate Exposure Assessment

Data needed to refine the preliminary aggregate exposure assessment is as follows:

- As noted in Section 4.3, additional groundwater and surface water monitoring data would be required to evaluate actual acute and chronic concentrations of endosulfan and the major transformation product endosulfan sulfate in Canadian drinking water sources.

There are no outstanding data requirements needed for a regulatory decision. However, several study citations from USEPA reports and reviews were used in the dietary assessment. These data (or equivalent) may be requested in the future. Additional residue chemistry data may also be required to support any future request for use expansion or MRL promulgation.

List of Abbreviations

µg	microgram
AAFC	Agriculture and Agri-Food Canada
ADI	acceptable daily intake
AR	application rate
ARfD	acute reference dose
ATPD	area treated per day
a.i.	active ingredient
BAF	bioaccumulation factor
BCF	bioconcentration factor
CAS	Chemical Abstracts Service
CEPA	*Canadian Environmental Protection Act*
cm	centimeter
CNS	central nervous system
CODEX	Codex Alimentarius Commission of the Food and Agriculture Organization and the World Health Organization
CR	chemical-resistant
DACO	data code
DEEM	Dietary Exposure Evaluation Model
DFR	dislodgeable foliar residue
DNT	developmental neurotoxicity
DT_{50}	time required for 50% dissipation
DWLOC	drinking water level of concern
EC	emulsifiable concentrate
EC_{50}	effect concentration 50%
EDSP	Endocrine Disruptor Screening Program
EEC	expected environmental concentration
EXAMS	Exposure Analysis Modeling System
GABA	γ-amino butyric acid
GC-MS	gas chromatography with mass spectrometry
ha	hectare
HC_5	concentration that does not exceed the LC_{50} of 95% of the species
HCB	hexachlorobenzene
IUPAC	The International Union of Pure and Applied Chemistry
JPC	joint probability curve
kg	kilogram
$K_{oc}s$	soil organic carbon partition coefficient
K_p	skin permeability coefficient
L	litre
LC_{50}	mean lethal concentration
LD_{50}	mean lethal dose
LEACHM	Leaching Estimation and Chemistry Model
LOAEL	lowest observed adverse effect level
ln	natural logarithm
LOD	limit of detection

M/L/A	mixer/loader/applicator
MoA	mode of action
MOE	margin of exposure
MRL	maximum residue limit
N/A	not applicable
ng	nanogram
nm	nanometer
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration for survival
PACR	Proposed Acceptability for Continuing Registration
PCB	polychlorinated biphenyl
PHI	pre-harvest interval
pg	picogram
ppm	parts per million
PHED	Pesticide Handlers Exposure Database
PMRA	Pest Management Regulatory Agency
PPE	personal protective equipment
PRZM	Pesticide Root Zone Model
REI	restricted-entry interval
RQ	risk quotient
SST	species sensitivity distribution
TC	transfer coefficient
TMF	trophic magnification factor
TSMP	Toxic Substances Management Policy
URMULE	User Requested Minor Use Label Expansion
USEPA	United States Environmental Protection Agency
WP	wettable powder

Appendix I Toxicology Endpoints for Health Risk Assessment of Endosulfan

Table 1 Summary of Toxicological Endpoints for Endosulfan

Exposure Scenario	Endpoint(s)	Study	NOAEL (mg/kg bw/day)	UF/SF or MOE[a]
Acute Dietary General Population (includes females 13–50, infants, children)	Stilted gait, squatting posture, irregular respiration, decreased activity in female rats at 3 mg/kg bw	Acute neurotoxicity—rat	1.5	1000
	ARfD = 0.0015 mg/kg bw/day			
Chronic dietary (ADI)	Reduced body-weight gain, increased marked progressive glomerulonephritis, blood vessel aneurysm in male rats at 2.9 mg/kg bw/day	Two-year chronic dietary—rat	0.6	300
	ADI = 0.002 mg/kg bw/day			
Short-[b] and intermediate-term[c] dermal	Spasms, tremors	Overall NOAEL from 4 short-term dermal studies— rat	3.0[e]	300
Short-[b] intermediate-[c] long[d]-term inhalation	Decreased body-weight gain and decreased leukocyte count in males at 0.387 mg/kg bw/day	21-day inhalation—rat	0.2[f]	300
Long-term oral/dermal	Reduced body-weight gain, increased marked progressive glomerulonephritis, blood vessel aneurysm in male rats at 2.9 mg/kg bw/day	Two-year chronic dietary—rat	0.6	300

[a] UF/SF refers to total of uncertainty and/or safety factors for dietary assessments, MOE refers to desired margin of exposure for occupational assessments.
[b] Duration of exposure is 1–30 days.
[c] Duration of exposure is 1–6 months.
[d] Duration of exposure is > 6 months.
[e] No route-to-route extrapolation is required because the NOAEL was from a dermal study.
[f] No route-to-route extrapolation is required because the NOAEL was from an inhalation study.

Appendix II Summary of Occupational Risk Estimates for Endosulfan

Table 1 Route-Specific MOEs for Mixer/Loaders and Applicators—Airblast

Crop	Area Treated (ha/day)[a]	Formulation Type	Rate (kg a.i./ha)	Target MOE = 300[b]		Kg a.i. handled/day to Achieve Target MOE[e]
				Dermal MOE[c]	Inhalation MOEs[d] (no respirator)	
Airblast: maximum engineering controls (closed mix/load with coveralls, gloves; closed cab)						
Apple, peach, pear	16	WP	2.8	94	411	14.1
			2.25	117	512	
			1.3	203	886	
Apricot, cherry, plum	6	WP	2.25	313	1365	N/A
Ornamental trees	16	WP	2.8	94	411	14.1
		EC	2.8	91	453	13.6
Grape	16	WP	1.5	176	768	14.1
Airblast: closed mix/load (with coveralls and gloves) + open cab application with chemical-resistant coveralls, chemical-resistant headgear and gloves						
Apricot, cherry, plum	6	WP	2.25	229	173	7.8
			1.6	322	244	
Airblast: closed mix/load (with coveralls and gloves) + open cab application with chemical-resistant coveralls, chemical-resistant headgear, gloves and respirator						
Apricot, cherry, plum	6	WP	1.6	322	1919	10

[a] Area treated per day based on default values for airblast tree fruit/orchard and ornamental trees (16 ha/day). These values can be refined using crop-specific information.

[b] Values in shaded cells are below the target MOE.

[c] Dermal MOE = dermal NOAEL/dermal exposure. The short- intermediate-term dermal NOAEL is 3 mg/kg bw/day. Dermal exposure is calculated using the use rate (kg a.i./ha) × area treated per day (ha/day) × dermal unit exposure value (µg a.i./kg a.i. handled) ÷ by bw (70 kg).

[d] Inhalation MOE = inhalation NOAEL/inhalation exposure. The short- intermediate-term inhalation NOAEL is 0.2 mg/kg bw/day. Inhalation exposure is calculated using the use rate (kg a.i./ha) × area treated per day (ha/day) × inhalation unit exposure value (µg a.i./kg a.i. handled) ÷ by bw (70 kg).

[e] Maximum kg a.i. handled/day is determined considering both the inhalation and dermal routes of exposure.

Table 2 Route-Specific MOEs for Mixer/Loaders and Applicators—Groundboom

Crop	Area Treated (ha/day)[a]	Formulation Type	Rate[b] (kg a.i./ha)	Target MOE = 300[c]		Kg a.i. handled/day to Achieve Target MOE[f]
				Dermal MOE[d]	Inhalation MOEs[e] (no respirator)	
Groundboom: farmer—closed mix/load (with coveralls and gloves) + open cab application with chemical-resistant coveralls						
Broccoli, Brussels sprouts, cabbage, cauliflower, celery, lettuce, rutabaga, turnip	30	EC	0.8	309	545	N/A
		WP	0.875	300	468	
Cucumber, melon, pumpkin, squash	30	EC	0.6	411	727	
		WP	0.5	477	744	
Ornamental flowers and shrubs, (including potted plants)	10	EC	2.8	264	467	24.7
		WP		281	439	26.3
Strawberries	10	EC	1.1	673	1189	N/A
		WP		716	1116	
Groundboom: farmer—closed mix/load (with coveralls and gloves) + open cab application with coveralls and gloves						
Broccoli, Brussels sprouts, cabbage, cauliflower, celery, lettuce, rutabaga, turnip cucumber, melon, pumpkin, squash (0.6 EC/0.5 WP)	30	EC	0.6[g]	381	727	N/A
		WP	0.5[g]	439	744	
Eggplant, pepper	30	WP	0.5[g]	483	819	
Groundboom: farmer—closed M/L (with coveralls and gloves) + open cab application with a single layer of clothing[h] and gloves						
Strawberries	10	EC	1.1	371	1189	N/A
		WP		353	1116	
Groundboom: farmer—maximum engineering controls: closed mix/load (coveralls, gloves) + closed cab application (applications that do not achieve target MOE with open cab)						
Bean	100	EC	1	102	824	33.9
Corn	80	EC	1.7	75	606	
Eggplant, pepper, field Tomato	30	EC	1.68	202	1634	
Eggplant, pepper, field tomato		EC	1.2[g]	282	2288	
Eggplant, pepper	30	WP	1.125	328	1728	N/A
Peas	100	EC	0.8	127	1029	33.9
Potato	65	EC	0.8	195	1584	
		WP	0.875	195	1026	37.9
Sugar beet	100	EC	1.1	92	749	33.9

Crop	Area Treated (ha/day)[a]	Formulation Type	Rate[b] (kg a.i./ha)	Target MOE = 300[c]		Kg a.i. handled/day to Achieve Target MOE[f]
				Dermal MOE[d]	Inhalation MOEs[e] (no respirator)	
Groundboom: custom—maximum engineering controls: closed mix/load (with coveralls and gloves) + closed cab application						
Bean	300	EC	1	34	275	33.9
Corn	140	EC	1.7	43	346	
Peas	300	EC	0.8	42	343	
Potato	300	EC	0.8	42	343	
	300	WP	0.875	42	222	37.9
Sugar beet	300	EC	1.1	31	250	33.9

[a] Area treated per day based on default values: groundboom farmer high-acreage crops = 100 ha; groundboom farmer low-acreage crops (vegetables) = 30 ha; groundboom custom = 300 ha/day. These values can be refined using crop-specific information.

[b] Maximum registered application rate unless otherwise specified.

[c] Values in shaded cells are below the target MOE.

[d] Dermal MOE = dermal NOAEL/dermal exposure. The short- intermediate-term dermal NOAEL is 3 mg/kg bw/day. Dermal exposure is calculated using the use rate (kg a.i./ha) × area treated per day (ha/day) × dermal unit exposure value (µg a.i./kg a.i. handled) ÷ by bw (70 kg).

[e] Inhalation MOE = inhalation NOAEL/inhalation exposure. The short- intermediate-term inhalation NOAEL is 0.2 mg/kg bw/day. Inhalation exposure is calculated using the use rate (kg a.i./ha) × area treated per day (ha/day) × inhalation unit exposure value (µg a.i./kg ai handled) ÷ by bw (70 kg).

[f] Maximum kg a.i. handled/day is determined considering both the inhalation and dermal routes of exposure.

[g] Lowest registered application rate.

[h] Single layer of clothing = a long-sleeved shirt and long pants.

Table 3 Route-Specific MOEs for Mixer/Loaders and Applicators—Handheld Sprayers

Application Equipment	Crop	Maximum Application Rate	Default Values for Volume/Day	Target MOE = 300[a]		Kg a.i. handled/day to Achieve Target MOE[b]
				Dermal	Inhalation	
MOEs based on coveralls over a single layer of clothing, gloves and no respirator						
Low- pressure sprayer	Greenhouse: tomato, cucumber, pepper, lettuce	0.6 kg a.i./1000L	150 L/day	3174	3441	1
	Bark treatment, ornamentals	0.75 kg a.i./1000 L		2539	2753	
	Strawberry	0.55 kg a.i./1000 L		3462	3754	
High-pressure sprayer	Greenhouse: tomato, cucumber, pepper, lettuce	0.6 kg a.i./1000L	3750 L/day	38	41	0.29
	Bark treatment, ornamentals					
	Strawberry	0.55 kg a.i./1000 L		41	45	
Backpack Sprayer	Greenhouse: tomato, cucumber, pepper, lettuce	0.6 kg a.i./1000L	150 L/day	898	2505	0.27
	Bark treatment, ornamentals	0.75 kg a.i./1000 L		719	2004	
	Strawberry	0.55 kg a.i./1000 L		980	2733	
MOEs based on chemical-resistant coveralls, gloves and no respirator						
Low-pressure sprayer	Greenhouse: tomato, cucumber, pepper, lettuce	0.6 kg a.i./1000L	150 L/day	3364	3441	1
	Bark treatment, ornamentals	0.75 kg a.i./1000 L		2691	2753	
	Strawberry	0.55 kg a.i./1000 L		3670	3754	
High-pressure sprayer	Greenhouse: tomato, cucumber, pepper, lettuce	0.6 kg a.i./1000L	3750 L/day	51	41	0.38
	Bark treatment, ornamentals					
	Strawberry	0.55 kg a.i./1000 L		56	45	
Backpack Sprayer	Greenhouse: tomato, cucumber, pepper, lettuce	0.6 kg a.i./1000L	150 L/day	1151	2505	0.35
	Bark treatment, ornamentals	0.75 kg a.i./1000 L		921	2004	
	Strawberry	0.55 kg a.i./1000 L		1256	2733	

The maximum amount of product able to be handled per day while still achieving the target MOE for each sprayer was calculated for each sprayer type. The lowest value for maximum amount handled per day was then applied to all sprayer types as it is difficult to place restrictions of use on specific handheld sprayers (i.e. separate use conditions on high-pressure versus low-pressure sprayers).

This table demonstrates that, in the case of the high-pressure sprayer, there is only an incremental improvement in MOEs based on consideration of chemical-resistant coveralls (due to the limitations of the exposure data). As such, further consideration of mitigation options were based only on coveralls over single layer of clothing with gloves.

[a] Dermal MOE = dermal NOAEL/dermal exposure. The short- intermediate-term dermal NOAEL is 3 mg/kg bw/day. Dermal exposure is calculated using the use rate (kg a.i./ha) × area treated per day (ha/day) × dermal unit exposure value (µg a.i./kg ai handled) ÷ by bw (70 kg).
Inhalation MOE = inhalation NOAEL/inhalation exposure. The short- intermediate-term inhalation NOAEL is 0.2 mg/kg bw/day. Inhalation exposure is calculated using the use rate (kg a.i./ha) × area treated per day (ha/day) × inhalation unit exposure value (µg a.i./kg ai handled) ÷ by bw (70 kg).

[b] Maximum kg a.i. handled/day is determined considering both the inhalation and dermal routes of exposure.

Table 4 MOEs for Low-Volume Mist Sprayer, Bait and Root-Dip Treatment

Activity	Area Treated/Day	Rate	Data Used	Formulation Type	Dermal MOE	Inhalation MOE
Low-Volume Mist Sprayer (stationary/automated) for Greenhouse Lettuce						
PPE: open M/L— long pants, long-sleeved shirt, gloves; no respirator						
Mix/Load sprayer (not including application)	3 ha[a]	0.6 kg a.i./ha	PHED M/L Liquid	EC	2280	4861
Bait: Mixing and Placing in Food Processing Areas						
PPE: open M/L and apply— chemical-resistant coveralls over a single layer of clothing, gloves and respirator						
Mix active ingredient with bait, place on trays, tray placement	3.2–16 kg bait[b]	11 g a.i./kg bait	PHED: M/L WP APPLY: Granular bait dispersed by hand	WP	35–173	1203–6015 (602 without resp. at low ATPD)
Root Dip of Peach Seedlings						
PPE: open M/L— Single layer of clothing with gloves						
Mixer/Loader	150 L dip solution prepared/day[c]	0.76 kg a.i./day	PHED: M/L liquid	EC	5424	11558
Root dipper					< 1–3	ND[d]
Apply: coveralls over a single layer of clothing and gloves						
Root dipper	N/A	N/A	Kp model estimates systemic exposure to be between 1.7 and 35 mg/kg/day	EC	Systemic exposure is greater than NOAELs in oral dosing studies; therefore, it is not acceptable	

[a] Estimated average area of vegetable greenhouse in Canada.

[b] Area of 120 m × 120 m of warehouse (480 m perimeter) was based on a warehouse volume of 56 700 m^3 (USEPA 2000). A ceiling height of 4 m was assumed to calculate area and perimeter. Assumed bait placed every 15.2 m (based on label instruction). Assumption of 0.1 to 0.5 kg bait per tray was based on professional judgement (consistent with other bait products; however, these are based on rodent pests). 480 m/15.2 m = 31.5 trays at 0.1 to 0.5 kg/tray = 3.2 to 16 kg bait.

[c] Value is based on personal communication with the California Department of Pesticide Regulation on their assumptions and research associated with root dipping of nursery stock for cherry peach and plum seedlings for treatment of peachtree borer.

[d] ND = not determined. In the case of an individual dipping roots, the dermal MOEs indicated that the target risk was not achieved; therefore, it was not considered necessary to determine inhalation exposure/risk at this time.

Table 5 Summary of REIs for All Postpplication Activities for EC Formulations

Crop	No. of Applications	Application Rate (kg a.i./ha)	Activity	TC (cm^2/h)	REI	DFR[a] ($\mu g/cm^2$)	Dermal Exposure[b] (µg/kg bw/day)	MOE[c]
Bean	2	1	Hand harvesting	2500	12	0.035	9.82	306
			Irrigation, scouting	1500	9	0.058	9.66	311
			Scouting, thinning, hand weeding	100	0	0.875	6.31	475
Broccoli, Brussels sprouts, cabbage, cauliflower	2	0.8	Harvesting, irrigation, hand pruning (full foliage)	5000	16	0.0175	10	300
			Scouting (full foliage)	4000	14	0.022	9.73	308
			Hand weeding (full/min foliage); scouting, thinning, irrigation (minimum foliage)	2000	10	0.044	8.61	349
		0.6 (min)	Harvesting, irrigation, hand pruning (full foliage)	5000	14	0.0159	9.12	329
			Scouting (full foliage)	4000	12	0.0206	9.42	318
			Hand weeding (full/min foliage); scouting, thinning, irrigation (minimum foliage)	2000	8	0.041	9.38	320
Celery, lettuce	2	0.8	Hand harvesting	2500	11	0.035	9.13	329
			Irrigation, scouting (full foliage)	1500	8	0.058	9.38	320
			Hand weeding (full/minimum foliage); irrigation, scouting (minimum/foliage)	500	4	0.175	7.89	380
Sweet corn	1	1.7	Detasseling, hand harvesting	17000	> 22[d]	0.005	57.15	52
			Irrigation, scouting, hand weeding (full foliage)	1000	10	0.0875	9.15	328
			Scouting (low-crop height)	400	6	0.218	8.2	366
			Hand weeding	100	1	0.875	7.85	382
Cucumber, melon, pumpkin, squash	2	0.6	Hand harvesting, pruning, thinning, turning (full foliage)	2500	9	0.035	9.66	311
			Irrigation, scouting, hand weeding (full foliage)	1500	7	0.058	8.68	346
			Scouting, thinning, hand weeding (minimum foliage)	500	3	0.175	7.74	387

Crop	No. of Applications	Application Rate (kg a.i./ha)	Activity	TC (cm^2/h)	REI	DFR[a] ($\mu g/cm^2$)	Dermal Exposure[b] (µg/kg bw/day)	MOE[c]
Eggplant, pepper, field tomato	2	1.68	Hand harvesting and pruning, staking, tying (full foliage)	1000	10	0.0875	9.04	332
			Irrigation, scouting (full foliage), hand pruning (minimum)	700	8	0.125	9.2	326
			Weeding, scouting, thinning	500	6	0.175	10.13	296
		1.2	Hand harvesting and pruning, staking, tying (full foliage)	1000	8	0.0821	9.38	320
			Irrigation, scouting (full foliage), hand pruning (minimum)	700	6	0.126	10.13	296
			Weeding, scouting, thinning	500	5	0.161	9.19	327
Peas	2	0.8	Hand harvesting	2500	11	0.035	9.13	329
			Irrigation, scouting (full foliage)	1500	8	0.058	9.38	320
			Hand weeding (full foliage), scouting, thinning, irrigation (minimum foliage)	100	0	0.875	5.05	594
Potato	2	0.8	Irrigation, scouting (full foliage)	1500	8	0.058	9.38	320
			Hand weeding (full foliage), irrigation, scouting (minimum foliage)	300	2	0.291	8.22	365
Rutabaga, turnip	2	0.8	Hand harvesting	2500	11	0.035	9.13	329
			Irrigation, scouting, hand weeding (full foliage), thinning (min. foliage)	300	2	0.291	8.22	365
Sugar beet	1	1.1	Irrigation, scouting (full foliage)	1500	10	0.058	8.88	338
			Thinning, hand weeding (full foliage); irrigation, scouting (minimum foliage)	100	0	0.875	6.94	432
Strawberry	2	1.1	Hand harvesting, hand pinching, training (full foliage)	1500	10	0.058	8.88	338
			Irrigation, mulching, scouting, weeding	400	4	0.218	8.68	346
		0.5	Hand harvesting, hand pinching, training (full foliage)	1500	6	0.052	9.04	332
			Irrigation, mulching, scouting, weeding	400	1	0.201	9.23	325

Crop	No. of Applications	Application Rate (kg a.i./ha)	Activity	TC (cm^2/h)	REI	DFR[a] ($\mu g/cm^2$)	Dermal Exposure[b] (µg/kg bw/day)	MOE[c]
Ornamentals (cut flowers)	2	2.8	All	7000	> 22[d]	0.0484	38.76	77
		1.4	All	7000	> 2[d]	0.0242	19.38	155
Ornamentals (potted plants)	2	2.8	All	400	8	0.191	8.76	343
		1.4	All	400	5	0.187	8.58	350
Ornamentals (trees; Christmas trees)	1	2.8	Shaping Christmas trees	500	1	0.133	7.62	394
			Hand-line irrigations in Christmas trees	1100	3	0.08	9.43	318
		1.4	Shaping Christmas trees	500	1	0.0667	3.81	788
			Hand-line irrigations in Christmas trees	1100	1	0.0667	8.38	358
Greenhouse cucumber, tomato	1	0.75	All	1800	> 0[e]	1.215	250	12
Greenhouse pepper	1	0.6	All	1800	> 0[e]	0.972	200	15
Greenhouse lettuce	1	0.6	All	400	> 0[e]	0.972	44	68

[a] DFR calculations are based on actual data points from a study on peaches. The melon DFR calculations are based on a log-quadratic model. For greenhouse vegetables, estimated residues on day 0 are based on 20% of the application rate being dislodgeable.

[b] Dermal exposure = DFR × TC × 8 h /70 kg.

[c] Based on the short- and intermediate-term dermal NOAEL of 0.7 mg/kg/day (target MOE = 300); values in shaded cells indicate where target MOE is not met.

[d] At this day, the curve predicted by the log-quadratic equation beings to increase in value; therefore, this is the last relevant datapoint in the curve.

[e] REIs could not be established because DFR data were not provided for greenhouse crops and there is no default dissipation value for indoor crops.

Table 6 Summary of REIs for All Postpplication Activities for WP Formulations

Crop	No. of Applications	Application Rate (kg a.i./ha)	Activity	TC (cm^2/h)	REI	DFR[a] ($\mu g/cm^2$)	Dermal Exposure[b] (µg/kg bw/day)	MOE[c]
Apples, pear	1	2.8	Thinning (full/minimum foliage)	3000	> 3[d]	0.0415	14.24	211
			Hand harvest	1500	21	0.0573	9.82	306
			Hand pruning, scouting, pinching, tying, training	500	9	0.167	9.52	315
Apples, apricot, cherry, peach, pear, plum	1	2.25	Thinning (full/minimum foliage)	3000	> 32	0.0333	11.45	262
			Hand harvest	1500	18	0.056	9.61	312
			Hand pruning, scouting, pinching, tying, training	500	7	0.172	9.83	305
		1.4	Thinning (full/minimum foliage)	3000	21	0.0286	9.82	306
			Hand harvest	1500	13	0.0537	9.21	326
			Hand pruning, scouting, pinching, tying, training	500	4	0.162	9.27	324
Ornamental trees	1	2.8	Christmas tree hand line irrigation	1100	17	0.0752	9.46	317
			Shaping Christmas trees	500	9	0.167	9.52	315
			Grading/tagging Christmas trees	100	1	0.607	6.94	433
		1.4	Christmas tree hand line irrigation	1100	10	0.0741	9.31	322
			Shaping Christmas trees	500	3	0.198	10.76	280
			Grading/tagging Christmas trees	100	0	0.3034	3.47	865
Broccoli, Brussels sprouts, cabbage, cauliflower	2	0.875	Harvesting, irrigation, hand pruning (full foliage)	5000	> 26	0.0175	12.91	323
			Scouting (full foliage)	4000	26	0.0218	10.33	291
			Hand weeding (full/min foliage); scouting, thinning, irrigation (minimum foliage)	2000	15	0.0438	9.24	325
Broccoli, Brussels sprouts, cabbage, cauliflower	2	0.5 (min)	Harvesting, irrigation, hand pruning (full foliage)	5000	18	0.017	9.73	308
			Scouting (full foliage)	4000	16	0.0206	9.42	318
			Hand weeding (full/min foliage); scouting, thinning, irrigation (minimum foliage)	2000	11	0.0411	9.41	319

Crop	No. of Applications	Application Rate (kg a.i./ha)	Activity	TC (cm^2/h)	REI	DFR[a] ($\mu g/cm^2$)	Dermal Exposure[b] (µg/kg bw/day)	MOE[c]
Celery, lettuce	2	0.875	Hand harvesting	2500	17	0.033	9.31	322
			Irrigation, scouting (full foliage)	1500	13	0.053	9.03	332
			Hand weeding (full/min. foliage); irrigation, scouting (min./foliage)	500	7	0.158	8.19	337
Cucumber, melon, pumpkin, squash	4	0.55	Hand harvesting, pruning, thinning, turning (full foliage)	2500	13	0.035	9.46	317
			Irrigation, scouting, hand weeding (full foliage)	1500	10	0.058	9.24	325
			Scouting, thinning, hand weeding (min foliage)	500	5	0.175	8.87	338
		0.5 (min)	Hand harvesting, pruning, thinning, turning (full foliage)	2500	12	0.0349	9.99	300
			Irrigation, scouting, hand weeding (full foliage)	1500	9	0.0591	10.13	296
			Scouting, thinning, hand weeding (minimum foliage)	500	4	0.18	10.34	290
Eggplant, pepper	2	1.125	Hand harvesting and pruning, staking, tying (full foliage)	1000	12	0.0875	8.79	341
			Irrigation, scouting (full foliage), hand pruning (minimum)	700	10	0.125	8.63	348
			Weeding, scouting, thinning	500	8	0.175	9.07	331
Eggplant, pepper	2	0.5 (min)	Hand harvesting and pruning, staking, tying (full foliage)	1000	7	0.0891	10.19	295
			Irrigation, scouting (full foliage), hand pruning (minimum)	700	6	0.111	8.92	336
			Weeding, scouting, thinning	500	4	0.18	10.34	290
Potato	4	0.875	Irrigation, scouting (full foliage)	1500	13	0.058	9.03	332
			Hand weeding (full foliage), irrigation, scouting (minimum foliage)	300	5	0.292	8.47	354
Potato	4	0.5 (min)	Irrigation, scouting (full foliage)	1500	9	0.0591	10.13	296
			Hand weeding (full foliage), irrigation, scouting (min foliage)	300	2	0.308	10.57	284

Crop	No. of Applications	Application Rate (kg a.i./ha)	Activity	TC (cm^2/h)	REI	DFR[a] (µg/cm^2)	Dermal Exposure[b] (µg/kg bw/day)	MOE[c]
Rutabaga, turnip	2	0.875	Hand harvesting	2500	17	0.033	9.31	322
			Irrigation, scouting, hand weeding (full foliage), thinning (min foliage)	300	5	0.247	8.47	354
Strawberry	2	1.1	Hand harvesting, hand pinching, training (full foliage)	1500	14	0.0576	9.88	304
			Irrigation, mulching, scouting, weeding	400	7	0.196	8.96	335
Ornamentals (cut flowers)	2	2.8	All	7000	> 24[d]	0.072	57.59	52
		1.4	All	7000	> 26[d]	0.0361	28.91	104
Ornamentals (potted plants)	2	2.8	All	400	12	0.196	8.95	335
		1.4	All	400	8	0.202	9.23	325
Greenhouse cucumber, tomato	1	0.75	All	1800	> 0[e]	1.5	309	10
Grapes	2	1.5	Girdling	19300	> 24[e]	0.15	331	9
			Hand harvesting, training, thinning, hand pruning, tying, leaf pulling	8500	> 24[e]	0.15	146.8	21
			Scouting, hand weeding	700	> 24[e]	0.15	12	250

[a] DFR calculations for melon, peach and grape are based on the log-quadratic model (USEPA 1998). For greenhouse vegetables, estimated residues on day 0 are based on 20% of the application rate being dislodgeable.

[b] Dermal exposure = DFR minimum TC × 8 h /70 kg.

[c] Based on the short- and intermediate-term dermal NOAEL of 3 mg/kg bw/day (target MOE = 300); values in shaded cells indicate where target MOE is not met.

[f] At this day, the curve predicted by the log-quadratic equation beings to increase in value; therefore, this is the last relevant datapoint in the curve.

[g] REIs could not be established because DFR data were not provided for greenhouse crops and there is no default dissipation value for indoor crops.

Table 7 Postpplication Dermal Exposure for Adults and Youths Hand Harvesting Strawberries Treated With Endosulfan

Scenario	TC (cm^2/h)	DFR (µg/cm^2)[a]	Day of DFR Value	Exposure Via the Dermal Route[b] (µg/kg bw/day)	MOE[c] Target = 1000
EC Formulations at 1.1 kg a.i./ha					
At PHI					
Adult	1500	0.19	Day 7	1.87	803
Youth	1034			2.31	649
At REI Achieving Target MOE					
Adult	1500	0.062	Day 9	1.25	1202
Youth	1034	0.0518	Day 10	1.29	1162
WP Formulations at 1.1 kg a.i./ha					
At PHI					
Adult	1500	0.0744	Day 7	3.95	380
Youth	1034			4.89	307
At REI Achieving Target MOE					
Adult	1500	0.066	Day 13	1.33	1125
Youth	1034	0.057	Day 14	1.44	1044

[a] DFR for strawberries based on melon DFR for WP and EC, as used in occupational postapplication assessment.

[b] Exposure = DFR × TC (cm^2/h) × duration × dermal absorption /body weight.

[c] MOE = NOAEL/dermal exposure. NOAEL is 1.5 mg/kg bw/day with a target of 1000. Shaded cells indicate where the target MOE is not met.

Table 8 Aggregate Exposure for Adults and Youths Performing Pick-Your-Own Activities in Strawberries Treated With Endosulfan

Population	Day of DFR Data	Exposure (µg a.i./kg bw/day)			MOE[a] (target 1000)
		Dermal	Acute Dietary	Aggregate	
EC Formulation					
Adult (70 kg)	Day 9	1.25	0.103	1.35	1111
Youth (39 kg)	Day 10	1.29	0.081	1.37	1094
WP Formulation					
Adult (70 kg)	Day 13	1.33	0.103	1.43	1049
Youth (39 kg)	Day 14	1.44	0.081	1.48	1014

[a] MOEs are based on an acute NOAEL of 1.5 mg/kg bw/day and a target of 1000.

Table 9 Proposed Mitigation Measures and Feasibility for EC Products

Crop	Proposed Application Mitigation Measure[a]	Feasible?[b]	Proposed Postapplication Mitigation Measure	Feasible?[b]
Beans	Groundboom—closed M/L/A, handling a maximum of 34 kg a.i. handled/day (34 ha at maximum rate of 1.0 kg a.i./ha)	Unlikely	REI: 12 days for hand harvesting 9 days for other activities	Unknown
Broccoli, Brussels sprouts, cabbage, cauliflower	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 16 days 14 days at low application rate (0.6 kg a.i./ha)	Unlikely
Celery, lettuce	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 8 days PHI of 14 days addresses harvesting REI of 11 days	Unknown
Corn (sweet)	Groundboom—closed M/L/A, handling a maximum of 34 kg a.i. handled/day (20 ha at maximum rate of 1.7 kg a.i./ha)	Unknown	REI: 10 days No hand detasselling or hand harvesting	Unknown
Cucumber, melon, pumpkin, squash	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 9 days	Unlikely
Eggplant, pepper, field tomato	Groundboom—closed M/L/A, handling a maximum of 34 kg a.i. handled/day (20 ha at maximum rate of 1.68 kg a.i./ha)	Unknown	REI: 10 days 8 days at low application rate (1.2 kg a.i./ha)	Unknown
Peas	Groundboom—closed M/L/A, handling a maximum of 34 kg a.i. handled/day (43 ha at maximum rate of 0.8 kg a.i./ha)	Unlikely	REI: 11 days for hand harvesting 8 days for other activities	Unknown
Potato	Groundboom—closed M/L/A, handling a maximum of 34 kg a.i. handled/day (43 ha at maximum rate of 0.8 kg a.i./ha)	Unlikely	REI: 8 days	Unknown
Rutagage, turnip	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 2 days PHI of 45 days addresses harvesting exposure	Likely
Strawberries	Groundboom—closed M/L, open A with CR coveralls Handwands—closed M/L, coveralls over a single layer of clothing for application. Limit amount handled to 0.27 kg a.i./day (490 L at max rate of 0.55 kg a.i./1000 L).	Likely	REI: 10 days For both occupational exposure and for pick-your-own activities	Unknown
Sugar beets	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 10 days	Unknown
Ornamentals (potted)	Groundboom—closed M/L, open A with CR coveralls Handwands—closed M/L, coveralls over single layer for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Likely	REI: 8 days	Unknown
Ornamentals (cut flower)	Groundboom—closed M/L, open A with CR coveralls Handwands—closed M/L, coveralls over single layer for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Likely	REI: > 22 days[c]	Unlikely

Crop	Proposed Application Mitigation Measure[a]	Feasible?[b]	Proposed Postapplication Mitigation Measure	Feasible?[b]
Ornamentals (trees)	Airblast—closed M/L/A, handling a maximum of 14 kg a.i. handled/day (5 ha at maximum rate of 2.8 kg a.i./ha)	Unknown	REI: 3 days	Likely
Greenhouse—tomato, cucumber, lettuce, pepper	Handwands—closed M/L, coveralls over single layer for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Likely	MOEs < target on day 0 Unable to extrapolate past day 0[d]	No

[a] Closed M/L = closed mixing/loading (water-soluble packaging; open A = open-cab application; CR coveralls = chemical-resistant coveralls
Handwands = low-pressure handwand, high-pressure handwand, backpack application equipment, etc. Any limitation of the amount handled per day applies to all handwands.
Closed M/L/A = closed mixing/loading and closed cab. If closed cabs are not feasible, than an open cab with the applicator wearing chemical-resistant coveralls, chemical-resistant headgear, chemical-resistant gloves and a respirator is acceptable.

[b] Feasible for growers, farmers, commercial applicators, etc

[c] At this day, the curve predicted by the log-quadratic equation begins to increase in value; therefore, this is the last relevant datapoint in the curve.

[d] No applicable indoor DFR studies were submitted.

Table 10 Proposed Mitigation Measures and Feasibility for WP Products

Crop	Proposed Application Mitigation Measure[a]	Feasible?[b]	Proposed Postapplication Mitigation Measure	Feasible?[b]
Broccoli, Brussels sprouts, cabbage, cauliflower	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: > 26 days[d] 18 days at low application rate (0.5 kg a.i./ha)	Unlikely
Celery, lettuce	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 17 days If PHI can be increased to 17 days (currently 14 days), then the REI for other activities can be reduced to 13 days	Unlikely
Cucumber, melon, pumpkin, squash	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 13 days Restrict to 2 applications per season	Unknown
Eggplant, pepper	Groundboom—closed M/L/A, handling a maximum of 38 kg a.i. handled/day (34 ha at maximum rate of 1.12 kg a.i./ha)	Unknown	REI: 12 days 7 days at low application rate (0.5 kg a.i./ha)	Unknown
Potato	Groundboom—closed M/L/A, handling a maximum of 38 kg a.i. handled/day (43 ha at maximum rate of 0.875 kg a.i./ha)	Unlikely	REI: 13 days Restrict to 2 applications per season	Unknown
Rutabaga, turnip	Groundboom—closed M/L, open A with CR coveralls	Likely	REI: 5 days PHI of 45 days addresses harvesting exposure	Likely
Strawberries	Groundboom—closed M/L, open A with CR coveralls Handwands—closed M/L, coveralls over a single layer of clothing for application. Limit amount handled to 0.27 kg a.i./day (490 L at maximum rate of 0.55 kg a.i./1000 L).	Likely	REI: 10 days For both occupational exposure and for pick-your-own activities	Unknown
Ornamentals (potted)	Groundboom—closed M/L, open A with CR coveralls Handwands—closed M/L, coveralls over a single layer of clothing for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Likely	REI: 12 days 8 days at low application rate (1.4 kg a.i./ha)	Unknown
Ornamentals (cut flower)	Groundboom—closed M/L, open A with CR coveralls Handwands—closed M/L, coveralls over a single layer of clothing for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Likely	REI: > 24 days[d]	Unlikely
Ornamentals (trees)	Airblast—closed M/L/A, handling a maximum of 14 kg a.i. handled/day (5 ha at maximum rate of 2.8 kg a.i./ha)	Unknown	REI: 17 days 10 days at low application rate (1.4 kg a.i./ha)	Unknown
Apples, apricot, cherry, peach, pear, plum	Airblast—closed M/L/A, handling a maximum of 14 kg a.i. handled/day (5 ha at maximum rate of 2.8 kg a.i./ha) Handwands—closed M/L, coveralls over a single layer of clothing for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Unknown	REI: > 32 days[c] for thinning; 21 days at low application rate (1.4 kg a.i./ha) REI: 21(apples, pear) and 18 days (other fruit) for hand harvest (PHI: 15 days) 9 (apple, pear) to 7 days (other fruit) for other activities Restrict to 1 application/season for airblast	Unlikely

Crop	Proposed Application Mitigation Measure[a]	Feasible?[b]	Proposed Postapplication Mitigation Measure	Feasible?[b]
Grapes	Airblast—closed M/L/A, handling a maximum of 14 kg a.i. handled/day (9 ha at maximum rate of 1.5 kg a.i./ha)	Unknown	REI: > 24 days[c]	Unlikely
Greenhouse—tomato, cucumber	Handwands—closed M/L, coveralls over a single layer of clothing for application. Limit amount handled to 0.27 kg a.i./day (450 L at maximum rate of 0.6 kg a.i./1000 L).	Likely	MOEs < target on day 0. Unable to extrapolate past day 0[d]	No

[a] Closed M/L = closed mixing/loading (water-soluble packaging; open A = open-cab application; CR coveralls = chemical-resistant coveralls
Handwands = low-pressure handwand, high-pressure handwand, backpack application equipment, etc. Any limitation of the amount handled per day applies to all handwands.
Closed M/L/A = closed mixing/loading and closed cab. If closed cabs are not feasible, than an open cab with the applicator wearing chemical-resistant coveralls, chemical-resistant headgear, chemical-resistant gloves and a respirator is acceptable.

[b] Feasible for growers, farmers, commercial applicators, etc

[c] At this day, the curve predicted by the log-quadratic equation begins to increase in value; therefore, this is the last relevant datapoint in the curve.

[d] No applicable indoor DFR studies were submitted.

Appendix III Dietary and Drinking Water Risk Assessment

Table 1 Acute and Chronic Dietary Risk in Canada

Population	Acute Risk (% ARfD)[a]				Chronic Risk (% ADI)[c]
	All	Imported Only	Mitigation[b]	0 LOD	
General population	89	42	54	45	2
All infants (< 1 year)	113	64	89	55	3
Nursing infants	97	48	85	36	1
Non-nursing infants	114	69	89	62	4
Females 13–19 (not pregnant or nursing)	67	32	38	36	1
Females 20+ (not pregnant or nursing)	80	34	40	39	1
Males 13–19 years	75	32	45	43	1
Males 20+ years	71	32	39	38	1
Children 1–2 years	**168**	**94**	**115**	**91**	**7**
Children 3–5 years	145	78	98	87	5
Children 6–12 years	100	48	59	56	3
Children 7–12 years	71	32	42	40	2
Youth 13–19 years	73	31	38	36	1
Adults 20–49 years	79	36	43	42	1
Adults 50+ years	75	33	38	37	1

[a] Acute risk given as percent of reference dose (% ARfD) where ARfD = 0.0015 mg/kg bw/day for whole population. Monte Carlo iterations = 500, seed = 1.

[b] Proposed mitigation restricts usage to apple, celery, cucumber, eggplant, pepper, pumpkin, rutabaga, sugar beet and turnip.

[c] Chronic risk given as percent of acceptable daily intake (%ADI), where ADI = 2.0 µg/kg bw/day.

Table 2 Drinking Water Level of Comparison for Endosulfan

Population	DWLOC (µg/l)[a]		EEC (µg/l)[b]	
	Chronic	Acute	Chronic	Acute
General population	69	**24**	0.81–2.19	8.3–27.8
All infants < 1 year	20	**2**		
Children 1–6 years	28	**0**		
Children 7–12 years	38	**12**		
Females > 20 years	61	29		

[a] Entries in bold indicate that range of EEC exceeds level of concern.

[b] Tier 2 calculations of EEC using LEACHM (groundwater) and PRZM/EXAMS (water bodies). Groundwater values were reported as 0 and are of no concern.

Table 3 Violations of MRL for Imported and Domestic Commodities

IMPORTED	Size[a]	Detects[b]	MRL[c] (ppm)	Violations		
				Number[d]	Concentration[e] (ppm)	Period[f]
Bean	518	21	1	1	1.06	2001–2002
Endive	98	3	0.1	1	0.24	1999–2000
Grape	2180	3	1	1	2.13	1999–2000
Grapefruit	1208	1	0.1	1	0.48	2001–2002
Snow pea	522	12	0.5	1	0.78	1998–1999
Spinach	512	1	1	1	1.45	2000–2001
Star fruit	32	1	0.1	1	0.19	2001–2002
Strawberry	656	3	1	1	1.81	1998–1999
Tomato	2445	40	1	3	1.19–2.28	2002–2003
Zucchini	458	34	0.1	3	0.11–0.27	1998–1999

DOMESTIC[g]	Total	Detects	MRL (ppm)	Violations		
				Number	Range (ppm)	Period
Beet*	196	3	0.1	3	0.12	1999–2000
Chinese vegetables*	88	3	0.1	1	1.13–2.81	2001–2003
Cucumber, greenhouse	149	16	1	1	1.121	2002–2003
Endive*	87	2	0.1	2	0.83–1.41	1999–2003
Lettuce and leaf lettuce	746	22	2	3	2.02–2.98	1999–2003
Zucchini*	141	1	0.1	1	0.16	1998–1999

[a] **Size**: total number of samples taken during 1998–2003

[b] **Detects**: number of samples with readings above LOD.

[c] **MRL**: maximum residue limit as per subsection B.15.002 of the Food and Drug Regulations

[d] **Number**: number of violations during period

[e] **Concentration**: concentration range

[f] **Period**: violation period

[g] An asterix (*) indicates non-registered usage.

Table 4 Codex Maximum Residue Limits in Canada and in the United States

Commodity	Maximum Residue Limits (ppm)		
	Canada	United States	Codex
Apple	2	2	1
Apricot	2	2	2
Artichoke	1	2	2
Bean	1	2	2
Bean, succulent	1	R	2
Broccoli	2	2	2
Brussels sprout	2	2	2
Cabbage	2	2	2
Cauliflower	1	2	2
Celery	1	2	2
Cherry	2	2	1
Cucumber	1	2	2
Eggplant	1	2	2
Grape	1	R	2
Lettuce	2	2	2
Melon	1	2	2
Pea, dry	0.5	—	2
Pea, succulent	0.5	R	0.5
Peach/Nectarine	2	2	2
Pear	2	2	1
Pepper	1	2	2
Plum	2	2	1
Pumpkin	1	2	2
Spinach	2	R	2
Squash	1	2	2
Strawberry	1	2	2
Tomato	1	2	2
Turnip	0.1	2	2
Watercress	1	2	—
Milk and Byproducts			
Milk and dairy products	0.1	0.5	0.004
Butter	0.1	0.5	0.004
Cheese	0.1	0.5	0.004
Meat and Byproducts			
Cattle	0.1	0.2	0.1
Goat	0.1	0.2	0.1
Hog	0.1	0.2	0.1
Sheep	0.1	0.2	0.1
Poultry	0.1	—	—

Appendix IV Endosulfan Products Currently Registered (excluding discontinued products or products with a submission for discontinuation) as of July 2006

Registration Number	Marketing Class	Registrant	Product Name	Formulation Type	Guarantee
21712	Technical	Makhteshim Agan of North America Inc.	Thionex Endosulfan Technical	Solid	95%
24993	Technical	Bayer CropScience Inc.	Endosulfan Technical Active Insecticide	Solid	96%
25675	Manufacturing Concentrate	Bayer CropScience Inc.	Thiodan Manufacturing Use Product	Wettable powder	50%
14617	Commercial	United Agri Products Canada Inc.	Thionex 50W Wettable Powder Insecticide	Wettable powder	50%
15333	Commercial	Makhteshim Agan of North America Inc.	Thionex 50WP Endosulfan Commercial Insecticide	Wettable powder	50%
15747	Commercial	Bayer CropScience Inc.	Thiodan 4EC Insecticide Liquid Emulsifiable Concentrate	Emulsifiable concentrate	400 g/L
15821	Commercial	Bayer CropScience Inc.	Thiodan 50WP Insecticide Wettable Powder	Wettable powder	50%
23453	Commercial	Makhteshim Agan of North America Inc.	Thionex EC (Endosulfan) Insecticide	Emulsifiable concentrate	400 g/L
27021	Commercial	United Agri Products Canada Inc.	Endosulfan 400E Insecticide	Emulsifiable concentrate	400 g/L
14009	Domestic	Spectrum Brands IP Inc.	Wilson Borer and Weevil Killer Liquid Insecticide	Emulsifiable concentrate	5.2%

Appendix V The Registered Commercial Class Canadian Uses of Endosulfan (as of July 2006)

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 5: Greenhouse Food Crops									
Cucumber, tomato	Aphids, whitefly	EC, WP	Conventional ground application equipment	600 (EC) 750 (WP) 600/1000 L with high-pressure handwand application[c]	Not able to calculate as no limit to the number of applications is provided.	Apply as necessary	Not stated on labels	Y	
Lettuce	Green peach aphid	EC	Conventional ground application equipment	600 600/1000 L with high-pressure handwand application[c]	600	1	Not applicable	Y, M	
			Fogger	600					
Pepper	Aphids, tarnished plant bug	EC	Conventional ground application equipment	600 600/1000 L with high-pressure handwand application[c]	1200	2	Not stated on labels	Y, M	
Use-Site Category 6: Greenhouse Ornamental Crops									
Ornamentals	Aphids, cyclamen mite, Elm leaf beetle, rose chafer, spruce gall aphid, whitefly	EC, WP	Conventional ground application equipment	700 g/1000 L (EC) 750 g/1000 L (WP)	Not able to calculate as no limit to the no. of applications is provided.	Not stated on the labels	Not stated on the labels	N	• These uses are not supported by the registrant and were not included in the proposed endosulfan use standard published in PACR2004-21. • Comments from the public and provincial governments were provided, regarding the lack of viable alternatives to endosulfan for greenhouse ornamental production.
	Black vine weevil	EC		700 g/1000 L					
Japanese yew	Black vine weevil	EC, WP		760 g/1000 L (EC) 750 g/1000 L (WP)					
Use-Site Category 13: Terrestrial Feed Crops									
Alfalfa, clover	Meadow spittlebug	EC	Conventional ground application equipment	300	Not able to calculate as no limit to the no. of applications is provided.	Not stated on labels	Not stated on labels	N	• These uses are not supported by the registrant and were not included in the proposed endosulfan use standard published in PACR2004-21. • No comments were received from the public.

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 14: Terrestrial Food Crops									
Apple, pear (Eastern Canada)	Green apple aphid, rosy apple aphid, pearleaf blister mite, tarnished plant bug	WP	Conventional ground application equipment	2250	2800[c]	2	Not stated on labels	Y	• There is a proposed limit to the spray concentration to be applied by high-pressure handwand (600 g a.i./1000 L). There is no proposed change to the registered rates in terms of g a.i./1000 L (i.e. spray concentration) for conventional ground equipment. • The proposed limit to the application rate per hectare (2800 g a.i./ha) will limit the volume of spray that can be applied per hectare to 3 733 L from the current 4500 L/ha. The proposed seasonal rate limitation (2800 g a.i./ha) may reduce the number of applications that can be made because the volume of spray required for thorough coverage will depend on the tree row volume (i.e. orchards requiring greater than 1867 L for thorough coverage may be sprayed only once).
	Rust mite, pear psylla, codling moth			2800[c]		Not stated on label			
	White apple leafhopper, potato leafhopper			1300	1300	1	Not applicable	Y, M	
Apple, pear (British Columbia)	Green apple aphid, leafhoppers, lygus bugs, rosy apple aphid			1625	2800[c]	Not stated on label	Not stated on labels	Y	
	Pearleaf blister mite, rust mites, woolly apple aphid			2250					
	White apple leafhopper, potato leafhopper			1300	1300	1	Not applicable		
Use-Site Category 14: Terrestrial Food Crops									
Apricot, cherry, peach, plum	Black cherry aphid, eyespotted bud moth, green peach aphid, leafhoppers, mealy plum aphid, peach silver mite, plant bugs, plum rust mite, stink bugs, twig borers	WP	Conventional ground application equipment	2250	2800[c]	2	Not stated on labels	Y	• There is a proposed limit to the spray concentration to be applied by high-pressure handwand (600 g a.i./1000 L). There is no proposed change to the registered rates in terms of g a.i./1000 L (i.e. spray concentration) for conventional ground equipment. • The proposed seasonal rate limitation (2800 g a.i./ha) may reduce the number of application to one, because a maximum of 5600 L of spray may be applied per hectare per season when using the maximum registered spray concentration of 500 g a.i./1000 L. An amount of 7467 L of spray may be applied per hectare per season using the lowest registered spray concentration of 375 g a.i./1000 L. The volume of spray required for thorough coverage will depend on the tree row volume.
	Lesser peachtree borer, peachtree borer (root borer)	EC, WP		2800[c]	2800[c]	3 Eastern Canada 2 British Columbia	21 (Eastern Canada) Not Stated (British Columbia)		• The proposed limit to the application rate per hectare (2800 g a.i./ha) will limit the volume of spray that can be applied per hectare to 3 733 L when using a spray concentration of 750 g a.i./1000 L.

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 14: Terrestrial Food Crops									
Bean	Bean aphids, Mexican bean beetle, potato leafhopper	EC, WP	Conventional ground application equipment	1000	2000	2[c]	Not stated on labels	P	• Endosulfan wettable powder formulation use on beans was not included in the proposed endosulfan use standard published in PACR2004-21, as it was not supported by the registrants. • The registrants support the continued use of emulsifiable concentrate formulations of endosulfan on dry beans.
	Black bean aphid, green cloverworm	EC							
Celery	Aphids, cabbage looper, imported cabbageworm, tarnished plant bug	EC		800	1100[c]	Not stated on labels	Not stated on labels	Y	• The proposed rate limitation will reduce the number of applications to 1.
		WP		875					
Cole crops (broccoli, Brussels sprouts, cabbage, cauliflower)	Aphids, cabbage looper, diamondback moth (larvae), flea beetles, imported cabbageworm	EC		800	1600[c]	2[c]	Not stated on labels	Y	
		WP		875	1750[c]				
Use-Site Category 14: Terrestrial Food Crops									
Corn (sweet) Corn (field)	Corn leaf aphid	EC	Conventional ground application equipment	1100	1100	1[c]	Not applicable	P (sweet corn only)	• Use of the EC formulation of endosulfan on sweet corn is supported by the registrant. Endosulfan wettable powder formulation use on sweet corn was not included in the proposed endosulfan use standard published in PACR2004-21, as it was not supported by the registrant. • Use of endosulfan (EC or WP formulation) on field corn is not supported by the registrant. No comments were received from the registrant or the public in response to PACR2004-21 .
		WP		1125	2250	2	Not stated on labels	N	
	Corn earworm	EC		1700	1700[c]	1[c]		P (sweet corn only)	
		WP		1625	3250	2		N	
Cucumber, melon, pumpkin, squash	Aphids, cucumber beetles, potato flea beetle, squash vine borer	EC		600	2200[c]	4[c]	7 days for squash vine borer. Not stated for other pests.	Y	• The proposed rate limitation of 2200 g a.i./ha per season will reduce the number of applications to 3 for the end use products formulated as emulsifiable concentrates.
		WP		550	2200[c]				
	Tarnished plant bug	WP		550	2200[c]	4[c]	Not stated	Y, M	

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 14: Terrestrial Food Crops									
Eggplant, pepper	Aphids, Colorado potato beetle, flea beetles, green peach aphid, hornworms, leafhoppers, pepper maggot,	EC	Conventional ground application equipment	1100	2200	2	Not stated on the labels	Y	
		WP		1125	2200[c]	2[c]			
	Tomato fruitworm (corn earworm)	EC		1200[c]					
		WP		1125					
Grape	Grape phylloxera (leaf form), leafhoppers	WP		1500	3000	2	Not stated on the labels	Y	• Endosulfan is registered for control of grape phylloxera in Ontario only. • The registrant initially did not support endosulfan use on grapes. As a result of comments from growers regarding PACR2004-21, the registrant currently supports endosulfan use on grapes to control grape phylloxera.
Lettuce (head)	Aphids, cabbage looper, cabbageworms, tarnished plant bug	EC		800	1600	2[c]	Not stated on the labels	Y	
		WP		875	1750				

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 14: Terrestrial Food Crops									
Pea (canning, seed)	Pea aphid, pea weevil	EC	Conventional ground application equipment	800	1600	2[c]	Not stated on the labels	P	• The registrants support the continued use of emulsifiable concentrate formulations of endosulfan on dry peas.
	Aphids, weevils								
	Pea aphid, pea weevil	WP		875	1750	2		N	• Endosulfan wettable powder formulation use on peas was not included in the proposed endosulfan use standard published in PACR2004-21, as it is not supported by the registrants.
Peach seedlings (preplant treatment)	Peachtree borer (root borer)	EC	Root dip	500 g a.i./100 L of solution	500 g a.i./100 L of solution	1	Not applicable	Y	
Potato	Aphids, Colorado potato beetle, leafhoppers, potato flea beetle, tuber flea beetle	EC	Conventional ground application equipment	800	2200[c]	4[c]	Not stated on the labels	Y	
		WP		750					
	Tarnished plant bug	EC		800					
		WP		875					
Use-Site Category 14: Terrestrial Food Crops									
Rutabaga, turnip	Aphids, cabbage looper, diamondback moth larvae, flea beetles, imported cabbageworm	EC	Conventional ground application equipment	800	1600	2	Not stated on the labels	Y	
		WP		875	1750				
Spinach	Aphids, cabbage looper, imported cabbage worm, tarnished plant bug	EC		800	800	1	Not applicable	N	• This use is not supported by the registrant and was not included in the proposed endosulfan use standard published in PACR2004-21.
		WP		875	875				
Strawberry	Cyclamen mite	EC, WP		1100[c]	2200[c]	2	Not stated on labels	Y	• The registered application rate range for the WP formulated endosulfan products to control cyclamen mite is 1000–4500 g a.i./ha. The registered rate to control cyclamen mite for the EC formulated endosulfan products is 2000 g a.i./ha. The proposed rate reduction to 1100 g a.i./ha would require efficacy data or a scientific rationale to support the pest control claim at the reduced rate for EC products.
	Meadow spittlebug	EC		1000	2000	2[c]			
		WP		1100[c]	1100[c]	1			
	Strawberry aphid	EC		1000	2000	2[c]			
		WP		1100[c]	2200[c]				
	Tarnished plant bug	EC		1000	2000	2	10		
		WP		1100[c]	2200[c]				

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 14: Terrestrial Food Crops									
Sugar beet	Beet webworm, green peach aphid	EC		1100	1100	1	Not applicable	Y	• The registrant initially did not support endosulfan use on sugar beet. As a result of comments from growers regarding PACR2004-21, the registrant currently supports endosulfan on sugar beet.
Sunflower	Sunflower beetle	EC		600	600	1	Not applicable	N	• This use is not supported by the registrant and was not included in the proposed endosulfan use standard published in PACR2004-21.
Tomato	Aphids, Colorado potato beetle, flea beetles, green peach aphid, hornworms, leafhoppers, pepper maggot	EC		1100	2200[c]	4[c]	Not stated on the labels	Y	• The registered rate range to control these pests is 600–1100 g a.i./ha. The seasonal rate limit of 2000 g a.i./ha will reduce the number of applications at the lowest registered rate of 600 g a.i./ha to 3. Up to 2 applications may be made at 1100 g a.i./ha
	Tomato fruitworm (corn earworm)			1200[c]					• The registered rate range to control this pest is 1100–1680 g a.i./ha The seasonal rate limit of 2200 g a.i./ha will reduce the number of applications at the lowest registered rate of 1100 g a.i./ha to 2. Up to 1 application may be made at the maximum application rate of 1200 g a.i./ha.
Use-Site Category 14: Terrestrial Food Crops									
Tomato	Aphids, Colorado potato beetle, flea beetles, green peach aphid, hornworms, leafhoppers, pepper maggot, tomato fruitworm (corn earworm)	WP	Conventional ground application equipment	1125	Not able to calculate as no limit to the no. of applications is provided.	Not stated on the labels	Not stated on the labels	N	• Endosulfan wettable powder formulation use on tomatoes was not included in the proposed endosulfan use standard published in PACR2004-21.
Use-Site Category 20: Structural									
Food processing plant (outdoor areas)	Sap beetle (*Glischronchilus quadrisiganatus*)	WP	Bait	250 g/22.5 kg of bait	Not able to calculate as no limit to the no. of applications is provided.	Not stated on the labels	Not stated on the labels	Y	

Site(s)	Pests(s)	Formulation Type	Application Methods and Equipment	Application Rate (g a.i./ha)		Maximum Number of Applications per Year[a]	Minimum Number of Days Between Applications[a]	Supported Use[b]	Comments
				Maximum Single[a]	Maximum Cumulative[a]				
Use-Site Category 27: Outdoor ornamentals									
Ornamentals	Aphids, cyclamen mite, elm leaf beetle rose chafer, spruce gall aphid, whitefly	EC, WP	Backpack sprayers, hydraulic sprayers	700 g/1000 L (EC) 750 g/1000 L (WP) 600 g/1000 L using high-pressure handwand[c]	2800[c]	Not stated on the labels	Not stated on the labels	P	• There is a proposed limit to the concentration to be applied by high-pressure handwand (600 g a.i./1000 L). • Use of endosulfan products on ornamental plants in residential areas is not supported by the registrant. Use of endosulfan products for outdoor commercial production is supported by the registrant.
	Black vine weevil	EC		700 g/1000 L					
Japanese yew	Black vine weevil	EC, WP	Conventional ground application equipment	760 g/1000 L (EC) 750 g/1000 L (WP) 600 g/1000 L using high-pressure handwand[c]	2800[c]	Not stated on the labels	Not stated on the labels	P	

[a] Application information is from the registered labels unless otherwise indicated.

[b] Y = use is supported by the registrant; N = use is not supported by the registrant; P = the registrant partially supports the use pattern; and M = use was registered as a User Requested Minor Use Label Expansion (URMULE).

[c] Use limitation proposed in PACR2004-21

Appendix VI Alternative Registered Active Ingredients to Endosulfan for Those Site-Pest Combinations of Commercial Class Products That Are Not Supported by the Technical Registrant or for Which Risk Concerns Have Been Identified

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 5: Greenhouse Food Crops				
Cucumber	Aphids	Major pest • BC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • AB, ON, QC, NS: widespread yearly occurrence with low- to moderate-pest pressure.	• 1B: Dichlorvos, Naled[e] • 4: Imidacloprid (mature plants), Nicotine • Other: insecticidal soap[e]	Y
	Whiteflies	Major pest • BC, AB, ON, QC, NS: widespread yearly occurrence with high-pest pressure.	• 1B: Dichlorvos, Naled[e] • 3: Permethrin • 4: Imidacloprid (mature plants) • Other: insecticidal soap[e]	Y
Lettuce	Green peach aphid	Major pest • BC, AB, ON, QC, NS: widespread yearly occurrence with high-pest pressure.	• 1B: Malathion • 4: Nicotine • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y, M
Pepper	Aphids	Major pest • BC, AB, ON, QC, NS: widespread yearly occurrence with high-pest pressure.	• 1B: Diazinon • 4: Imidacloprid (green peach aphid), Nicotine • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin • 9: Pymetrozine	Y, M
	Tarnished plant bug	Minor pest • BC, AB, ON, QC, NS: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure.	None	Y, M
Use-Site Category 5: Greenhouse Food Crops				
Tomato	Aphids	Minor pest • BC, ON: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • AB, NS: no data • SK, QC: widespread yearly occurrence with low- to moderate-pest pressure.	• 1B: Diazinon, Dichlorvos, Naled[e] • 4: Imidacloprid (mature plants), Nicotine • Other: Insecticidal soap[e] • 9: Pymetrozine	Y
	Whitefly	Major pest (greenhouse, sweetpotato whitefly) • BC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • AB, NS: no data • SK, ON, QC: widespread yearly occurrence with high-pest pressure (greenhouse whitefly; sweetpotato whitefly not present in ON and QC.) Minor pest (banded wing whitefly) • BC, SK, QC: pest is not present. • AB, NS: no data • ON: localized yearly occurrence with low- to medium-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure.	• 1B: Dichlorvos, Naled[e] • 3: Permethrin • 4: Imidacloprid (mature plants) • Other: insecticidal soap[e]	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 6: Greenhouse Ornamental Crops				
Ornamentals	Aphids	No crop profile available from Agriculture and Agri-Food Canada (AAFC).	• 1A: Pirimicarb[f] • 1B: Acephate (roses), Chlorpyrifos[f], Dichlorvos, Malathion, Naled[e] (roses and cut flowers) • 4: Acetamiprid, Imidacloprid, Nicotine • 7: Kinoprene • 9: Pymetrozine • Other: insecticidal soap[e], insecticidal soap[e]pyrethrin	N
	Whiteflies		• 1B: Acephate (roses), Dichlorvos, Chlorpyrifos, Malathion (greenhouse whitefly), Naled[e] (roses and cut flowers) • 3: Permethrin[f] • 4: Acetamiprid, Imidacloprid • 7: Kinoprene • 9: Pymetrozine • 21:Ppyridaben • Other: insecticidal soap[e]/pyrethrin (greenhouse whitefly)	N
	Cyclamen mite		• 1B: Malathion • 3: Dicofol • Other: insecticidal soap[e]	N
	Rose chafer		None	N
	Elm leaf beetle		None	N
Use-Site Category 6: Greenhouse Ornamental Crops				
Ornamentals	Spruce gall aphid	• No crop profile available from AAFC.	• 1B: Chlorpyrifos, Dichlorvos, Malathion, Naled[e] (roses and cut flowers) • 4: aAetamiprid, Imidacloprid, Nicotine • 7: Kinoprene • 9: Pymetrozine • Other: insecticidal soap[e]	N
	Black vine weevil		None	N
Japanese yew	Black vine weevil		None	N
Use-Site Category 13: Terrestrial Feed Crops				
Alfalfa	Meadow spittlebug	No crop profile available from AAFC.	• 1B: Malathion	N
Clover	Meadow spittlebug		1 • B: Malathion	N
Use-Site Category 14: Terrestrial Food Crops				
Apple	Green apple aphid	Minor pest • BC, ON: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • QC, NS: widespread yearly occurrence with low- to moderate-pest pressure. • NB, PEI: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure.	• 1A: Methomyl, Oxamyl (non-bearing), Pirimicarb (Eastern Canada only) • 1B: Diazinon, Malathion, phosalone, Phosmet • 3: Pyhalothrin-lambda, Dltamethrin • 4: Acetamiprid, Imidacloprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Apple	Rosy apple aphid	Minor pest • BC, QC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON: widespread yearly occurrence with low- to moderate-pest pressure. • NB, PEI: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NS: Widespread yearly occurrence with high-pest pressure.	• 1A: Methomyl, Oxamyl (non-bearing), Primicarb (Eastern Canada only) 1 • B: Diazinon, Malathion, Phosalone, Phosmet • 3: Cyhalothrin-lambda, Deltamethrin • 4: Acetamiprid, iIidacloprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Woolly apple aphid	Minor pest • BC, NB, PEI: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON, NS: widespread yearly occurrence with low- to moderate-pest pressure. • QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure.	• 1A: Carbaryl, Methomyl, Pirimicarb (Eastern Canada only) • 1B: Diazinon, Malathion, Phosalone,Phosmet • 3: Cyhalothrin-lambda, Deltamethrin • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Pearleaf blister mite	• No data for this pest in the AAFC crop profile for apples.	• 1A: Carbaryl • 1B: Diazinon, Malathion, Phosalone Other: lime sulphur, insecticidal soap[e]	Y
Use-Site Category 14: Terrestrial Food Crops				
Apple	Tarnished plant bug	Minor pest • BC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON, QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NB: widespread yearly occurrence with low- to moderate-pest pressure. • PEI, NS: widespread yearly occurrence with high-pest pressure.	• 1A: Carbaryl, Oamyl (non-bearing) • 1B: Azinphos-methyl[g], Phosmet • 3: Cyhalothrin-lambda, Cypermethrin, Permethrin • Other: kaolin clay	Y
	Leafhoppers	Minor pests (see white apple leafhopper and potato leafhopper for details)	• 1A: Carbaryl (apple leafhopper), Formetanate hydrochloride (white apple leafhopper), Methomyl (white apple leafhopper), Oxamyl (non-bearing), Pirimicarb (white apple leafhopper; Eastern Canada only) • 1B: Azinphos-methyl[g], Diazinon, Phosalone • 3: Cyhalothrin-lambda (white apple leafhopper), cCpermethrin (white apple leafhopper), Deltamethrin (white apple leafhopper; Eastern Canada and British Columbia only), Permethrin (white apple leafhopper) • 4: Acetamiprid, iIidacloprid (white apple leafhopper) • Other: kaolin clay	Y, M

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Apple	White apple leafhopper	Minor pest • BC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON: widespread yearly occurrence with low- to moderate-pest pressure. • QC, NB, PEI: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NS: widespread yearly occurrence with high- pest pressure.	• 1A: Carbaryl, fFrmetanate hydrochloride, Methomyl, Oxamyl (non-bearing), Pirimicarb (Eastern Canada only) • 1B: Azinphos-methyl[g], Diazinon Phosalone • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin (Eastern Canada and British Columbia only), Permethrin • 4: Acetamiprid, Imidacloprid • Other: kaolin clay	Y, M
	Potato leafhopper	Minor pest • BC, NS, PEI: pest is not present. • ON: widespread yearly occurrence with low- to moderate-pest pressure. • QC, NB: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure.	• 1A: Oxamyl (non-bearing) • 1B: Azinphos-methyl[g], Diazinon, Phosalone • 4: Acetamiprid • Other: kaolin clay	Y, M
	Rust mite	Minor pest • BC, ON, NB, PEI: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. NS: widespread yearly occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl, Oxamyl (non-bearing) • 1B: Diazinon, Malathion, Phosalone (suppression) • 3: Dicofol • 21: Pyridaben • Other: insecticidal soap[c], lime sulphur • 23: Spirodiclofen	Y
Use-Site Category 14: Terrestrial Food Crops				
Apple	Pear psylla	• No data for this pest in the AAFC crop profile for apples.	• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon, Malathion, Phosalone • 4: Acetamiprid • Other: mineral oil, kaolin clay, insecticidal soap[c]	Y
	Codling moth	Major pest • BC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON, QC, PEI, NS: widespread yearly occurrence with high-pest pressure. • NB: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure.	• 1A: Carbaryl, Methomyl • 1B: Azinphos-methyl[g], Diazinon, Malathion, Phosalone, Phosmet • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 4: Acetamiprid • 18: Tebufenozide, Methoxyfenozide • Other: pheromone[c], kaolin clay (first generation), *Cydia pomonella* granulovirus	Y
Apricot	Peachtree borer (root borer)	• No crop profile available from AAFC.	• 1B: Diazinon • Other: Pheromone	Y
	Lesser peachtree borer		• 1A: carbaryl • 1B: diazinon	Y
	Twig borer		• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon	Y
	Black cherry aphid		• 1B: Diazinon, Malathion • Other: insecticidal soap[c], insecticidal soap[c]/pyrethrin	Y
	Eyespotted bud moth		• 1B: Diazinon • 5: Spinosad	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Apricot	Green peach aphid	No crop profile available from AAFC.	• 1B: Diazinon, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Leafhoppers		None	Y
	Mealy plum aphid		• 1B: Diazinon, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Peach silver mite		• 1A: Carbaryl • 23: Spirodiclofen • Other: insecticidal soap[e]	Y
	Plant bugs		• 1A: Carbaryl • 1B: Azinphos-methyl[g]	Y
	Plum rust mite		• Other: insecticidal soap[e]	Y
	Stink bugs		• 1A: Carbaryl (cat-facing insects) • 1B: Azinphos-methyl[g]	Y
Bean	Bean aphids	No data for this pest in the AAFC crop profile for dry beans. No crop profile available from AAFC for snap beans.	• 1B: Diazinon, Dimethoate, Malathion, Naled[e] (dry or field bean, lima bean) • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	P (EC formulation supported)
	Mexican bean beetle		• 1A: Carbaryl • 1B: Diazinon, Dimethoate, Malathion	P (EC formulation supported)
Use-Site Category 14: Terrestrial Food Crops				
Bean	Potato leafhopper	Major pest • AB: pest is not present. • MB: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON: widespread yearly occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Dimethoate, Malathion	P (EC formulation supported on dry bean)
	Black bean aphid	• No data for this pest in the AAFC crop profile for dry beans. • No crop profile available from AAFC for snap beans.	• See bean aphids	P (EC formulation supported on dry bean)
	Green cloverworm		• 1B: Diazinon	P (EC formulation supported on dry bean)
Broccoli	Aphids	Major pest • BC: widespread yearly occurrence with high-pest pressure. • ON, QC: widespread yearly occurrence with low- to moderate-pest pressure. • NB, NL: no data	• 1B: Diazinon, Dimethoate, Malathion, Methamidophos, Naled[e] • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Flea beetles	Minor-major • BC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON: widespread yearly occurrence with low- to moderate-pest pressure. • QC: widespread yearly occurrence with high-pest pressure. • NB, NL: no data	• 1A: Carbaryl • 1B: Diazinon, Malathion • 3: Cyhalothrin-lambda (crucifer flea beetle), Cypermethrin, Permethrin (crucifer flea beetle)	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Broccoli	Imported cabbageworm	Major pest • BC, ON: widespread yearly occurrence with high-pest pressure. • QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NB, NL: no data	• 1A: Carbaryl, Methomyl • 1B: Diazinon, Malathion, Methamidophos, Naled[e] • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Diamondback moth	Major pest • BC, ON, QC: widespread yearly occurrence with high-pest pressure. • NB, NL: no data	• 1A: Carbaryl, Methomyl• 1B:Diazinon, Methamidophos, Naled[e] • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Cabbage looper	Major pest • BC: widespread yearly occurrence with high-pest pressure. • ON, QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NB, NL: no data	• 1A: Carbaryl, Methomyl • 1B:Diazinon, Malathion, Methamidophos, naled[e] • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
Brussels sprouts	Aphids	• No crop profile available from AAFC.	• 1B: Acephate (green peach aphid), Diazinon, Dimethoate, Malathion, Methamidophos, Naled[e] • 4: Acetamiprid,Iimidacloprid (green peach and cabbage aphid) • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
Use-Site Category 14: Terrestrial Food Crops				
Brussels sprouts	Flea beetles	No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Diazinon, Malathion • 3: Cyhalothrin-Lambda (crucifer flea beetle), Cypermethrin, Permethrin (crucifer flea beetle)	Y
	Imported cabbageworm		• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Malathion, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var kurstaki	Y
	Diamondback moth		• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Cabbage looper		• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Malathion, Methamidophos, Naled[e] • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Cabbage	Aphids	Major pest • BC: Widespread yearly occurrence with high-pest pressure. • ON, QC: Widespread yearly occurrence with low- to moderate-pest pressure. • NS: Localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • MB, NB, PEI, NL: No data	• 1B:Acephate (green peach aphid), Diazinon, Malathion, Methamidophos, Naled[e] • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Flea beetles	Major pest • BC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • MB, NB, PEI, NL: no data • ON, QC: widespread yearly occurrence with low- to moderate-pest pressure. • NS: widespread yearly occurrence with high-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Malathion • 3: Cyhalothrin-lambda (crucifer flea beetle), Cypermethrin, Deltamethrin (Eastern Canada and British Columbia only), Permethrin (crucifer flea beetle)	Y
	Imported cabbageworm	Major pest • BC, ON, NS: widespread yearly occurrence with high-pest pressure. • QC: widespread yearly occurrence with low- to moderate-pest pressure. • MB, NB, PEI, NL: no data	• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Malathion, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
Use-Site Category 14: Terrestrial Food Crops				
Cabbage	Diamondback moth	Major pest • BC, ON, NS: widespread yearly occurrence with high-pest pressure. • QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • MB, NB, PEI, NL: no data	• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Cabbage looper	Major pest • BC: widespread yearly occurrence with high-pest pressure. • ON, QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NS: widespread yearly occurrence with low- to moderate-pest pressure. • MB, NB, PEI, NL: no data	• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Malathion, Methamidophos, Naled[e] • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
Cauliflower	Aphids	No crop profile available from AAFC.	• 1B: Acephate (green peach aphid), Diazinon, Dimethoate, Malathion, Methamidophos, Naled[e] • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Flea beetles		• 1A: Carbaryl • 1B: Diazinon • 3: Cyhalothrin-lambda (crucifer flea beetle), Cypermethrin, Permethrin (crucifer flea beetle)	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Cauliflower	Imported cabbageworm	• No crop profile available from AAFC.	• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Malathion, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Diamondback moth		• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Cabbage looper		• 1A: Carbaryl, Methomyl • 1B: Acephate, Diazinon, Methamidophos, Naled[e], Trichlorfon • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
Use-Site Category 14: Terrestrial Food Crops				
Celery	Aphids	• No crop profile available from AAFC.	• 1A: Pirimicarb (green peach, potato, foxglove and lettuce aphid in Ontario and Quebec only) • 1B:Acephate (green peach aphid only), Dimethoate, Malathion, Naled[e] • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cabbage looper		• 1B: Naled[e] • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Imported cabbageworm		• 1A: Carbaryl • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Tarnished plant bug		• 1A: Carbaryl • 1B: Acephate	Y
Cherry	Peachtree borer (root borer)	(sweet cherry) Minor pest • BC: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure. • ON: No data	• 1B: Diazinon • Other: Pheromone	Y
	Lesser peachtree borer	• No data	• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon	Y
	Twig borer	• No data	• 1A: Carbaryl • 1B: Diazinon, Phosmet (sour cherry)	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Cherry	Black cherry aphid	(sweet cherry) Major pest (aphids) • BC: widespread yearly occurrence with high-pest pressure. • ON: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Malathion, Phosalone • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Eyespotted bud moth	(sweet cherry) Minor pest • BC: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure. • ON: no data	• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon • 5: Spinosad	Y
	Green peach aphid	Major pest (aphids) • BC: widespread yearly occurrence with high-pest pressure. • ON: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure.	• 1B: Diazinon • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Leafhoppers	• No data for this pest in the AAFC crop profile for sweet cherry.	• 1A: Carbaryl (oak and prune leafhopper) • 1B: Fiazinon	Y
Use-Site Category 14: Terrestrial Food Crops				
Cherry	Mealy plum aphid	Major pest (aphids) • BC: widespread yearly occurrence with high-pest pressure. • ON: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Peach silver mite	• No data for this pest in the AAFC crop profile for sweet cherry.	• 1B: Diazinon • 3: Dicofol • Other: lime sulphur, insecticidal soap[e]	Y
	Plant bugs		None	Y
	Plum rust mite	Minor pest (rust mite) • BC: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON: no data	• 1B: Diazinon Other: lime sulphur, sulphur, insecticidal soap[e]	Y
	Stink bugs	• No data for this pest in the AAFC crop profile for sweet cherry.	None	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Corn (field)	Corn leaf aphid	Minor pest • BC: widespread yearly occurrence with low- to moderate-pest pressure. • AB, MB, QC, NB, NS: No data • ON: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	N
	Corn earworm	Minor pest • BC, AB, MB, NB: No data • ON, QC, NS: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl • 1B: Malathion (grain, forage corn) • 3: Cyhalothrin-lambda, Cypermethrin	N
Corn (sweet)	Corn leaf aphid	• No crop profile available from AAFC.	• 1A: Methomyl, Pirimicarb • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	P (EC formulation supported)
	Corn earworm		• 1A: Carbaryl, Methomyl • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin	P (EC formulation supported)
Use-Site Category 14: Terrestrial Food Crops				
Cucumber	Aphids	• No crop profile available from AAFC.	• 1B: Diazinon, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cucumber beetle		• 1A: Carbaryl • 1B: Diazinon, Malathion • Other: kaolin clay (suppression only)	Y
	Potato flea beetle		• 1A: Carbaryl • 1B: Diazinon, Malathion	Y
	Squash vine borer		• 1B: Diazinon	Y
	Tarnished plant bug		None	Y, M
Eggplant	Colorado potato beetle	• No crop profile available from AAFC.	• 1A: Carbaryl • 4: Imidacloprid • 5: Spinosad	Y
	Flea beetles		• 1A: Carbaryl • 1B: Malathion	Y
	Aphids		• 1B: Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Green peach aphid		• 1B: Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Hornworms		• 1A: Carbaryl	Y
	Pepper maggot		None	Y
	Leafhoppers		• 1A Carbaryl • 1B: Malathion	Y
	Tomato fruitworm (corn earworm)		• 1A: Carbaryl	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Grape	Grape phylloxera (leaf form)	Minor pest • BC, ON, NS: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate prest pressure. • QC: pest is not present	• 1B: Malathion (for treating nursery stock to control the root form of grape phylloxera)	Y
	Leafhoppers	Minor-major pests (several species identified) • BC: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate prest pressure (western grape leafhopper, Virginia creeper leafhopper). • QC: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate prest pressure (potato, three-banded, grape, grapevine leafhopper). • ON: widespread yearly occurrence with high-pest pressure (potato, grape leafhopper). Localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate prest pressure (three-banded leafhopper). • NS: no data	• 1A: Carbaryl • 1B:Azinphos-methyl[g], Diazinon, Malathion, Phosalone • 3:Ccypermethrin (grape leafhopper), Permethrin • 4: Acetamiprid • Other: kaolin clay	Y
Use-Site Category 14: Terrestrial Food Crops				
Lettuce (head, field)	Aphids	• No crop profile available from AAFC.	• 1A: Pirimicarb (green peach, potato, lettuce, foxglove aphid) • 1B:Acephate (green peach on head lettuce), Diazinon, Dimethoate, Malathion, Methamidophos (head lettuce), Naled[e] • 4: Acetamiprid, Imidacloprid Lettuce aphid) • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cabbage looper		• 1A: Carbaryl, Methomyl (field lettuce) • 1B: Acephate (crisphead only), Diazinon, Malathion, Methamidophos, Naled[e] • 3: Cyhalothrin-lambda (head lettuce) • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Cabbageworms		• 1A: Carbaryl • 1B: acephate (crisphead only), diazinon, malathion • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	Y
	Tarnished plant bug		• 1A: Carbaryl • 3: Cyhalothrin-lambda (head lettuce)	Y
Melon	Aphids		• 1B: Diazinon, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cucumber beetles		• 1A: Carbaryl • 1B: Diazinon, Malathion • Other: kaolin clay (suppression only)	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Melon	Potato flea beetle	No crop profile available from AAFC.	• 1A: carbaryl • 1B: diazinon	Y
	Squash vine borer		• 1B: diazinon	Y
	Tarnished plant bug		None	Y, M
Peach	Lesser peachtree borer	Minor pest • Information is only available for pest status.	• 1A: Carbaryl • 1B: Diazinon	Y
	Prachtree borer (root borer)	Major pest • Information is only available for pest status.	• 1B: Diazinon • Other: Pheromone	Y
	Twig borer	Major pest • Information is only available for pest status.	• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon, Phosalone, Phosmet • 3: Deltamethrin • Other: lime sulphur	Y
	Eyespotted bud moth	• No data for this pest in the AAFC crop profile for peach.	• 1B: Diazinon • 5: Spinosad	Y
	Green peach aphid	Major pest • Information is only available for pest status.	• 1A: Pirimicarb • 1B: diazinon, Dimethoate (non-bearing) • 3: Cyhalothrin-lambda • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Black cherry aphid	• No data • No data for these pests in the AAFC crop profile for peach.	• 1B: Diazinon, Dimethoate (non-bearing), Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Leafhoppers		1B: Diazinon	Y
Use-Site Category 14: Terrestrial Food Crops				
Peach	Mealy plum aphid	No data for this pest in the AAFC crop profile for peach.	• 1B: Diazinon, Dimethoate (non-bearing), Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Peach silver mite	Minor pest • Information is only available for pest status.	• 1A: Carbaryl • 1B: Dimethoate (non-bearing), Malathion • 3: Dicofol • 23: Spirodiclofen • Other: insecticidal soap[e]	Y
	Plant bugs	Major pest • Information is only available for pest status.	• 1A: Carbaryl • 1B: Azinphos-methyl[g], Dimethoate (non-bearing), Phosmet • 3: Cyhalothrin-lambda, Cypermethrin, Permethrin	Y
	Plum rust mite	• No data for these pests in the AAFC crop profile for peach.	• 1B: Dimethoate (non-bearing), Malathion • Other:insecticidal soap[e]	Y
	Stink bugs		• 1B: Azinphos-methyl[g]	Y
Pears	Green apple aphid	• No data	• 1B: Diazinon, Dimethoate, Malathion, Phosalone • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Rosy apple aphid		• 1B: Diazinon, Dimethoate, Malathion, Phosalone • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Pear	Woolly apple aphid	• No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Diazinon, Dimethoate, Malathion, Phosalone • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Pearleaf blister mite		• 1A: Carbaryl • 1B: Diazinon, Dimethoate, Phosalone • Other: insecticidal soap, lime sulphur, paraffinic mineral oil	Y
	Tarnished plant bug		• 1A: Carbaryl • 1B: Azinphos-methyl[g], Dimethoate • 3: cypermethrin • Other: kaolin clay	Y
	Leafhoppers		• 1A: Carbaryl (apple leafhopper) • 1B: Azinphos-methyl[g], Dimethoate, Phosalone • 4: acetamiprid • Other: kaolin clay	Y
	White apple leafhopper		• 1A: Carbaryl • 1B: azinphos-methyl[g], diazinon, phosalone • 4: acetamiprid • Other: kaolin clay	Y
	Potato leafhopper		• 1B: azinphos-methyl[g], diazinon, phosalone • 4: acetamiprid • Other: kaolin clay	Y
Use-Site Category 14: Terrestrial Food Crops				
Pear	Rust mite	No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Diazinon, Dimethoate, Phosalone, Phosmet • 3: Dicofol • 6: Abamectin • 21: Pyridaben • 23: Spirodiclofen • Other: insecticidal soap[e], lime sulphur, sulphur[e]	Y
	Pear psylla		• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon, Dimethoate Malathion (suppression), Phosalone, Phosmet • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 4: Acetamiprid • 6: Abamectin • 21: Pyridaben • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin, kaolin clay, paraffinic base mineral oil, mineral oil, Mancozeb	Y
	Codling moth		• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon, Dimethoate, Malathion, Phosalone, Phosmet • 3: Cypermethrin, Cyhalothrin-lambda, Permethrin • 4: Acetamiprid • 18: Tebufenozide • Other: kaolin clay (1st generation only), pheromone[e]	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Peas	Aphids (including pea aphid)	Major pest • BC, ON, QC: localized yearly occurrence with low- to moderate-pest pressure	• 1A: Methomyl (pea aphid),Ppirimicarb (pea aphid) • 1B: Dimethoate, Malathion, Naled[e] (peas for processing) • 3: Cyhalothrin-lambda (pea aphid) • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	P (EC formulation supported on dry peas)
	Weevils (including pea weevil)	No data for this pest in the AAFC crop profile for field pea.	• 1B: Malathion (pea weevil)	P (EC formulation supported on dry peas)
Pepper	Colorado potato beetle	No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Diazinon • 5: Spinosad	Y
	Flea beetles		• 1A: Carbaryl • 1B: Diazinon	Y
	Aphids		• 1A: Ppirimicarb (green peach aphid) • 1B: Acephate (green peach aphid on bell peppers), Diazinon, Dimethoate, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Green peach aphid		See aphids	Y
	Hornworms		• 1A: Carbaryl • 1B: Diazinon	Y
	Pepper maggot		• 1B: Acephate (bell pepper), Dimethoate, Malathion, Trichlorfon	Y
	Leafhoppers		• 1A: carbaryl • 1B: diazinon, malathion	Y
	Tomato fruitworm (corn earworm)		• 1A: carbaryl • 1B: diazinon	Y
Use-Site Category 14: Terrestrial Food Crops				
Plum	Peachtree borer (root borer)	No crop profile available from AAFC.	• 1B:Aazinphos-methyl[g], Diazinon • Other: pheromone	Y
	Lesser peachtree borer		• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon	Y
	Twig borer		• 1A: Carbaryl • 1B: Azinphos-methyl[g], Diazinon	Y
	Black cherry aphid		• 1A: Carbaryl • 1B: Diazinon, Malathion, Phosalone • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin, lime sulphur (dormant season egg control)	Y
	Eyespotted bud moth		• 1A: Carbaryl l • 1B: Azinphos-methyl[g], Diazinon • 5:Sspinosad	Y
	Green peach aphid		• 1B: Diazinon, Phosalone • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin, lime sulphur (dormant season egg control)	Y
	Leafhoppers		• 1A: Carbaryl (oak and prune leafhopper) • 1B: Diazinon, Phosalone	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Plum	Mealy plum aphid	No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Diazinon, Malathion, Phosalone • 3: Cyhalothrin-lambda • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin, lime sulphur (dormant season egg control)	Y
	Peach silver mite		• 3: Dicofol • Other: lime sulphur , insecticidal soap[e]	Y
	Plant bugs		• 1B: Azinphos-methyl[g]	Y
	Plum rust mite		• Other: lime sulphur, insecticidal soap[e]	Y
	Stink bugs		• 1B: Azinphos-methyl[g]	Y
Potato	Aphids	Major pest • BC , PEI: widespread yearly occurrence with high-pest pressure. • AB, SK, QC: widespread yearly occurrence with low- to moderate-pest pressure. • MB, ON, NS: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NL: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure.	• 1A: Methomyl, Oxamyl, Pirimicarb • 1B: Acephate (green peach and potato aphid), Diazinon, Dimethoate, Malathion, Methamidophos, Phosmet (potato aphid only) • 3: Deltamethrin (potato aphid, buckthorn aphid; Eastern Canada and BC only) • 4: Imidacloprid • 9: Pymetrozine • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
Use-Site Category 14: Terrestrial Food Crops				
Potato	Colorado potato beetle	Major pest • BC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • AB, SK: widespread yearly occurrence with low- to moderate-pest pressure. • MB, ON, QC, NB, NS, PEI: widespread yearly occurrence with high-pest pressure. • NL: pest not present	• 1A: Carbaryl, Carbofuran, Oxamyl • 1B: Chlorpyrifos, Diazinon, Malathion, Methamidaphos, Naled[e], Phosmet • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 4: Imidacloprid • 5: Spinosad • 11: *Bacillus thuringiensis* var *tenebrionis* • 17: Cyromazine (Ontario, Quebec and Atlantic provinces only)	Y
	Potato flea beetle	Major pest • BC: pest not present • AB, NL: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • SK, MB, NB: widespread yearly occurrence with low- to moderate-pest pressure. • ON, QC: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure. • NS, PEI: widespread yearly occurrence with high-pest pressure.	• 1A: Carbaryl, Carbofuran, Methomyl, Oxamyl • 1B: Acephate, Chlorpyrifos, Diazinon, Methamidophos, Naled[e], Phosmet • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 4: Imidacloprid	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Potato	Tuber flea beetle	Major pest • BC: widespread yearly occurrence with high-pest pressure. • AB: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • SK, MB, ON, QC, NB, NS, PEI, NL: pest is not present.	• 1A: Carbaryl, Methomyl, Oxamyl • 1B: Diazinon, Naled[e], • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin (British Columbia and Eastern Canada)	Y
	Leafhoppers	Major pest • BC, SK, MB, NB, PEI, NL: localized yearly occurrence with low- to moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • AB: widespread yearly occurrence, low- to moderate-pest pressure. • ON: widespread yearly occurrence with high-pest pressure. • QC, NS: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure.	• 1A: Carbaryl, Carbofuran (potato leafhopper), Methomyl, oxamyl (potato leafhopper) • 1B: Acephate(potato leafhopper), Diazinon, Dimethoate, Malathion, Methamidophos (potato leafhopper), Naled[e], Phosmet (potato leafhopper) • 3: Cyhalothrin-lambda (potato leafhopper), Cypermethrin, Deltamethrin, Permethrin (potato leafhopper) • 4: Imidacloprid (potato leafhopper)	Y
	Tarnished plant bug	Major pest • BC, AB, SK, QC: widespread yearly occurrence with low- to moderate-pest pressure. • MB, NB, NL: localized yearly occurrence with low- to • moderate-pest pressure or widespread sporadic occurrence with low- to moderate-pest pressure. • ON, NS, PEI: localized yearly occurrence with high-pest pressure or widespread sporadic occurrence with high-pest pressure.	• 1A: Carbaryl, Carbofuran, Oxamyl • 1B: Acephate, Chlorpyrifos, Methamidophos (Ontario only) • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin	Y
Use-Site Category 14: Terrestrial Food Crops				
Pumpkin	Aphids	No crop profile available from AAFC.	• 1B: Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cucumber beetles		• 1A: Carbaryl • 1B: Malathion • Other: kaolin clay (suppression only)	Y
	Potato flea beetles		• 1A: Carbaryl	Y
	Squash vine borer		None	Y
	Tarnished plant bug		None	Y, M
Rutabaga	Aphids	Major pest • BC, QC: widespread yearly occurrence with high-pest pressure. • SK, NB, NS: No data. • ON, NL: pest is not present. • PEI: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• 1B: diazinon, malathion • Other: mineral oil, insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cabbage looper	Major pest • BC, ON, NL: widespread yearly occurrence with high-pest pressure. • SK, NB, NS: no data. • QC: widespread yearly occurrence with low- to moderate-pest pressure. • PEI: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Malathion • 5: Spinosad	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Rutabaga	Diamondback moth	Major pest • BC, NL: widespread yearly occurrence with high-pest pressure. • SK, NB, NS: No data. • ON: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure. • QC: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure. • PEI: widespread yearly occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Trichlorfon • 5: Spinosad	Y
	Flea beetle	Major pest • BC, ON, QC: widespread yearly occurrence with high-pest pressure. • SK, NB, NS: no data. • PEI: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure. • NL: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl • 1B: Diazinon • 3: Cypermethrin (crucifer flea beetle)	Y
Use-Site Category 14: Terrestrial Food Crops				
Rutabaga	Imported cabbageworm	Major pest • BC, ON, NL: widespread yearly occurrence with high-pest pressure. • SK, NB, NS: no data. • QC: widespread yearly occurrence with low- to moderate-pest pressure. • PEI: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• 1A: Carbaryl • 1B: Diazinon, Malathion, Trichlorfon • 5: Spinosad	Y
Spinach	Aphids	No crop profile available from AAFC.	• 1A: Pirimicarb (green peach aphid in southern Ontario only) • 1B: Diazinon, Malathion, Naled[e] • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	N
	Cabbage looper		• 1B: Diazinon, Naled[e] • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	N
	Imported cabbageworm		• 1A: Carbaryl • 1B: Diazinon • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki*	N
	Tarnished plant bug		• 1A: Carbaryl	N

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Squash	Aphids	No crop profile available from AAFC.	• 1B: Diazinon, Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cucumber beetles		• 1A: Carbaryl • 1B: Diazinon, Malathion • Other: kaolin clay (suppression only)	Y
	Potato flea beetle		• 1A: Carbaryl • 1B: Diazinon, Malathion	Y
	Squash vine borer		• 1B: Diazinon	Y
	Tarnished plant bug		None	Y, M
Strawberry	Strawberry aphid	Major pest (aphids) • BC, NL: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure. • AB, SK, ON, QC, NB, NS: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure. • MB: widespread yearly occurrence with low- to moderate-pest pressure. • PEI: widespread yearly occurrence with high-pest pressure.	• 1A: Pirimicarb (non-bearing) • 1B: Diazinon, Dimethoate, Malathion, Naled[e] • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
Use-Site Category 14: Terrestrial Food Crops				
Strawberry	Tarnished plant bug	Major pest • BC, NS: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure. • AB, SK, MB, ON, QC, NB, PEI: widespread yearly occurrence with high-pest pressure. • NL: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure.	• 1A: Carbofuran (Eastern Canada only) • 1B: Dimethoate • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin (Eastern Canada and British Columbia only)	Y
	Meadow spittlebug	Minor pest • BC, MB: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure. • AB, ON, QC, PEI: widespread yearly occurrence with low- to moderate-pest pressure. • SK, NB, NS: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure. • NL: widespread yearly occurrence with high-pest pressure.	• 1A: Carbaryl, Carbofuran (British Columbia only) • 1B: Diazinon, Naled[e] • 3: Cyhalothrin-lambda, Cypermethrin	Y

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Strawberry	Cyclamen mite	Major pest • BC, ON: localized yearly occurrence with high-pest pressure or sporadic widespread occurrence with high-pest pressure. • AB, NS: widespread yearly occurrence with low- to moderate-pest pressure. • SK: localized yearly occurrence with low- to moderate-pest pressure or sporadic widespread occurrence with low- to moderate-pest pressure. • MB, QC, NB, PEI: widespread yearly occurrence with high-pest pressure. • NL: No data	• 1B: diazinon, dimethoate • 3: dicofol • Other: insecticidal soap[e]	Y
Sugar beet	Green peach aphid	No crop profile available from AAFC.	• Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Beet webworm		• 1B: trichlorfon	Y
Sunflower	Sunflower beetle		• 1A: carbofuran • 3: cyhalothrin-lambda, cypermethrin, deltamethrin	N
Use-Site Category 14: Terrestrial Food Crops				
Tomato	Colorado potato beetle	No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Acephate, Diazinon, Malathion • 3: Cyhalothrin-lambda, Cypermethrin, Deltamethrin, Permethrin • 4: Acetamiprid, Imidacloprid (Ontario, Quebec and Atlantic Canada) • 5: Spinosad • 11: *Bacillus thuringiensis* var *tenebrionis*	P (EC formulation supported)
	Flea beetles		• 1A: Carbaryl • 1B: Acephate, Diazinon • 3: Cyhalothrin-lambda (potato flea beetle), Cypermethrin (potato flea beetle), Permethrin (potato flea beetle)	P (EC formulation supported)
	Aphids		• 1A: Methomyl • 1B: Acephate, Diazinon, Dimethoate, Malathion • 4: Acetamiprid • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	P (EC formulation supported)
	Green peach aphid		• See aphids	P (EC formulation supported)
	Hornworms		• 1A: Carbaryl • 1B: Diazinon, Naled[e] • 3: Permethrin (tomato hornworm) • 11: *Bacillus thuringiensis* var *kurstaki*	P (EC formulation supported)
	Pepper maggot		None	P (EC formulation supported)

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 14: Terrestrial Food Crops				
Tomato	Leafhoppers	No crop profile available from AAFC.	• 1A: Carbaryl • 1B: Diazinon, Dimethoate, Malathion • 3: Cyhalothrin-lambda (potato leafhopper), Cypermethrin, Permethrin (potato leafhopper)	P (EC formulation supported)
	Tomato fruitworm (corn earworm)		• 1A: Carbaryl, Methomyl • 1B: Diazinon, Naled[e] • 3: Permethrin • 11: *Bacillus thuringiensis* var *kurstaki*	P (EC formulation supported)
Turnip	Aphids	See rutabaga	• 1B: Diazinon, Dimethoate (turnip greens), Malathion • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	Y
	Cabbage looper		• 1A: Carbaryl • 1B: Diazinon, Malathion • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki* (turnip greens)	Y
	Diamondback moth		• 1A: Carbaryl • 1B: Diazinon, Trichlorfon • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki* (turnip greens)	Y
	Flea beetles		• 1A: Carbaryl • 1B: Diazinon • 3: Cypermethrin (crucifer flea beetle), Permethrin (crucifer flea beetle)	Y
Use-Site Category 14: Terrestrial Food Crops				
turnip	imported cabbageworm	See rutabaga	• 1A: Carbaryl • 1B: Diazinon, Malathion, Trichlorfon • 5: Spinosad • 11: *Bacillus thuringiensis* var *kurstaki* (turnip greens)	Y
Use-Site Category 20: Structural				
Food processing plants (outdoors)	Sap beetle	No data	None	Y
Use-site category 27: outdoor ornamentals				
Japanese yew	Black vine weevil	• Pest status and incidence data is not available in the AAFC crop profile for field production or container production.	None	P
Ornamentals	Black vine weevil		• 1A: Carbaryl[f]	P
	Aphids		• 1A: Carbaryl[f] (cooley and eastern spruce gall aphid, elm leaf aphid, rose aphid), Pirimicarb[f] • 1B: Acephate[f], Chlorpyrifos[f], Diazinon, Dimethoate[f], Malathion, Naled [5, 6] • 3: Permethrin, Pyrethrin/Piperonyl butoxide[f], d-trans Allethrin/Piperonyl butoxide/N-octyl bicycloheptene dicarboximide (ornamental trees, shrubs and flowers[f]) • 4: Acetamiprid • 9: Pymetrozine • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	P

Site(s)	Pest	Pest Status/Incidence[a]	Alternative Registered Active Ingredients (resistance management mode of action group no.)[b, c]	Supported Use of Endosulfan (Y/N/P/M[d])?
Use-Site Category 27: Outdoor Ornamentals				
Ornamentals	Spruce gall aphid	Pest status and incidence data is not available in the AAFC crop profile for field production or container production.	• 1A: Carbaryl[f] • 1B: Chlorpyrifos, Diazinon, Malathion • 3: D-trans Allethrin/Piperonyl butoxide/N-octyl bicycloheptene dicarboximide • 4: Acetamiprid • 9: Pymetrozine • Other: insecticidal soap[e], insecticidal soap[e]/pyrethrin	P
	Whiteflies		• 1B: Acephate[f] (greenhouse whitefly) Chlorpyrifos, Dimethoate (azalea, gardenia, poinsettia), Malathion • 3: Pyrethrin/Piperonyl butoxide[f] • 4: Acetamiprid • Other: insecticidal soap[e], mineral oil (whitefly larvae on shade trees, conifers and shrubs)	P
	Cyclamen mite		• 1B: Diazinon (carnation, chrysanthemum), Dimethoate[f], Malathion • 3: Dicofol • Other: insecticidal soap[e]	P
	Rose chafer		• 1A: Carbaryl[f] • 1B: Diazinon (roses)	P
	Elm leaf beetle		• 1A: Carbaryl • 1B: Acephate (larvae on Chinese or Siberian elms) • 5: Spinosad	P

[a] Pest status and incidence data from the AAFC crop profiles published on the AAFC Pest Management Centre Publications web site: www.agr.gc.ca/env/pest/index_e.php?s1=pub&page=intro. BC = British Columbia, MB = Manitoba, SK = Saskatchewan, ON = Ontario, QC = Quebec, NB = New Brunswick, NS = Nova Scotia, PEI = Prince Edward Island, NL = Newfoundland.

[b] This is a list of registered alternatives only (as of July 2006). The PMRA does not endorse any of the alternatives listed. A number of the listed alternative active ingredients are in the process of being re-evaluated by the PMRA, including the following active ingredients for which proposal and information update documents have been published: acephate, carbaryl, diazinon, malathion, phosalone and phosmet. The registration status of active ingredients under re-evaluation may change pending the final regulatory decision. For additional information, consult the PMRA publications website at: www.pmra-arla.gc.ca/english/pubs/pubs-e.html.

[c] Resistance Management Group Numbers for insecticides: 1A = acetylcholinesterase inhibitors (carbamates); 1B = acetylcholinesterase inhibitors (organophosphates); 3 = sodium channel modulators; 4 = acetylcholine receptor agonists/antagonists; 5 = acetylcholine receptor modulators; 6 = chloride channel activators; 7 = juvenile hormone mimics; 9 = compounds of unknown or non-specific site of action; 11 = microbial disruptors of insect mid-gut membranes; 17 = inhibition of chitin biosynthesis; 18 = ecdysone agonist; 21 = site I electron transport inhibitors; 23 = inhibitors of lipid synthesis

[d] Y = use is supported by the registrant, N = use is not supported by the registrant, P = the registrant partially supports the use pattern, M = use was brought in as a User Requested Minor Use Label Expansion (URMULE) and by default is supported.

[e] The re-evaluation of the following active ingredients is complete: insecticidal soap (RRD2004-26); sulphur (RRD2004-19); codling moth pheromone (RRD2004-02); and naled (RRD2006-24).

[f] Registered for use on specific host plants only.

[g] The re-evaluation of azinphos-methyl is complete. The use of azinphos-methyl is proposed to be phased out as outlined in RRD2004-05. The last date of use of products containing azinphos-methyl was 31 December 2005 for the following crops: alfalfa, blueberry, boysenberry, broccoli, Brussels sprouts, cabbage (including tight heading varieties of Chinese cabbage), cauliflower, clover, cucumber, loganberry, melon, potato, pumpkin, quince, rutabaga, rye, strawberry, tomato, turnip, walnut, outdoor ornamentals, nursery plants, forest trees and shade trees. The phase-out for remaining crops have been revised to a later date: apple, crab apple, apricot, blackberry, cherry, cranberry, grape, pear, peach, plum, prune and raspberry.

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A list of published studies cited in this document is included below. References to unpublished proprietary data and monitoring reports that were considered in this Preliminary Risk and Value Assessment will be available when the final decision is made.

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