Pest Management Regulatory Agency
Agence de réglementation de la lutte antiparasitaire

Proposed Acceptability for Continuing Registration

PACR2003-03

Phase 2 of the Re-evaluation of Chlorpyrifos

The organophosphate active ingredient chlorpyrifos and associated end-use products were proposed for re-evaluation under Section 19 of the Pest Control Products Regulations in June 1999.

Chlorpyrifos has been re-evaluated in two phases based on use patterns. The first phase mainly covered the non-agricultural uses (e.g., indoor and outdoor residential uses). Phase 1 regulatory actions were announced on September 28, 2000. This document describes the outcome of the second phase (agricultural and forestry uses) of the Pest Management Regulatory Agency's (PMRA) re-evaluation of the insecticide chlorpyrifos and its end-use products. It includes a human health risk assessment, an environmental risk assessment and information on the value of chlorpyrifos to pest management in Canada.

As a result of the re-evaluation, the PMRA is proposing that certain measures be implemented to reduce environmental and occupational risks. These measures include discontinuation of chlorpyrifos use on certain crops (corn, filberts, lentils, oats, peppers, sugar beet, and tobacco). It is proposed that use on peaches and nectarines be allowed to continue until 2006. For the uses proposed for continued registration (canola, barley, carrot, flax, potato, wheat, strawberry, radish, Asian radish, celery, cucumber, cole crops, garlic, sunflower seeds, and rutabaga, and peaches and nectarines until 2006), it is proposed that environmental and occupational risks be mitigated by a reduction of the number of applications per season, restriction in aerial applications, buffer zones to protect aquatic ecosystems, implementation of engineering controls and personal protective equipment for workers, and establishment of re-entry intervals for post-application workers.

By way of this Proposed Acceptability for Continuing Registration document, the Agency is soliciting written comments from all interested parties on the decisions and mitigation measures proposed in Phase 2, and is requesting that registrants or other stakeholders identify crops that they intend to support. The PMRA is also interested in receiving comments on the accuracy and utility of use pattern information, particularly with respect to the grouping into key uses, important uses and crops with little or no uses.

Comments, forwarded to the Publication Coordinator at the address below, will be accepted up to 60 days from the date of publication of this document.

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Foreword

The re-evaluation of the active ingredient chlorpyrifos, and the associated end-use products (EPs) for use on several food, feed and non-food areas, has been completed by the Pest Management Regulatory Agency (PMRA).

The PMRA announced in June 1999 that organophosphate active ingredients, including chlorpyrifos, were subject to re-evaluation under authority of Section 19 of the Pest Control Products (PCP) Regulations.[1]

The PMRA has carried out an assessment of available information and has concluded that the use of chlorpyrifos and associated EPs on some crops does not entail an unacceptable risk of harm to human health or the environment pursuant to Section 20 of the PCP Regulations, provided that the proposed mitigation measures described in this document are implemented.

The PMRA will accept written comments on this proposal up to 60 days from the date of publication of this document to allow interested parties an opportunity to provide input into the proposed re-evaluation decision for these products.

[1] Re-evaluation Document REV99-01, *Re-evaluation of Organophosphate Pesticides*

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1.0 Purpose

Chlorpyrifos has been re-evaluated in two phases based on use patterns. The first phase mainly covered the non-agricultural uses (e.g., indoor and outdoor residential uses). Phase 1 regulatory actions were announced on September 28, 2000.[2] This document describes the outcome of the second phase (agricultural and forestry uses) of the Pest Management Regulatory Agency's (PMRA) re-evaluation of the insecticide chlorpyrifos and its end-use products (EPs). It includes a human health risk assessment, an environmental risk assessment and information on the value of chlorpyrifos to pest management in Canada. By way of this document, the Agency is soliciting comments from all interested parties on the decisions and mitigation measures proposed in Phase 2, and is requesting that registrants or other stakeholders identify those crops that they intend to support.

The Agency is also interested in receiving comments on the use pattern information, particularly with respect to the grouping into key uses, important uses and crops with little or no uses.

2.0 General background on re-evaluation

The PMRA is re-evaluating, under Section 19 of the Regulations pursuant to the *Pest Control Products Act* (PCPA), all pesticides, both active ingredients and formulated EPs, that were registered prior to 1995. As outlined in Regulatory Directive DIR2001-03, *PMRA Re-evaluation Program*, a modern scientific approach is used to determine the continuing acceptability of older active ingredients in relation to human health and the environment. Chlorpyrifos is under reassessment in the United States (U.S.) as a result of the *Food Quality Protection Act* and therefore is being re-evaluated by the PMRA under Program 3. The following components are addressed and considered in this re-evaluation:

Risk to human health
The initial focus of the re-evaluation of a pest control product in Program 3 is the risk to human health. As indicated in DIR2001-03, the reassessment in Program 3 pays particular attention to:

- pest control products with a common mechanism of toxicity,
- aggregate exposure to a pesticide arising from its residues in food and in drinking water, and from non-occupational exposure, such as from treatments in and around homes, and
- susceptibility and exposure of infants and children that may be different from that of adults during critical developmental stages.

[2] Re-evaluation Note REV2000-05, *Chlorpyrifos*

The re-evaluation of risks to human health also includes a re-examination of the acceptability of risks resulting from occupational exposure. Once the reassessments of all the individual active ingredients have been completed, a cumulative assessment of all the remaining uses of active ingredients sharing a common mechanism of toxicity will be conducted.

Risk to the environment

The environmental assessments will be tiered, with refined environmental risk assessments taking place only on those actives, products or uses that pass the cumulative health risk assessment or, for unique mechanisms of toxicity, that are acceptable from a human health perspective. At the first tier, based on an identification of hazards to non-target organisms, measures to reduce environmental exposures will be implemented where warranted. These measures may include removing uses that are obsolete, reducing the number of applications, requiring buffer zones to protect sensitive habitats and taking regulatory action against uses that have been determined to be an extremely high risk to organisms in the environment. In general, uses that remain after the first tier assessment will be revisited when the results of refined environmental assessments are available.

A tiered approach is necessary for several reasons. For some products, initial environmental assessments indicate a high hazard. However, there is considerable uncertainty with regard to the frequency and magnitude of exposure and effects. For some products there is also little data on field concentrations and (or) adverse effects. A tiered approach to environmental risk assessment would allow for development and implementation of refined ecological risk assessment methods, for additional data to be provided to refine the environmental exposure assessments and for consideration of the preferability of existing alternatives and the development of new ones. In addition, a tiered approach would make the most efficient use of assessment resources.

Value

The PMRA seeks to understand, as early as possible in the re-evaluation process, the current uses of products under review and their importance for pest management in agriculture, the nursery trades, forestry and public health. The PMRA relies to a great extent on provincial and territorial government input. Registrants and users are also an important source of information. Environment Canada, the Department of Foreign Affairs and International Trade, the Canadian Food Inspection Agency and Agriculture and Agri-Food Canada are also contacted, as needed, in the re-evaluation process for information specific to their areas of expertise.

The outcome of the re-evaluation of each pesticide, including proposed risk mitigation measures, will be published in a consultation document at the end of the aggregate human health risk assessment and the first tier environmental risk assessment. In some cases, the PMRA will implement changes in regulatory status of products prior to public consultation, especially where the PMRA considers risk mitigation ineffective or impractical, or where registrants have opted for voluntary discontinuation of the sale of products.

3.0 Re-evaluation of chlorpyrifos

Chlorpyrifos is one of the 27 organophosphate (OP) insecticides subject to re-evaluation in Canada. The re-evaluation of chlorpyrifos was announced in Re-evaluation Document REV99-01, *Re-evaluation of Organophosphate Pesticides*. Chlorpyrifos is a broad spectrum, non-systemic insecticide with contact, ingestion (as stomach poison) and vapour activity. Like other OPs, chlorpyrifos inhibits acetylcholinesterase enzyme, interrupting the transmission of nerve impulses. First registered in 1969, chlorpyrifos has been used for control of arthropod pests on over 30 food, feed and oilseed crops in Canada, including wheat, canola, corn, potatoes and vegetable crops. It has also been registered for control of a wide range of arthropod pests in non-food areas including turf, ornamentals, homes, commercial and farm buildings, and for application to water bodies for control of mosquitoes.

This re-evaluation of chlorpyrifos has been carried out in two phases. The first phase focussed on non-agricultural uses, especially uses in and around residential areas. As a result of Phase 1, actions have already been taken on residential uses of chlorpyrifos in consideration of risks to human health and the environment. Regulatory actions are also being taken to lower maximum residue limits (MRLs) for chlorpyrifos residues in apples, grapes and tomatoes. This is consistent with regulatory changes occurring in the U.S. for the same food commodities. The regulatory actions taken in Phase 1 are summarized in Appendix I.

The second phase of the re-evaluation is focussing on agricultural and forestry uses and is the subject of this document.

Much of the scientific information used by the PMRA in its assessment of chlorpyrifos came from reviews conducted by the U.S. Environmental Protection Agency (EPA). The EPA review for chlorpyrifos can be referenced for further details regarding the scientific studies used by the PMRA. These reviews, as well as other information on the regulatory status of chlorpyrifos in the U.S., can be found at the website for the EPA, http://www.epa.gov/pesticides/reregistration/status.htm.

4.0 Human health assessment

4.1 Toxicology summary

The toxicology database supporting chlorpyrifos is extensive; numerous studies were available from the registrants as well as from the published literature. In laboratory animals, chlorpyrifos was found to be highly acutely toxic following acute oral and inhalation exposures and slightly acutely toxic by the dermal route of exposure. Following both single and repeated dosing, the most sensitive indicator of toxicity was the inhibition of acetylcholinesterase, an enzyme necessary for the proper functioning of the nervous system. Clinical signs of cholinergic toxicity were typically observed in animals only when acetylcholinesterase was inhibited to a significant degree

(i.e., at higher doses). Anaemia and effects on the adrenal gland, liver and eyes were also noted in intermediate- to long-term animal studies, but only at relatively high doses. Chlorpyrifos was not found to be mutagenic nor was it carcinogenic to either rats or mice. Chlorpyrifos did not cause fetal malformations in either rats or rabbits, nor did it cause reproductive toxicity in rats other than a slight increase in post-implantation loss at very high doses. The majority of submitted developmental toxicity studies did not demonstrate any quantitative sensitivity of young animals relative to adult animals. Therefore, the unborn or nursing animals that are exposed to chlorpyrifos only indirectly (i.e., in utero or via maternal milk) would be protected as long as the maternal animals were not adversely affected. However, the PMRA found some evidence to suggest that young rats exposed directly to chlorpyrifos (oral dosing) may be more sensitive to the acetylcholinesterase inhibiting effects of chlorpyrifos than adult rats. As well, a number of publications suggest that chlorpyrifos may have the potential to affect brain development by altering a number of cellular processes and that these effects may be independent of its effects on acetylcholinesterase. The registrant has indicated that a dog study, with cholinesterase measures of peripheral nervous tissues, will be submitted for further review.

Reference doses for various populations have been set based on no observed adverse effect levels (NOAELs) for the most sensitive indicator of toxicity, namely acetylcholinesterase, and incorporate various uncertainty and safety factors to account for extrapolating between rats and humans as well as for variability within human populations. The PMRA has established separate reference doses for females of child-bearing age, since there is some evidence to suggest that pregnant rats may be slightly more sensitive to the effects of chlorpyrifos. The PMRA has also established separate reference doses that incorporate an additional safety factor (in light of the above observations regarding sensitivity of the young) for children up to 12 years of age.

4.2 Occupational risk assessment

Significant changes are being proposed to provide additional protection for individuals who are occupationally exposed to chlorpyrifos including workers who mix, load and apply chlorpyrifos in a variety of settings and workers who enter treated fields to perform various activities, e.g., scouting, thinning and harvesting.

Occupational risk is estimated by comparing potential exposure (in mg active ingredient (a.i.)/kg body weight/day (bw/d)) to an acceptable exposure level (AEL) (also in mg a.i./kg bw/d). The risk exceeds the PMRA's level of concern if the estimated exposure exceeds the AEL.

The most sensitive worker population was considered by the PMRA to be pregnant women; therefore, the PMRA established an AEL for short-, intermediate- and long-term dermal exposure scenarios, of 0.001 mg/kg bw/d (systemic dose) based on a lowest observed adverse effect level (LOAEL) of 0.3 mg/kg bw/d that the PMRA determined to be appropriate for acetylcholinesterase inhibition in pregnant rats in a 25-day developmental neurotoxicity study [1]. A total margin of exposure (MOE) of 300-fold

was required, 10-fold to account for the extrapolation between test animals and humans, 10-fold to account for the variability within the human population and an additional 3-fold uncertainty factor that the PMRA considered necessary to account for the lack of a NOAEL in the developmental neurotoxicity study. The PMRA also considers this AEL to be protective of a worker's unborn or nursing child, in that it provides an intrinsic 1000-fold margin of safety (MOS) to the NOAEL of 1.0 mg/kg bw/d that the PMRA observed for the offspring developmental effects in this same study.

The AEL for short-, intermediate- and long-term inhalation exposure scenarios was 0.001 mg/kg bw/d (systemic dose), based on an overall NOAEL of 20 ppb (equal to 0.0003 mg/L in air and equivalent to approximately 0.1 mg/kg bw/d as an internal dose) that the PMRA derived from several short-term ($\leq$14 days) and intermediate length (90 days) vapour inhalation studies [2]. This NOAEL is the highest dose tested in these studies and represents the highest attainable vapour concentration for chlorpyrifos. A total MOE of 100-fold was required (10-fold to account for interspecies extrapolation and 10-fold for intraspecies variability). This AEL is considered to be protective of the pregnant worker in that it provides a 300-fold MOS to the LOAEL of 0.3 mg/kg bw/d that the PMRA observed for maternal toxicity from the developmental neurotoxicity study. It is also protective of the worker's indirectly exposed unborn child.

4.2.1 Mixer/loader/applicator

Handler exposure potential was estimated using chemical-specific biological monitoring studies and the Pesticide Handlers' Exposure Database (PHED), Version 1.1, coupled with information on the amount of chlorpyrifos handled per day. The amount of chlorpyrifos handled per day is based upon the maximum label application rate and a high end estimate of area of crop that can reasonably be treated in one day.

The PHED is a compilation of generic mixer/loader/applicator passive dosimetry data that can be used to generate scenario-specific dermal and inhalation exposure estimates based on formulation type, application equipment, mix/load systems and level of personal protective equipment (PPE). Three handler exposure scenarios were generated from the PHED in a tiered approach based on different levels of PPE and engineering controls.

(a) The baseline scenario is based on minimum PPE and no engineering controls: a single clothing layer, open cab and open mix/load systems.

(b) The maximum PPE scenario is based on chemical resistant coveralls over a single clothing layer, chemical resistant gloves, respirator, open cab and open mix/load systems.

(c) The engineering controls scenario includes closed cab and closed mix/load systems (e.g., water soluble bags) and variable levels of PPE, depending on the crop/formulation scenario.

Occupational exposure estimates are based on the best available data at this time. They are not expected to underestimate risk as a conservative approach was adopted. The assessment could be refined with the following:

- survey data on typical areas treated per day with chlorpyrifos by farmers and commercial applicators,
- exposure data representative of modern spray equipment and engineering controls (e.g., closed cabs and closed mixing loading systems) meeting the modern Worker Protection Standards, and
- post registration surveillance of workers using passive dosimetry, biological monitoring or cholinesterase monitoring.

The PMRA estimates of potential mixer/loader/applicator exposure exceeded the AEL for all scenarios when little protective equipment was used and (or) where there were no engineering controls, e.g., open mixing/loading systems.

Comparisons of potential exposure to the AEL indicate that exposures are acceptable for agricultural applications when engineering controls and protective equipment are incorporated into the assessment.

To achieve acceptable levels of risk for some occupational use patterns, the PMRA is proposing the mitigation measures as described in Section 9.0.

4.2.2 Post-application worker

Workers who re-enter treated sites to conduct activities involving foliar contact, e.g., pruning, thinning, harvesting and scouting, may be exposed to chlorpyrifos. Potential exposure to re-entry workers was estimated using activity specific transfer coefficients and dislodgeable foliar residue (DFR) data. Transfer coefficients measure the relationship between exposure and DFRs for individuals engaged in a specific activity (e.g., scouting or harvesting) for a specific crop or crop group. The registrant is a member of the Agricultural Re-entry Task Force (ARTF) that is finalizing a substantial database of transfer coefficients. Conservative default transfer coefficients based on the ARTF data were used for this assessment pending full review of the ARTF database by the PMRA. Risk will be managed by establishing re-entry intervals for specific tasks under Canadian conditions of use (e.g., application rates). A re-entry interval is the duration of time that must elapse before dislodgeable residues decline to a level so entry into a treated area to perform a specific activity does not result in exposures above the AEL. The re-entry intervals were established during the Phase 1 review and are outlined in Appendix I.

4.3 Dietary risk assessment

In a dietary exposure assessment, the PMRA determines how much of a pesticide residue may be ingested with the daily diet, including residues in milk and meat for all uses registered in Canada and in imported produce. These dietary assessments are age specific and incorporate the different eating habits of the population at various stages of life. For example, assessments take into account childrens' greater consumption of fruit, vegetables and juices for their body weight compared with adults.

Acute dietary risk was calculated considering food consumption and residue values in food. A probabilistic statistical analysis allows all possible combinations of consumption and residue levels to be combined to estimate a distribution of the amount of chlorpyrifos residue that might be eaten in a day. A value representing the high end (99.9^{th} percentile) of this distribution is compared with the acute reference dose (ARfD), which is the dose at which an individual could be exposed on any given 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 chronic dietary risk is calculated by considering the average consumption of different foods, and average residue values on those foods, over a 70-year lifetime. This expected intake of residues is compared with the acceptable daily intake (ADI), which is the dose at which an individual could be exposed over the course of a lifetime and expect no adverse health effects. When the expected intake from residues is less than the ADI, the expected intake is not considered to be of concern.

The PMRA determined that the acute (single day) dietary reference dose (ARfD) for the general adult population (i.e., excluding women of child-bearing age) is 0.01 mg/kg bw/d, based on a NOAEL of 1 mg/kg bw/d that the PMRA derived from two acute neurotoxicity studies in rats [3]. A standard 100-fold uncertainty factor is applicable to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold), which results in an ARfD of 0.01 mg/kg bw/d.

For women of child-bearing age (13–50 years of age), a separate ARfD of 0.001 mg/kg bw/d was established to protect this sensitive population and their unborn or nursing children. This was based on a LOAEL of 0.3 mg/kg bw/d for pregnant rats as identified by the PMRA in a developmental neurotoxicity study [1] and a 300-fold uncertainty factor (10-fold for each of interspecies extrapolation and intraspecies variability and 3-fold for the fact that the PMRA observed that there was a lack of a NOAEL in the study). This ARfD provides a 1000-fold MOS to the offspring NOAEL of 1 mg/kg bw/d that the PMRA observed in the same study and thus is protective of the indirectly exposed unborn or nursing child.

For infants and children (up to age 12) directly exposed to chlorpyrifos through their diets, an ARfD of 0.00075 mg/kg bw/d was established by the PMRA. This was based on the NOAEL of 0.75 mg/kg bw/d observed by the PMRA for neonatal rats after a single dose [4] and a 1000-fold safety and uncertainty factor that is required to account for interspecies extrapolation and intraspecies variability (total of 100-fold), as well as an additional 10-fold for the increased sensitivity in the young that was observed by the PMRA.

The chronic (lifetime) dietary reference dose or acceptable daily intake value (ADI) for the general adult population, excluding women of child-bearing age, is 0.01 mg/kg bw/d, based on a NOAEL of 1 mg/kg bw/d that the PMRA derived from numerous repeat dose studies in 3 species [5]. A standard 100-fold uncertainty factor is applicable to account for interspecies extrapolation (10-fold) and intraspecies variability (10-fold), which results in an ADI of 0.01 mg/kg bw/d.

For women of child-bearing age (13–50 years of age), a separate ADI of 0.001 mg/kg bw/d was established based on the same toxicology end point and MOS as used for the ARfD for this population.

For infants and children (up to age 12) directly exposed to chlorpyrifos through their diets, an ADI of 0.00075 mg/kg bw/d was established by the PMRA. This was based on the NOAEL of 0.75 mg/kg bw/d observed by the PMRA for neonatal rats in a 14-day repeat dose study [4] and a 1000-fold safety and uncertainty factor that is required to account for interspecies extrapolation and intraspecies variability (total of 100-fold), as well as an additional 10-fold for the increased sensitivity in the young.

Acute and chronic dietary risk assessments (DRAs) were conducted for the general Canadian population and for various subpopulations based on all current registered uses and imports and considering the changes in use pattern for apples, grapes and tomatoes (Phase 1 mitigation; see Appendix I). Data used in the DRAs included MRLs, U.S. residue data, Canadian residue data, monitoring and surveillance data, market basket survey data, percent crop treated data and processing factors. For the acute DRA at the 99.9^{th} percentile exposure, the potential daily intake (PDI) accounted for 71 and 74% of the ARfD for children 1–6 years and females 13–50 years, respectively. Other subpopulations had PDIs of <74% of the ARfD.

For chronic dietary exposure, the PDI accounted for <2% of the ADI for all subpopulations.

These chronic and acute DRAs demonstrated that there were no dietary health concerns for any population subgroup in Canada, including infants, children, teenagers, adults and seniors resulting from the currently registered uses of chlorpyrifos. In addition, no dietary health concerns were evident for nursing or pregnant females or based on gender in general.

Although there is confidence in the DRAs that use residue and processing data from many sources, there are significant data gaps in the field residue data. Field data are used to establish the MRLs that are used in compliance and enforcement activities to ensure that crops are being treated according to registered rates. The existing MRLs were established many years ago and the data in many cases do not meet the modern Residue Chemistry Guidelines and may not reflect current rates and methods of application. However, it is important to note that monitoring has shown the residues of OP pesticides on foods in trade are usually very low. During the four-year period (1994–1998), of the 44 379 shipments of fruits and vegetables tested by the CFIA, only 0.3% of the domestic and 1.9% of the imported samples had detectable levels of chlorpyrifos. Of the 23 domestic and 705 imported samples found to contain chlorpyrifos, only 7 and 81 samples, respectively, were found to have residues higher than the current MRLs.

4.3.1 Acute and long-term aggregate risk

The PMRA does not have sufficient reliable monitoring data to quantify the risk from drinking water. Canadian drinking water levels of comparison (DWLOCs) were derived from the overall allowable risk from residues permitted in the diet after considering the contribution by food. The DWLOC is the maximum concentration in drinking water that, when considered together with dietary exposure, does not exceed a level of concern based on the respective reference dose. For acute risk, the DWLOCs range from 2.9 to 690 µg/L, and for chronic risk, the DWLOCs range from 7.4 to 700 µg/L. The PMRA requires drinking water monitoring data to ensure residue levels are below the DWLOC.

4.3.2 Short-term aggregate risk

The short-term aggregate exposure from diet (excluding water) and residential (non-occupational) uses takes into account that Phase 1 mitigation actions have been implemented and that therefore, potential chlorpyrifos exposure in food and in the residential and recreational environment has been reduced. The updated aggregate assessment of chlorpyrifos includes potential exposure resulting from continued chlorpyrifos use on golf courses at a reduced rate of 1 kg a.i./ha, in addition to potential exposure as a result of mosquito abatement activities. Aggregate MOEs for short-term exposure (excluding drinking water exposure) do not exceed the PMRA’s level of concern.

5.0 Environmental assessment

Information and data used in the assessment of environmental risk are based upon the U.S. EPA Re-evaluation Document, *The EFED Revised Environmental Fate and Effects Assessment for Chlorpyrifos*, January 2000 [6]. Details regarding the EPA's environmental assessment for chlorpyrifos can be found at the website for the EPA (see Section 3.0). Some supplementary data on earthworms and bees and environmental fate data in aquatic environments were obtained from Barron and Woodburn (1995) and Racke (1993) [7]. The risk assessment and conclusions also take into consideration recent probabilistic risk assessments published in the literature [8].

The PMRA considers that the available toxicity studies for wildlife indicate that chlorpyrifos is acutely toxic to a wide range of organisms, including birds (lethal dose 50% (LD_{50}) = 5.0–476 mg a.i./kg), mammals (LD_{50} = 97–530 mg a.i./kg), fish (lethal concentration 50% (LC_{50}) = 1.8–380 µg a.i./L) and aquatic invertebrates (LC_{50} = 0.09–65 µg a.i./L). Based on its chemical properties and available environmental fate data, chlorpyrifos shows moderate persistence in the environment.

In assessing the environmental risk of chlorpyrifos, an initial Tier I risk assessment was conducted. In this assessment, risk was characterized by the quotient method, calculated as the ratio of the estimated environmental concentration to the effects end point of concern. Quotient values less than one are considered indicative of a low hazard to non-target organisms, whereas values greater than one are considered to indicate that some degree of hazard exists for effects on non-target organisms.

In the initial assessment, estimated environmental concentrations for aquatic and terrestrial ecosystems were determined for a wide range of agricultural uses of chlorpyrifos based on maximum label rates and maximum numbers of applications. Effects end points included both acute and chronic end points, chosen from the range of toxicity tests and species available. Effects end points, chosen for the most sensitive species, are used as surrogates for the wide range of species that can be potentially exposed following treatment with chlorpyrifos.

Based on the results from the initial assessment, the PMRA identified high levels of hazard to most non-target organisms, with the exception of non-target plants. The results summarized here are from the assessment of agricultural uses only.

5.1 Terrestrial assessment

Based on the acute dietary toxicity of chlorpyrifos to birds, and using standard exposure scenarios, the PMRA found that quotients ranged from 0.5 to 17 for foliar applications of chlorpyrifos. These values are classified as a low to high hazard. Most crops were classified by the PMRA as presenting a moderate hazard of acutely lethal effects through consumption of contaminated food. The available dietary toxicity data was for water fowl and upland game birds, and the PMRA considered that it did not allow an assessment of

the effects on smaller bird species such as songbirds, which are more typical in the agricultural areas where chlorpyrifos is used. Typically smaller species are more sensitive than either bobwhite quail or mallard duck.

Similar conclusions were reached for mammals, where the PMRA found quotients ranging from <1 to 181. Quotients were greatest for small to medium sized insectivores and granivores. Chlorpyrifos was determined by the PMRA not to be an acute hazard to large mammals (>1 kg).

Assessment of chronic toxicity to birds by the PMRA resulted in quotients that ranged from 0.3 to 12. Based on the assessment, the PMRA considers chronic toxicity of chlorpyrifos as classified low to high hazard for birds, depending on the use scenario.

In addition to foliar applications, an initial assessment of granular applications was also conducted for terrestrial ecosystems. The PMRA concluded that granular chlorpyrifos presents a high to very high hazard to small birds such as the house sparrow and red-winged blackbird with quotients ranging from 29 to 405. For larger birds such as the mallard, the PMRA considers the hazard low to moderate with quotients ranging from 0.2 to 1.2. Granular chlorpyrifos applications present a moderate hazard for smaller (15 g) and medium sized (35 g) mammals with quotients ranging from 5 to 77 and were found to be a lower risk to larger sized (1.0 kg) mammals with quotients ranging from 0.2 to 1.2.

Chlorpyrifos is highly toxic to honeybees (*Apis mellifera*) and based on the initial assessment was classified as a high hazard for all application rates.

The initial Tier I risk assessment concluded that for birds, mammals and beneficial insects (e.g., bees), that hazards from agricultural uses of chlorpyrifos ranged from low to high for both acute and chronic effects. Based on the results of the initial assessment, mitigation measures will be required.

5.2 Aquatic assessment

In the initial aquatic assessment, the PMRA calculated quotients for aquatic invertebrates and fish. Estimated environmental concentrations were determined by the PMRA using a simplistic model to determine concentrations for the different rates and numbers of applications. In general, quotients were very high for both aquatic invertebrates and fish for all use patterns. For freshwater fish, quotients ranged from 370 to 4900 for acute effects and 117 to 1549 for chronic effects, with greater values for estuarine species. For aquatic invertebrates, quotients ranged from 6600 to 88 000 for acute effects and from 1600 to 22 000. These values indicate a very high hazard for aquatic organisms.

The initial PMRA environmental assessment concluded that for freshwater aquatic organisms (both fish and aquatic invertebrates) acute and chronic effects from the use of chlorpyrifos range from very high to extremely high hazard.

For agricultural uses, available monitoring data was limited. A monitoring program in the Niagara fruit belt detected chlorpyrifos in 12 of 76 surface water samples with concentrations up to 0.417 µg/L, during the period of chlorpyrifos application [9]. This concentration exceeds the threshold concentration for effects in aquatic invertebrate communities by 4×.

5.3 Environmental assessment conclusions

The PMRA environmental assessment for agricultural uses of chlorpyrifos indicates that effects on non-target organisms may occur, even for single applications at the lowest rates. A major factor in effects for chlorpyrifos is the acute toxicity at low concentrations. In general, the magnitude of the risk will be related to the application rate, with highest risks to both terrestrial and aquatic systems associated with highest application rates and extent of use. Although granular formulations may result in somewhat reduced runoff concentrations, compared with foliar or soil drench applications, and are not prone to drift, they represent an increased risk of acute effects to birds.

5.4 Need to refine environmental assessment methods

The PMRA recognizes the uncertainty associated with the initial environmental assessment of chlorpyrifos. While the toxicity of chlorpyrifos is relatively well characterized for most organisms, the concentrations to which non-target organisms are exposed are less certain. Current assessment approaches do not allow analyses of the frequency or magnitude of effects.

Currently, within the pesticide regulatory community involved with environmental risk assessments, there is a considerable amount of work being done to refine the approaches and methods used for the environmental assessments of pest control products. The PMRA has been involved in these efforts together with the EPA. The refined methods to characterize risk are based on probabilistic risk assessment that will provide a more thorough picture of the risk and associated uncertainties. These methods to refine the risk assessments were not sufficiently advanced when the re-evaluation of chlorpyrifos was initiated. March 2001, the EPA proposed refined approaches for both aquatic and terrestrial assessments. The PMRA believes that these refined approaches, combined with additional field-derived information on exposure of non-target organisms, will considerably reduce the uncertainty with respect to the understanding of the environmental effects resulting from the agricultural use of chlorpyrifos.

5.5 Potential for environmental mitigation

For aquatic systems, inputs from both runoff and drift are potential sources of contamination. Runoff is difficult to effectively mitigate. Available information suggests that vegetative filter strips may partially mitigate contamination of aquatic systems from runoff. However, sufficient information does not yet exist to determine if such management practices would sufficiently reduce concentrations in receiving waters, nor would such measures be necessarily practical or desirable in all situations.

Spray drift can be effectively mitigated in some cases through the use of spray buffer zones, or through a combination of buffer zones and the use of low drift application technologies. Buffer zones are useful for preventing drift into non-target habitat, both terrestrial and aquatic. Currently, a single spray buffer zone for either ground or for aerial applications is set based on a standard set of assumptions for spray configuration and weather conditions, yet many and variable conditions exist at any spray site. To allow for increased flexibility and to encourage the use of buffer zones, the Agency is developing, together with the provinces, a proposal that would allow the applicator to factor in the actual values for spray characteristics, wind speed and, to the extent possible, the sensitivity of the habitat to be protected. There would also be the possibility of factoring in technological advances in spray technology that can reduce drift (e.g., low drift nozzles, shrouds). Individual users could potentially decrease the size of the spray buffer zone if they were employing measures that are more protective of the habitat in question than those that were assumed in the buffer zone calculation. Until this proposal goes through consultation and acceptance, the buffer zones calculated using standard assumptions will be used (see Appendix III).

Effects in the terrestrial ecosystem are often difficult to mitigate due to the occurrence of non-target species in treated areas. For bees, it may be possible to prevent non-target effects by increasing awareness of applicators and improving the communications between applicators and bee keepers. For other terrestrial organisms, such as birds, options are limited and include decreased rates, numbers and (or) frequencies of application. Reductions of application rates could impact the efficacy of the product.

The Agency is interested in suggestions for mitigation of effects on terrestrial non-target organisms, particularly for birds.

6.0 Value

Chlorpyrifos is registered for use on over 30 food, feed and oilseed crops in Canada. Chlorpyrifos is registered for use on these same crops in the U.S., with the exception of the following crops on which there are no registered uses in the U.S.: canola, carrots, celery, flax, garlic, oats and potatoes.

Information regarding actual field use of chlorpyrifos on food crops was obtained from a survey of OP use conducted in 1998 with the cooperation the provincial governments, and from consultation with crop production specialists. The surveys identified the level and extent of use of chlorpyrifos on food crops, and the importance of chlorpyrifos as a pest management tool for specific uses.

Currently registered uses of chlorpyrifos have been grouped according to the following criteria.

6.1 Key uses

Certain uses of chlorpyrifos are described as key, i.e., either no alternative pesticides or methods to manage the insect pest, or the only alternatives are other OPs, or maintaining the registration is key in resistance management (see Appendix II).

6.2 Important uses

Chlorpyrifos has been reported to be an important pest management tool for certain other uses (e.g., ≥10% of the given crop has been reported to receive treatment with chlorpyrifos in some provinces). Non-OP alternatives are registered for each of these uses; however, chlorpyrifos is reported to be either the primary pest control product for that use, or one of the preferred products for that use (see Appendix II).

6.3 Crops with little or no reported use

For certain other registered uses, the extent of use of chlorpyrifos is reported to be low (i.e., no more than 5% of the crop in any province is treated with chlorpyrifos) and non-OP alternatives are registered. Chlorpyrifos is also registered for use on certain food crops for which the PMRA received no information back regarding the extent of use as a result of the survey (see Appendix II).

7.0 Toxic Substances Management Policy considerations

During the review of chlorpyrifos, the PMRA has considered the implications of the federal Toxic Substances Management Policy (TSMP) and the PMRA Regulatory Directive DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*.

The PMRA has concluded that chlorpyrifos is persistent because its half-life in soil (up to 200 days) meets the TSMP Track-1 criterion for soil (≥182 days).

The PMRA has concluded that chlorpyrifos does not meet the TSMP criterion for bioaccumulation. The octanol–water partition coefficient is 4.7, which is below the TSMP Track-1 cut-off criterion of ≥5.0. In addition, maximum bioconcentration factors (BCFs) are 1280, 3903 and 2729 for edible tissues (body, muscle, skin), non-edible tissues (fins, head, internal organs) and whole fish, respectively. These are below the TSMP Track-1 cut-off criterion of a BCF ≥5000.

The Agency's conclusions regarding the toxicity of chlorpyrifos are described in Sections 4.0 and 5.0 of this document.

The PMRA has concluded that chlorpyrifos technical does not contain any by-products or microcontaminants of concern. Laboratory analyses have shown that impurities of toxicological concern are not present as a result of the manufacturing process. The formulated product does not contain any formulants that are known to be TSMP Track-1 substances.

In the terrestrial environment, chlorpyrifos forms one major transformation product, 3,5,6-trichloro-2-pyridinol (TCP). The PMRA has concluded that TCP with a half-life in anaerobic soil of >500 d meets the TSMP Track-1 cut-off criterion for persistence in soil (≥182 d). The PMRA has concluded that TCP does not meet the TSMP criterion for bioaccumulation because the BCF for TCP (whole fish) ranges from 3 to 16, indicating low bioaccumulation potential.

Therefore, the PMRA has concluded that the parent compound, chlorpyrifos, and its major transformation product, TCP, do not meet the TSMP Track-1 classification criteria because although they are persistent, they do not bioaccumulate.

8.0 Other assessment considerations

As a part of the completion of the re-evaluation, guarantees for all products will be converted to nominal expression.

As a part of the re-evaluation, the PMRA has reviewed all of the chlorpyrifos EP formulations for List 1 formulants and has identified some products containing these formulants. Registrants have been asked to replace List 1 formulants in all products. When the final PMRA formulants policy is published, products containing chlorpyrifos will be subject to all the requirements in the policy and the time frames imposed in that policy.

9.0 Proposed regulatory action for Phase 2

The assessment of the risks to human health and the environment indicates that the acceptability for maintaining the registration of chlorpyrifos depends heavily on the implementation of significant mitigation measures. The outcome of the risk assessments indicate that regulatory action must be taken in two key areas: worker safety (handler and post-application) and environmental protection.

The proposed regulatory actions will reduce human and environmental exposure through:

- a reduction in the number of crops on which chlorpyrifos can be used,
- a reduction in the maximum number of applications,
- the implementation of engineering controls and (or) PPE and clothing for the handlers who mix, load and apply pest control products that contain chlorpyrifos,
- the establishment of re-entry intervals for post-application workers,
- buffer zones to reduce impacts on aquatic ecosystems,
- additional precautions to protect bees, and
- restrictions on applications by aircraft.

The proposed regulatory action aims to reduce environmental risks through a number of mitigative measures until refined environmental risk assessments can be conducted. The initial assessment of environmental risks indicates that mitigative environmental protection measures are necessary to reduce exposure and potential acute risks to aquatic organisms, i.e., aquatic invertebrates and fish, and to avian species. A reduction of spray drift and runoff potential are important considerations for the protection of aquatic organisms. The reduction of drift is to some degree achievable through specific label requirements. The reduction in runoff and of potential exposures and effects on birds are, however, more difficult to mitigate.

The assessment of the value of chlorpyrifos to agricultural pest management and the grouping of uses into key, important and less important uses was used to arrive at proposed regulatory actions that are the least disruptive to the need to protect agricultural crops from pests while at the same time protecting health and reducing the impact on the environment. The Agency is proposing to maintain key and important uses of chlorpyrifos, with the exception of peaches and nectarines, until the cumulative risk assessment on OPs and the refined environmental risk assessments are completed. The use of chlorpyrifos on peaches and nectarines for control of oriental fruit moth will be maintained until the end of 2006.

Appendix IV summarizes the proposed agricultural uses of chlorpyrifos acceptable for continued registration, together with proposed mitigation measures and use limitations of each use.

As outlined earlier in the document, the currently proposed actions represent an interim decision until cumulative assessments are completed. Uses that remain will be revisited when the results of refined environmental assessments are available. The Agency proposes to remove uses on crops for which there is little usage reported and for which non-OP alternatives are registered. It is anticipated that removal of such uses would have minimal impact on the pest management options available to growers. Based on the available information, the PMRA proposes that the registration of chlorpyrifos be removed for the following crops (see also Appendix II):

- Pepper, sugar beet: for control of cutworms
- Corn: for control of cutworms and corn rootworms
- Filbert: for control of filbert aphid
- Lentils: for control of grasshoppers and cutworms
- Oats: for control of armyworm, bertha armyworm, cutworms, grasshoppers, brown wheat mite and Russian wheat aphid
- Tobacco: for control of cutworms and seed corn maggot

Also, the PMRA is proposing that aerial application be restricted only to wheat and canola (i.e., aerial application to barley, flax and sunflowers would be removed).

As part of the proposed decision, the PMRA proposes that the registration be maintained for crops identified as important or key. For the uses proposed for continued registration, proposed mitigative actions include reducing the number of applications per season whenever possible (see Section 9.3).

Key uses

- Wheat*: for control of orange blossom wheat midge
- Cole crops** (cabbage, broccoli, Brussels sprouts, cauliflower, Chinese cabbage, pak choi), rutabaga**, radish* and Asian radish*: for control of cabbage maggot
- Celery*, strawberry*: for control of cutworm
- Garlic*: for control of onion maggot and cutworm
- Peaches*, nectarines*: for control of oriental fruit moth, (time limited, until the end of 2006)
- Onion***: for control of onion maggot

* applied as a liquid spray to foliage or soil
** applied as either an in-furrow application of granular product or a liquid spray or drench to the soil
*** granular formulation applied in-furrow

In addition to the uses noted above, two provinces have identified a key need for an effective control product for management of wireworms on potatoes. Emergency registrations for wireworm control were granted to British Columbia during 2000 and 2001 and Nova Scotia in 2001. However, one of the manufacturers of chlorpyrifos has informed the PMRA that it does not support this use.

Important uses*

- Canola: for control of bertha armyworm, diamondback moth and lygus bug
- Onion: for control of cutworms
- Cucumber: for control of cutworms
- Rutabaga: for control of cutworms
- Wheat (spring) and barley: for control of grasshoppers and cutworms
- Flax: for control of bertha armyworm
- Sunflowers: for control of cutworms and sunflower weevil
- Carrots: for control of cutworms
- Potatoes: for control of Colorado potato beetle.

* applied as a liquid spray to foliage or soil

All uses accepted for continuing registration will be subject to the following proposed regulatory actions and mitigation measures.

9.1 Proposed regulatory actions relating to human health

Labels of pesticide products carry statements regarding symptoms of poisoning and treatment, which are especially important for those who may be overexposed when working with the product in a commercial or industrial setting, e.g., mixers/loaders who handle the more concentrated forms. Based on the toxicological assessments for chlorpyrifos, the label text should be expanded and (or) standardized, as follows:

> "Toxicological Information:
>
> Chlorpyrifos is a cholinesterase inhibitor. Typical symptoms of overexposure to cholinesterase inhibitors include headache, nausea, dizziness, sweating, salivation, runny nose and eyes. This may progress to muscle twitching, weakness, tremor in coordination, vomiting, abdominal cramps and diarrhea in more serious poisonings. A life-threatening poisoning is signified by loss of consciousness, incontinence, convulsions and respiratory depression with a secondary cardiovascular component. Treat symptomatically. If exposed, plasma and red blood cell cholinesterase tests may indicate degree of exposure (baseline data are useful). Atropine, only by injection, is the preferable antidote. Oximes, such as Pralidoxime Chloride, may be therapeutic if used early; however, use only in conjunction with atropine. In cases of severe acute poisoning, use antidotes immediately after establishing an open airway and respiration. With oral exposure, the decision of whether to induce vomiting or not should be made by an attending physician."

For those products that contain greater than 10% petroleum distillates, the following text should also be added to the Toxicological Information section (placed at the end of the paragraph presented above), as an additional aid to the attending physician:

"**NOTE:** Product contains a petroleum distillate solvent."

9.1.1 Proposed regulatory actions relating to mixer/loader/applicator exposure

Paint brush application for indoor uses to be deleted from the label.

Prohibit the use of high pressure handwand equipment.

Label requirements regarding mixers/loaders

Liquid formulations packaged in containers more than 10 L

Mixers/loaders must use a closed mechanical transfer loading system. Mixers/loaders must wear:

- coveralls over long-sleeved shirt and long pants
- chemical resistant gloves
- an air purifying respirator with an -R or -P series filter
- socks and shoes

Liquid formulations packaged in containers holding 10 L or less

Mixers/loaders must wear:

- coveralls over long-sleeved shirt and long pants
- chemical-resistant gloves
- chemical-resistant apron
- chemical-resistant footwear plus socks
- an air purifying respirator equipped with an -R or -P series filter

Wettable powder formulations (must be packaged in water soluble bags)

Mixers/loaders must wear:

- long-sleeved shirt and long pants
- socks and shoes
- chemical resistant gloves
- chemical resistant apron

Mixers and loaders using water-soluble packets must have immediately available for use in emergency (such as a broken package, spill or equipment breakdown) additional PPE. These PPE include coveralls and chemical-resistant footwear and a non-powered air purifying respirator equipped with an -R or -P series filter.

Granular formulations

Mixers/loaders must wear:
- coveralls over long-sleeved shirt and long pants
- chemical resistant gloves
- chemical resistant footwear and socks
- an air purifying respirator equipped with an -R or -P series filter
- chemical resistant apron

Label requirements regarding applicators

Applicators using airblast equipment with a closed cab must wear:
- long-sleeved shirt and long pants
- socks and shoes
- chemical resistant gloves

Applicators using airblast equipment with an open cab must wear:
- long-sleeved shirt and long pants
- chemical resistant coveralls and head protection
- socks and shoes
- chemical resistant gloves
- an air purifying respirator with an -R or -P series filter

Applicators using ground equipment with a closed cab must wear:
- long-sleeved shirt and long pants
- chemical resistant gloves when leave cab for clean up and repair
- socks and shoes

Applicators using ground equipment with an open cab must wear:
- coveralls over long-sleeved shirt and long pants
- chemical resistant gloves
- socks and shoes

Applicators using aerial application equipment must use enclosed cockpits and must wear:
- long-sleeved shirt and long pants
- socks and shoes

Applicators using handheld equipment must wear:
- long-sleeved shirt and long pants
- chemical resistant coveralls and head protection (if spray is upward directed)
- chemical resistant footwear and shoes
- chemical resistant gloves
- an air purifying respirator with an -R or -P series filter

Implementation plan and schedule for mixer/loader/applicator risk mitigation

Closed mixing/loading systems where required are to be implemented by December 31, 2003. The registrant is to develop a detailed plan for implementation of these engineering control measures. The plan should outline the specifications and type of closed mixing system(s) proposed. It may be possible to reduce the extent of personal protective clothing and equipment required depending on the details of the proposed engineering controls.

By means of this consultation document, PMRA is requesting feedback from provinces and the agricultural industry (registrants, user organizations and users) regarding the extent of current use of closed cabs and the potential for converting to closed cabs for application, and a practical time-frame for implementation of this measure.

9.1.2 Proposed regulatory actions relating to worker post-application risk

Greenhouse ornamentals: Field crop DFR data was not considered a suitable surrogate for greenhouse ornamentals. Chemical specific data need to be developed. In the interim it is proposed that a reentry interval of 2 days for crop contact activities be added to labels for greenhouse use. One of the manufacturers of chlorpyrifos has informed the PMRA that they do not intend to provide the chemical specific data.

Re-entry intervals for agricultural crops were established during the Phase 1 review and are harmonized with the U.S. EPA. Restricted entry intervals are included in the proposed use standard in Appendix IV.

9.1.3 Proposed regulatory actions relating to dietary risk

(a) The residue of concern (ROC) will be changed from chlorpyrifos and TCP to the parent, chlorpyrifos, alone. TCP is of lower toxicity than chlorpyrifos and the magnitude of TCP is equal to or less than that of the parent, chlorpyrifos, in crops and animal tissues and fluids. This ROC definition is consistent with that of other regulatory jurisdictions, including the U.S., and with Codex.

(b) A 30-day restriction on plant back of rotational crops must be placed on labels. This restriction is required, since no residue data are available for secondary crops planted at less than 30-day plant back. In addition, this label restriction is consistent with chlorpyrifos labels in the U.S.

(c) Changes to maximum residue limits: In general, when the re-evaluation of a pesticide has been completed, the PMRA intends to prevent unauthorized use of the pesticide by recommending new MRLs at the limit of quantification for any agricultural commodities not approved for continued use in Canada. Additional MRLs for import purposes will be considered if sufficient data are provided by interested parties to allow a reassessment of those residues. The U.S. EPA undertakes similar action in such circumstances.

In the case of chlorpyrifos, sufficient data have been provided to support MRLs for some domestic and imported commodities, but not others. Table 1, below, indicates commodities where sufficient data were available for review, and provides a summary of current and proposed MRLs for those commodities.

For all other commodities, additional data are needed to support the establishment of MRLs. Of these commodities, MRLs are currently specified for peppers and rutabagas only. Currently, the residues of chlorpyrifos in all other commodities must be $\leq$0.1 ppm, a default value specified by the Food and Drugs Regulations, subsection B.15.002(1). However, the PMRA intends to set specific MRLs for each treated commodity in Canada, and nullify the default MRL for chlorpyrifos.

Table 2 indicates commodities registered for treatment in Canada that are lacking adequate supporting MRL data. Note that the registrant has indicated additional data are available for some commodities, but these data have not yet been reviewed.

Table 3 indicates additional comments regarding the MRLs of commodities with possible import or export implications. The registrant or other interested party must petition the PMRA for the establishment of import MRLs, as appropriate, to prevent trade irritants.

During this consultation period, the PMRA is requesting that registrants, or other stakeholders, identify those crops that they intend to support. If adequate data are not provided, the PMRA may be unable to recommend new MRLs for some commodities, and sale of those commodities with chlorpyrifos residues above the limit of quantification will not be allowed in Canada. Proposed amendments to the Food and Drugs Regulations reflecting these MRLs will be published in the Canada Gazette.

Table 1 Existing and proposed MRLs of commodities where sufficient data were available for review

Commodity	MRLs[1]	
	Existing	Proposed
Apple	1.5*	0.01[3]*
Broccoli	0.1	0.1
Brussels sprouts	0.1	0.1
Cauliflower	0.1	0.1
Cabbage	0.1	0.1
Chinese cabbage, type “Pe-tsai”	0.1	0.1
Citrus fruits	1.0*	1.0*
Cucumber	0.1	0.05
Eggs	0.1	0.01
Fat, cattle	1.0	0.05
Grape	0.1	0.01[3]*
Kiwifruit	2.0*	2.0*
Meat, cattle	1.0**	0.05**
Meat by-products, cattle	0.1	0.05**
Meat and meat by-products, poultry	0.1	0.01
Meat and meat by-products, sheep, goat, swine	0.1	0.05**
Milk, whole	0.1	0.01**
Milk, fat	0.1	0.25
Nectarine (until 2006)	0.1	0.05[2]
Peach (until 2006)	0.1	0.05[2]
Tomato	0.1	0.01[3]***

* to cover imported produce
** calculated on fat content
*** this is the limit of quantification

[1] The current MRLs are expressed as chlorpyrifos and TCP. Proposed MRLs are for chlorpyrifos per se.
[2] The registrant has informed the PMRA that additional residue data are either available or being generated for these crops. However, these data have not yet been reviewed by the PMRA.
[3] Changes to these MRLs were already announced in Re-evaluation Note REV2000-05.

Table 2 MRLs of commodities proposed for continued registration in Canada, indicating needed additional supporting data

Commodity	MRLs[1]	
	Existing	Proposed
Barley	0.1	TBD[2,3]
Canola	0.1	TBD[2,3]
Carrots	0.1	TBD[2,3]
Celery	0.1	TBD[2,3]
Chinese radish	0.1	TBD[2,3]
Flax	0.1	TBD[2]
Garlic	0.1	TBD[2]
Onions, bulb	0.1	TBD[2,3]
Potatoes	0.1	TBD[2,3]
Radish	0.1	TBD[2,3]
Rutabagas	0.5	TBD[2]****
Strawberry	0.1	TBD[2]
Sunflower seeds	0.1	TBD[2,3]
Wheat, grain	0.1	TBD[2,3]
All other commodities not listed in Table 1 or in this table	0.1	0.01***

*** this is the limit of quantification

**** MRL based on imports; Canadian residues are much lower

1 The current MRLs are expressed as chlorpyrifos and TCP. Proposed MRLs are for chlorpyrifos per se.

2 TBD, to be determined because additional data or label revisions are required.

3 The registrant has informed the PMRA that additional residue data are either available or being generated for these crops. However, these data have not yet been reviewed by the PMRA.

Table 3 MRL information for commodities with possible import or export implications

Commodity	Background
Uses proposed for discontinuation in Canada	
corn (field, grain, and sweet)[1], filberts, lentils, oat (grain), peppers, sugar beet (root)[1].	Current MRL for peppers is 1.0 ppm, for all other commodities is it 0.1 ppm, data are needed to support MRLs if treated produce will be sold in Canada (i.e., use maintained, or product imported)
Uses not registered in Canada, registered in U.S.	
Bananas, figs, pears, plums, legume vegetables, sweet potato, pumpkins	U.S. tolerances less than or equal to 0.1 ppm. Registrant should submit U.S. DERs or data to allow establishment of import MRLs < or = 0.1 ppm.
Alfalfa, almonds, asparagus, cranberries, lettuce, macadamia nut, peanut, pecan, peppermint, spearmint, sorghum, walnuts	U.S. tolerances >0.1 ppm, but no Canadian MRL. Registrant should petition for establishment of import MRLs.
Uses registered in Canada, no current U.S. tolerances	
Barley, canola, carrot, celery, garlic, flax, potato	The registrant and other potential data submitters are encouraged to petition U.S. EPA to establish import MRLs as appropriate.

[1] The registrant has informed the PMRA that additional residue data are either available or being generated for these crops. However, these data have not yet been reviewed by the PMRA.

9.2 Proposed regulatory action relating to the environment

Several environmental concerns were identified in the initial assessment. These include potential effects on birds and aquatic organisms. As part of the strategy outlined, the following interim mitigation measures will be required to decrease environmental risk.

(a) Spray drift has been identified as a source of contamination of aquatic ecosystems. The contamination of aquatic systems by drift can be effectively mitigated in some cases through the use of spray buffer zones. Spray buffer zones will be required as part of the interim mitigation strategy. Spray buffer zones for ground and airblast (orchard) applications have been determined and range from 28 to 74 m, depending on crop, application rates and method used. Spray buffer zones for aerial applications range from 54 to 1103 m. Details for how these buffer zones were derived are presented in Appendix III.

(b) Given the high application rates of chlorpyrifos used on peaches and nectarines, the difficulty in mitigating terrestrial and aquatic risks and the potential for alternative control products and strategies in the near term, a phase out of this use is proposed. Continued use of chlorpyrifos on peaches and nectarines will be permitted until December 31, 2006 to allow alternative pest management options to be developed and implemented.

(c) Label statements regarding toxicity to bees must be strengthened as follows:

"This product is highly toxic to bees exposed to direct treatment, drift or residues on blooming plants. Do not apply this product or allow it to drift to blooming plants if bees are visiting the treatment area. Applicators should inform local bee keepers prior to application if hives are in adjacent fields."

9.3 Proposed regulatory action relating to value

The following recommendations are based on results from the survey of OP use:

(a) The uses identified with little or no reported use could be deleted from labels of registered chlorpyrifos products. This includes corn (field, grain, and sweet), filberts, lentils, oats, peppers, sugar beet and tobacco. The PMRA is aware of the relatively low number of pest control tools available to allow continued production of certain minor use crops in Canada. Should anyone have further information regarding the value of chlorpyrifos on any of the existing labelled crops, that information should be sent to the provincial or territorial representative on the Federal/Provincial/Territorial Committee (FPT), and a copy sent to the PMRA.

(b) The future use of chlorpyrifos could be limited to a single application per season for the following crops: barley, canola, carrots, celery, cucumbers, flax, onions*, potato, radishes, strawberry, sunflowers and wheat.

* as either an in-furrow application of granular product or a spray onto the soil surface

(c) The future use of chlorpyrifos on other crops could be limited to the following maximum number of applications per season:

- Broccoli, cabbage, cauliflower, Chinese cabbage, pak choi: 2 (either 2 applications as a soil drench, or 1 in-furrow application of granular product plus 1 application as a soil drench)
- Brussels sprouts: 3 (either 3 applications as a soil drench, or 1 in-furrow application of granular product plus 2 applications as a soil drench)
- Asian radish (lo bok, daikon): 3 (as a soil drench)
- Rutabaga: 4 (either 4 applications as a soil drench, or 1 in-furrow application of granular product plus 3 applications as a soil drench)
- Garlic: 2 (as a soil drench)
- Peaches and nectarines: 2

(d) In addition to the changes already implemented for non-food uses of chlorpyrifos during Phase 1 of the review, the following additional change is proposed for non-food uses:

- Delete the use of chlorpyrifos for the control of mountain pine beetle in lodgepole pine forest stands. Information available to the PMRA indicates that little chlorpyrifos is used for control of this pest in forestry. Should anyone have further information regarding the value of this use of chlorpyrifos, that information should be sent to the provincial or territorial representative on the FPT committee, and a copy sent to the PMRA.

10.0 Additional data requirements

During the re-evaluation of chlorpyrifos, a number of deficiencies in the data were determined. To address some aspects of the health assessment and to complete refined environmental assessments for the remaining uses, the following data are required. Failure to adequately address these requirements will be interpreted as a lack of support for the product by registrants or other stakeholders.

The PMRA is open to submission of data from registrants or other stakeholders. Further, the Agency encourages the cooperation between stakeholders in the development of necessary data. Scientifically based rationales for data waivers may also be acceptable for some of the following data requirements.

10.1 Data requirements relating to dietary risk

(a) As indicated in 9.1.3, “Proposed regulatory actions relating to dietary risk”, residue data are required to determine appropriate MRLs for use in Canada on a number of crops. The registrant has indicated that there might be sufficient data in their files for the following crops: canola, celery, Chinese radish, cucumber, onions (bulb), radish, grain. Parties with additional supporting data for these crops, or that are willing to provide MRL support for flax, rutabagas, strawberry and wheat should contact the PMRA during this consultation period.

(b) As also indicated in 9.1.3, residue data are needed to determine appropriate import MRLs for any commodity not included in Appendix IV.

10.2 Data requirements relating to occupational risk

Greenhouse ornamentals: field crop DFR data was not considered a suitable surrogate for greenhouse ornamentals. Appropriate chemical specific DFR data needs to be developed.

10.3 Data requirements relating to aggregate risk

(a) Mosquito fogging: although fogging for mosquito control is not currently reported to be a practice in any province, should it become necessary due to public health concerns, confirmatory chemical specific air monitoring data following ground-based mosquitocide application to quantify inhalation post-application exposure is required. As this is also a data requirement in the U.S., data may become available as a result of uses in the U.S. and should be submitted to the PMRA.

(b) The registrant must provide confirmatory drinking water monitoring data. These data have also been requested by the U.S. EPA.

10.4 Data requirements relating to environmental risks

Data on exposure levels for non-target wildlife (birds and aquatic organisms) will be required. In particular, surface water monitoring data in Canada to characterize the contamination of surface waters resulting from chlorpyrifos use on crops representative of the major crop groups (grains and oilseeds, and vegetables) on appropriate spatial and temporal scales.

10.5 Other data requirements

To convert to nominal guarantees, registrants of the technical grade active ingredient (TGAI) and of EPs will be required to update Statement of Product Specification Forms for all products and to provide analyses of recent batches of the TGAI. If the nominal guarantee of the EP is the same as the previous minimum guarantee, historical batch data in support of the nominal value will be required.

11.0 Proposed re-evaluation decision

The PMRA has carried out an assessment of available information and has concluded that the use of chlorpyrifos and associated EPs does not entail an unacceptable risk of harm to human health or the environment pursuant to Section 20 of the PCP Regulations, provided that the proposed mitigation measures described in this document are implemented. Further measures may be necessary or proposed pending the outcome of the cumulative risk assessment for all OPs, which share a common mechanism of toxicity, and pending refinements to environmental risk assessment methodologies.

The PMRA will accept written comments on this proposal up to 60 days from the date of publication of this document to allow interested parties an opportunity to provide input into the proposed re-evaluation decision for these products.

List of abbreviations

a.i.	active ingredient
ADI	acceptable daily intake
AEL	acceptable exposure level
ARfD	acute reference dose
ARTF	Agricultural Re-entry Task Force
BCF	bioconcentration factors
bw	body weight
CFIA	Canadian Food Inspection Agency
DFR	dislodgeable foliar residue
DRA	dietary risk assessment
DWLOC	drinking water levels of comparison
EC	emulsifiable concentrate
EP	end-use product
EPA	Environmental Protection Agency (U.S.)
FPT	Federal/Provincial/Territorial Committee
GR	granular
IPM	integrated pest management
LD_{50}	lethal dose 50%
LOAEL	lowest observed adverse effect level
MOE	margin of exposure
MOS	margin of safety
MRL	maximum residue limit
NOAEL	no observed adverse effect level
OMAFRA	Ontario Ministry of Agricultur, Food and Rural Affairs
OP	organophosphate
PACR	Proposed acceptability for continuing registration
PCP	pest control product
PCPA	*Pest Control Product Act*
PDI	potential daily intake
PHED	Pesticide Handlers' Exposure Database
PMRA	Pest Management Regulatory Agency
PPE	personal protective equipment
ROC	residue of concern
SETAC	Society of Environmental Toxicology and Chemistry
TBD	to be determined
TCP	3,5,6-trichloro-2-pyridinol
TGAI	technical grade active ingredient
TSMP	Toxic Substances Management Policy
U.S.	United States
WP	wettable powder

Appendix I Phase 1 regulatory decisions

The following regulatory decisions, affecting mainly non-agricultural uses, have already been taken on chlorpyrifos products and are being implemented on the same schedule as in the U.S.

1. Residential uses of domestic and commercial class products (lawns, gardens and structures)

Sale at the retail level of all Domestic Class products and of Commercial Class products with residential uses, both indoor and outdoor, ends December 31, 2001. Residential uses include uses in and around homes, schools, restaurants parks and other public areas. Containerized low-concentration ant baits will continue to be registered.

2. Termiticide uses

Termite control, in small areas of the interior of British Columbia, the Sunshine Coast and Vancouver Island and in small areas of Toronto and Winnipeg, will be limited to pretreatment, i.e., during construction (no retail sale of product for post construction treatment effective December 31, 2001) and will be phased out completely by December 31, 2005, allowing for safer alternatives to be introduced.

3. Golf course turf and sod farms, highway rights of way

Although all residential lawn uses are being phased out, chlorpyrifos will remain registered for golf courses and sod farms with a reduced maximum application rate of 1 kg/ha. At this rate, margins of exposure were acceptable for golfers and workers. As this rate was found to be not effective for white grub control, that insect pest is being removed from labels.

4. Other structural uses

Uses inside and outside commercial buildings where there is limited access by the general public have been retained. This includes warehouses, railroad boxcars and industrial plants.

5. Mosquito control uses

The registration to control mosquito larvae (aerial or ground application) will be maintained for granular and liquid products at the request of the provinces of Alberta and Manitoba, but will be limited to use in temporary pools only in outlying areas of municipalities and to situations where the principles of integrated pest management (IPM) continue to be incorporated into the program, e.g., larval population surveys before treatment. The use in temporary pools only, as opposed to permanent water bodies, will mitigate potential for damage to non-target aquatic organisms, which are very sensitive to chlorpyrifos. This use also has limited potential for exposure to bystanders. Currently, the product is used in this way only by the municipalities of Edmonton and Winnipeg and with provincial authorization.

Although not currently used anywhere in Canada for this purpose, registration of chlorpyrifos for control of adult mosquitoes (ground application only, not aerial) will be maintained, in case of a public health concern such as an outbreak of West Nile Virus. It will also be a Restricted use requiring provincial authorization. It is only to be used after consultation with FPT regulatory agencies to address public health concerns.

6. Dutch elm disease

Chlorpyrifos has been registered as a general foliar spray and as a treatment to the bark of elm trees to control elm bark beetle, which is a carrier of the causal fungus of Dutch elm disease. Research in Winnipeg has shown that the treatment can be limited to one fifth of the currently labelled application rate, i.e., application to a 0.5 m band at the base of the trunk. Labelling will therefore reflect this reduced application rate and method of application. This treatment is currently used only in prairie towns and cities where the American elm is the principal shade tree and is under the authorization of the provinces. Alternative products are not available for this use.

7. Agricultural uses

Although chlorpyrifos is not registered for use on apples and grapes in Canada, MRLs were proposed to accommodate the importation of treated fruit from other countries, principally the U.S. The proposed MRL values in Canada were the same as proposed by the U.S. EPA for their crop residue tolerances, which reflected the residues expected after crops were treated following a revised U.S. label. Also, the U.S. EPA no longer allows the use of chlorpyrifos on tomatoes, and will be revoking their crop tolerances accordingly. The use of chlorpyrifos on tomatoes was not prevalent in Canada, and the voluntary discontinuation of this use from Canadian labels avoided trade problems with Canadian tomato exports to the U.S. The Canadian MRL for chlorpyrifos in tomatoes will be set at the limit of quantification.

Re-entry intervals for agricultural crops were established under Phase 1 and are harmonized with the U.S. EPA. The re-entry intervals are as follows:

Crop	Restricted entry intervals
fruit trees	4 days
cauliflower	10 days
all other crops	24 hours

Appendix II Summary of key and important agricultural uses of chlorpyrifos[2]

1. Key uses

Certain uses of chlorpyrifos are described as key (i.e., either no alternative pesticides or methods to manage the insect pest, or the only alternatives are other OPs, or maintaining the registration is key in resistance management). At this time, these uses are as follows:

- Wheat*: for control of orange blossom wheat midge. There are no non-OP products registered for this major pest of wheat.

- Cole crops** (cabbage, broccoli, Brussels sprouts, cauliflower, Chinese cabbage, pak choi), rutabaga**, radish* and Asian radish*: for control of cabbage maggot. There are no non-OP products registered for this major pest.

- Celery*, strawberry*: for control of cutworm. There is no registered alternative to chlorpyrifos for control of this pest on these crops. (Note: Effective non-OP alternatives (e.g., synthetic pyrethroids) are registered for control of cutworms on other crops but are not registered for this pest on celery or strawberry. The PMRA has no information on whether these alternative products would be efficacious against cutworms on celery or strawberry.)

- Garlic*: for control of onion maggot and cutworm. There is no registered alternative to chlorpyrifos for control of these pests on garlic. (Note: Effective non-OP alternatives (e.g., synthetic pyrethroids) are registered for control of cutworms on other crops but are not registered for this pest on garlic. The PMRA has no information on whether these alternative products would be efficacious against cutworms on this crop.)

- Peaches*, nectarines*: for control of oriental fruit moth. Although a more effective non-OP insecticide (i.e., synthetic pyrethroid) is available for control of oriental fruit moth on peaches and nectarines, chlorpyrifos is considered to be a key component of a resistance management strategy for this major pest of peaches and nectarines in Ontario. Applications of chlorpyrifos (targeting the first generation of larvae only) are rotated with the synthetic pyrethroids (targeting the second and third generations of larvae) in a strategy to delay the selection for resistance to the synthetic pyrethroids. Ontario considers this to be a short-term strategy to manage resistance until alternative products or pest management strategies are developed and become available for the management of oriental fruit moth.

[2] From results of a survey of OP use conducted in 1998 with the cooperation of provincial governments, and from consultation with crop production specialists.

- Onion***: for control of onion maggot. A non-OP alternative (insect growth regulator) is registered as a seed treatment for control of onion maggot but is registered for use in eastern Canada only and treated seed can not be planted in the same field in consecutive years. Therefore, this alternative treatment for onion maggot is not available for use in all onion-growing regions or for use in the same field every year.

* applied as a liquid spray to foliage or soil
** applied as either an in-furrow application of granular product or a liquid spray or drench to the soil
*** granular formulation applied in-furrow

In addition to the uses noted above, British Columbia and Nova Scotia have identified a key need for an effective control product for management of wireworms on potatoes. Emergency registrations for chlorpyrifos have been granted for control of wireworms on potatoes in British Columbia during 2000 and 2001 and in Nova Scotia in 2001.

2. Important uses

Chlorpyrifos has been reported to be an important pest management tool for certain other uses (e.g., $\geq$10% of the given crop has been reported to receive treatment with chlorpyrifos in some provinces). Non-OP products are registered for each of these uses; however, chlorpyrifos is reported to be either the primary pest control product for that use, or one of the preferred products for that use. These uses are as follows*:

- Canola: for control of bertha armyworm, diamondback moth and lygus bug. Alternative non-OP insecticides are registered (carbamates and (or) synthetic pyrethroids), but either do not provide residual activity as long as chlorpyrifos, or may not be as effective in hot weather.

- Onion: for control of cutworms. A non-OP insecticide (synthetic pyrethroid) is registered for control of cutworms on onion and is reported to be an effective alternative to chlorpyrifos.

- Cucumber: for control of cutworms. A non-OP insecticide (carbamate) is registered but is reported to be less effective than chlorpyrifos in some areas.

- Rutabaga: for control of cutworms. A non-OP insecticide (carbamate) is registered but is reported to be less effective than chlorpyrifos in some areas.

- Wheat (spring) and barley: for control of grasshoppers and cutworms. Non-OP insecticides (synthetic pyrethroids) are registered for control of these pests and are reported to be viable alternatives to chlorpyrifos from the standpoint of efficacy.

- Sunflowers: for control of cutworms and sunflower weevil. Non-OP insecticides (synthetic pyrethroids) are registered for control of these pests and are reported to be viable alternatives to chlorpyrifos from the standpoint of efficacy.

- Flax: for control of bertha armyworm. A non-OP insecticide (carbamate) is registered for control of this pest but is reported to be not as effective as chlorpyrifos.

- Carrots: for control of cutworms. A non-OP insecticide (synthetic pyrethroid) is registered for control of these minor pests of carrots.

- Potatoes: for control of Colorado potato beetle. Non-OP insecticides (carbamate, synthetic pyrethroid, neonicotinoid, microbial, organochlorine) are registered for control of this pest on potatoes. Populations of Colorado potato beetle in some regions have developed resistance to many of these chemistries, including OPs. Most use of chlorpyrifos for this use is reported to be in western Canada where resistance to OPs is not widespread. Although effective non-OP insecticides are available for use in all potato growing regions, growers consider the availability of numerous products with different modes of action (including OPs) are essential for IPM and resistance management strategies for this pest. Rotation of insecticides from different classes is recommended as a resistance management strategy.

* applied as a liquid spray to foliage or soil

3. Crops with little or no reported use

For certain other registered uses, the extent of use of chlorpyrifos is reported to be low (i.e., no more than 5% of the crop in any province is treated with chlorpyrifos) and non-OP alternatives are registered. Chlorpyrifos is also registered for use on certain food crops for which the PMRA has no information regarding the level or extent of use. These uses are as follows:

- Pepper, sugar beet: for control of cutworms. Cutworms are considered to be a minor pest of these crops. A small percentage of the crop is reported to be treated for this pest. Non-OP insecticides are registered for these uses (carbamate and (or) synthetic pyrethroid).

- Corn: for control of cutworms and corn rootworms. Only a small percentage of the crop is reported to be treated with chlorpyrifos for these pests. Effective non-OP insecticides (carbamate and (or) synthetic pyrethroid) are reported to be available for control of these pests. Filbert: for control of filbert aphid. PMRA has no information regarding the extent of uses of chlorpyrifos for this use. An alternative OP product is registered for this use.

- Lentils: for control of grasshoppers and cutworms. Only a small percentage of the crop is reported to be treated with chlorpyrifos for these pests. Effective non-OP insecticides (carbamate and (or) synthetic pyrethroid) are reported to be available for control of these pests.

- Oats: for control of armyworm, bertha armyworm, cutworms, grasshoppers, brown wheat mite and Russian wheat aphid. Insecticide use on oats is reported to be low due to the low value (price) of the crop and the minor importance of the pests.

- Tobacco: for control of cutworms and seed corn maggot. Only a small percentage of the crop is reported to be treated with chlorpyrifos for these pests. Non-OP insecticides (carbamate and (or) synthetic pyrethroid) are available for control of cutworms. Alternative OP insecticides are registered for control of seed corn maggot.

4. Aerial application

Aerial application of chlorpyrifos has been identified as important for control of certain key pests in some crops. For orange wheat blossom midge in wheat, the window for treatment is quite short (2–3 days) and the area requiring treatment can be large. Failure to treat when the insect is at the susceptible stage can result in significant crop damage. Aerial application allows for treatment of a larger area in a shorter period of time compared with ground equipment. Similarly, potentially large areas of canola may require treatment in a short period of time during outbreaks of lygus bug, bertha armyworm or diamondback moth. These pests of canola also occur later in the season when the crop canopy is dense. At this stage of the season, the crop may be prone to physical damage from ground equipment travelling over the fields.

Appendix III Spray drift management

1. General guidance

For the protection of non-target habitats, overspray to any body of water or other environmentally sensitive habitats must be avoided. Do not apply under conditions where drift to an unprotected person(s), occupied dwelling, or food or forage can occur.

Non-target environmentally sensitive areas must be buffered from drift through the use of the appropriate buffer zones as specified on the product label.

The interaction of many equipment and weather related factors determines the potential for spray drift. The applicator is responsible for considering all these factors when making application decisions.

Spray boom: Increased drift will occur during aerial applications when the spray boom is mounted too close to wing-tip vortices or rotor wash. For aerial applications, the spray boom should be mounted on the aircraft so as to minimize drift caused by wing-tip vortices.

Droplet size: An important factor influencing drift is the droplet size. Small droplets (<150 µm) drift to a greater extent than large droplets. Within typical equipment specifications, applications should be made to deliver the largest droplet spectrum that provides sufficient control and coverage. Formation of very small droplets may be minimized by the appropriate nozzle selection and (for aerial applications) by orienting nozzles away from the air stream as much as possible.

Spray height: Drift increases dramatically as the release height above the crop increases. For all applications, spray should be released at the lowest height consistent with efficacy and in the case of aerial applications, flight safety.

Wind: Increased drift will occur when there is dead calm, when winds are gusty or when the on-site sustained wind speed is greater than 16 km/h at the height of application. Applicators must use the appropriate buffer zones where any environmentally sensitive habitat is on the downwind side of any application.

Temperature inversions: Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain close to the ground and move laterally in a cloud. Temperature inversions are characterized by increasing temperature with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical mixing. Do not make aerial or ground applications during temperature inversions, as drift potential is high.

Humidity and temperature: Low humidity and high temperatures increase the evaporation rate of spray droplets and therefore the likelihood of increased spray drift. Avoid spraying during conditions of low humidity and (or) high temperature.

2. Spray drift buffer zones for chlorpyrifos

Drift resulting from applications of chlorpyrifos has been determined to be a hazard to aquatic ecosystems. For the purposes of determining buffer zones for chlorpyrifos, aquatic ecosystems consist of any form of water, such as, but not limited to, a lake, pond, stream, river, creek, slough, canal, coulee, prairie pothole or reservoir.

2.1 Aerial application

Limitations

- Aerial applications of chlorpyrifos can only be made for orange wheat blossom midge on wheat or for lygus bug on canola at a maximum rate of 480 g a.i./ha.

- Do not apply at airspeeds greater than 120 mph. The minimum practical boom length should be used but must not exceed 75% of the wing span or rotor diameter.

- Do not use hollow cone nozzles or rotary atomizers. These produce sprays that are very drift prone.

- Nozzles types are restricted to CP and FLAT FAN, with the following set-up restrictions: **For CP Nozzles:** Do not use greater than 30° deflection. **For Flat Fan Nozzles**: Do not use pressures greater than 30 psi. Do not use nozzles with fan angles greater than 40°, and do not deflect nozzles into the airstream.

- Do not release spray at a height greater than 3 m above the crop canopy.

- Do not apply during periods of dead calm, when winds are gusty or when wind speed is greater than 16 km/h at flying height at the site of application.

Non-target environmentally sensitive areas must be buffered from drift. Buffer zones vary depending on site specific application conditions (i.e., the type of nozzle used, the depth of the aquatic ecosystem to be protected, the wind speed and the temperature and relative humidity at the time of spray). It is the applicator's responsibility to (i) determine the maximum depth of any aquatic ecosystem downwind of the application, (ii) determine the atmospheric conditions and the time of application (temperature, humidity, wind speed and wind direction at the height of application) and (iii) observe the appropriate buffer zone for aquatic ecosystems from Table 1, based on the on-site conditions.

Table 1 Buffer zones for aerial applications of chlorpyrifos

Nozzle	Depth of water (m)	Wind speed (km/h)	Temperature and humidity	Buffer zone (m)
CP	<1	>10	>25°C and <50%	751
			>25°C and ≥50%	698
			≤25°C and <50%	779
			≤25°C and ≥50%	678
		≤10	>25°C and <50%	488
			>25°C and ≥50%	516
			≤25°C and <50%	536
			≤25°C and ≥50%	479
	≥1–3	>10	>25°C and <50%	441
			>25°C and ≥50%	382
			≤25°C and <50%	450
			≤25°C and ≥50%	273
		≤10	>25°C and <50%	268
			>25°C and ≥50%	241
			≤25°C and <50%	278
			≤25°C and ≥50%	201
	>3	>10	>25°C and <50%	236
			>25°C and ≥50%	81
			≤25°C and <50%	176
			≤25°C and ≥50%	69
		≤10	>25°C and <50%	139
			>25°C and ≥50%	65
			≤25°C and <50%	133
			≤25°C and ≥50%	54

Nozzle	Depth of water (m)	Wind speed (km/h)	Temperature and humidity	Buffer zone (m)
Flat fan	<1	>10	>25°C and <50%	1085
			>25°C and ≥50%	1103
			≤25°C and <50%	1077
			≤25°C and ≥50%	1065
		≤10	>25°C and <50%	868
			>25°C and ≥50%	762
			≤25°C and <50%	737
			≤25°C and ≥50%	689
	≥1–3	>10	>25°C and <50%	601
			>25°C and ≥50%	543
			≤25°C and <50%	623
			≤25°C and ≥50%	526
		≤10	>25°C and <50%	367
			>25°C and ≥50%	376
			≤25°C and <50%	394
			≤25°C and ≥50%	343
	>3	>10	>25°C and <50%	326
			>25°C and ≥50%	170
			≤25°C and <50%	326
			≤25°C and ≥50%	119
		≤10	>25°C and <50%	191
			>25°C and ≥50%	143
			≤25°C and <50%	195
			≤25°C and ≥50%	104

2.2 Ground boom application

Limitations

- Do not apply during periods of dead calm, when winds are gusty or when wind speed is greater than 16 km/h at 2 m high above ground at the site of application.

Non-target environmentally sensitive areas must be buffered from drift. Buffer zones for ground applications are dependent on the application rate specific to the crop and pest combination and depth of the aquatic ecosystem to be protected. It is the applicator's responsibility to (i) determine the correct rate for the crop being treated, (ii) determine the maximum depth of any aquatic ecosystem downwind of the application and (iii) observe the appropriate aquatic buffer zone from Table 2, based on application rate and depth of downwind aquatic ecosystems.

Table 2 Buffer zones (in metres) for protection of aquatic habitats of various water depths for ground boom applications of chlorpyrifos

Application rate (g a.i./ha)	Water depth		
	<1 m	1–3 m	>3 m
480	48	38	28
576	50	39	29
1125	56	45	35
2304	62	52	42

2.3 Orchard airblast application

Limitations

- Applications using ground based airblast equipment can be used only on peaches and nectarines against oriental fruit moth at a maximum rate of 1750 g a.i./ha.

- Do not direct spray above trees or vines and turn off outward pointing nozzles at row ends and outer rows.

- Do not apply during periods of dead calm, when winds are gusty or when wind speed is greater than 16 km/h at the application site as measured outside of the orchard or vineyard on the upwind side.

Non-target environmentally sensitive areas must be buffered from drift. Buffer zones for orchard airblast applications are dependent on the depth of nearby or adjacent aquatic ecosystem to be protected. It is the applicator's responsibility to (i) determine the correct rate for the crop being treated, (ii) determine the maximum depth of any aquatic ecosystem nearby or adjacent to the application site and (iii) observe the appropriate aquatic buffer zone from Table 3, based on application rate and depth of adjacent or nearby aquatic ecosystems.

Table 3 Buffer zones for airblast orchard applications of chlorpyrifos

Application rate (g a.i./ha)	Water depth		
	<1 m	1–3 m	>3 m
1750	74	62	39

Appendix IV Proposed use standard for agricultural uses of commercial class products containing chlorpyrifos

(Note 1: The information in this appendix summarizes the acceptable uses, limitations and precautions for agricultural uses of commercial class products containing chlorpyrifos, but does not identify all label requirements for such products. Registrants are referred to the PMRA Registration Handbook for further guidance on label requirements for pest control products.)

COMMON NAME: chlorpyrifos

CHEMICAL NAME: *O,O*-diethyl *O*-(3,5,6-trichloro-2-pyridinyl) phosphorothioate

FORMULATION TYPE:

EC	emulsifiable concentrate
GR	granular
WP	wettable powder

SITE CATEGORIES: Terrestrial Food Crops 14

TOXICOLOGICAL INFORMATION:

Chlorpyrifos is a cholinesterase inhibitor. Typical symptoms of overexposure to cholinesterase inhibitors include headache, nausea, dizziness, sweating, salivation, runny nose and eyes. This may progress to muscle twitching, weakness and tremor in coordination, vomiting, abdominal cramps and diarrhea in more serious poisonings. A life-threatening poisoning is signified by loss of consciousness, incontinence, convulsions and respiratory depression with a secondary cardiovascular component. Treat symptomatically. If exposed, plasma and red blood cell cholinesterase tests may indicate degree of exposure (baseline data are useful). Atropine, only by injection, is the preferable antidote. Oximes, such as Pralidoxime Chloride, may be therapeutic if used early; however, use only in conjunction with atropine. In cases of severe acute poisoning, use antidotes immediately after establishing an open airway and respiration. With oral exposure, the decision of whether to induce vomiting or not should be made by an attending physician.

[For those products that contain greater than 10% petroleum distillates, the following text should also be added to TOXICOLOGICAL INFORMATION section (placed at the end of the paragraph presented above), as an additional aid to the attending physician:

NOTE: Product contains a petroleum distillate solvent.]

PRECAUTIONS FOR MIXERS/LOADERS

For EC formulations packaged in containers more than 10 L

Mixers/loaders must use a closed mechanical transfer loading system. Mixers/loaders must wear:

- coveralls over long-sleeved shirt and long pants
- chemical resistant gloves
- an air purifying respirator with an -R or -P series filter
- socks and shoes

For EC formulations packaged in containers holding 10 L or less

Mixers/loaders must wear:

- coveralls over long-sleeved shirt and long pants
- chemical-resistant gloves
- chemical-resistant apron
- chemical-resistant footwear plus socks
- an air purifying respirator equipped with an -R or -P series filter

For WP formulations (must be packaged in water soluble bags)

Mixers/loaders must wear:

- long-sleeved shirt and long pants
- socks and shoes
- chemical resistant gloves
- chemical resistant apron

Mixers and loaders using water-soluble packets must have immediately available for use in emergency (such as a broken package, spill or equipment breakdown) additional PPE. These PPE include coveralls and chemical-resistant footwear and a non-powered air purifying respirator equipped with an -R or -P series filter.

For GR formulations

Mixers/loaders must wear:

- coveralls over long-sleeved shirt and long pants
- chemical resistant gloves
- chemical resistant footwear and socks
- an air purifying respirator equipped with an -R or -P series filter
- chemical resistant apron

PRECAUTIONS FOR APPLICATORS

Applicators using airblast equipment with a closed cab must wear:

- long-sleeved shirt and long pants
- socks and shoes
- chemical resistant gloves

Applicators using airblast equipment with an open cab must wear:

- long-sleeved shirt and long pants
- chemical resistant coveralls and head protection
- socks and shoes
- chemical resistant gloves
- an air purifying respirator with an -R or -P series filter

Applicators using ground equipment with a closed cab must wear:

- long-sleeved shirt and long pants
- chemical resistant gloves when leave cab for clean up and repair
- socks and shoes

Applicators using ground equipment with an open cab must wear:

- coveralls over long-sleeved shirt and long pants
- chemical resistant gloves
- socks and shoes

Applicators using aerial application equipment must use enclosed cockpits and must wear:

- long-sleeved shirt and long pants
- socks and shoes

Applicators using handheld equipment must wear:

- long-sleeved shirt and long pants
- chemical resistant coveralls and head protection (if spray is upwardly directed)
- chemical resistant footwear and shoes
- chemical resistant gloves
- an air purifying respirator with an -R or -P series filter

ENVIRONMENTAL PRECAUTIONS

This product is highly toxic to bees exposed to direct treatment, drift or residues on looming plants. Do not apply this product or allow it to drift to blooming plants if bees are visiting the treatment area. Applicators should inform local bee keepers prior to application if hives are in adjacent fields.

[All statements regarding spray drift management and buffer zones, as presented in Appendix III of this document, must appear on the label of EC and WP products.]

DIRECTIONS FOR USE

NOTE: Only agricultural uses for chlorpyrifos that were considered under Phase 2 of the review are summarized below. Acceptable uses for chlorpyrifos that were considered in Phase 1 (see Appendix I) of the review are not summarized below.

Application by aircraft is permitted only where specified in the directions for use.

A plant back interval of 30 d must be observed between application and planting of rotational crops.

Sites and pests	Rates (as active) and directions
CANOLA	EC formulation: Do not apply more than once per season. Do not apply within 21 days of harvest. Application is permitted by ground equipment or aircraft. Do not enter treated fields until 1 day after application.
bertha armyworm	EC formulation: Apply 360–480 g a.i. in 50–200 L/ha for ground application equipment, or in 10–30 L/ha for aircraft. Apply as a foliar spray. Use the higher rate of dilution when infestations are heavy and when the foliage is dense. Spray in the evening to reduce harm to pollinators.
diamondback moth (larvae)	EC formulation: Apply 480 g a.i. in 100–200 L/ha for ground application equipment, or in 40 L/ha for aircraft. Apply as a foliar spray. Use the higher rate of dilution when infestations are heavy and when the foliage is dense. Spray in the evening to reduce harm to pollinators.
lygus bugs	EC formulation: Apply 480 g a.i. in 50–200 L/ha for ground application equipment, or in 10–30 L/ha for aircraft. Apply as a foliar spray. Use the higher rate of dilution when infestations are heavy and when the foliage is dense. Spray in the evening to reduce harm to pollinators.
FLAX	EC formulation: Do not apply more than once per season. Do not apply within 21 days of harvest. Ground application only (do not apply by aircraft). Do not enter treated fields until 1 day after application.
bertha armyworm	EC formulation: Apply 360–480 g a.i. in 50–200 L/ha. Apply as a foliar spray.
WHEAT	EC formulation: Do not apply more than once per season. Do not apply within 60 days of harvest. Application is permitted by ground equipment or aircraft. Do not enter treated fields until 1 day after application.
orange wheat blossom midge	EC formulation: Apply 398–480 g a.i. in 50–200 L//ha for ground application equipment, or in 10–30 L/ha for aircraft. Apply when adults reach the economic threshold and when 25% of the wheat heads have emerged from the boot, but preferably delay spraying until 30% of the crop is flowering. Timing is critical to ensure good control. Applications should be made in the late afternoon or early evening when temperatures exceed 15°C and wind speed is less than 10 km/h.

Sites and pests	Rates (as active) and directions
PEACH, NECTARINE	WP formulation: Do not apply more than 2 times per season. Do not apply within 21 days of harvest. Ground application only (do not apply by aircraft). Do not enter treated fields until 4 days after application to conduct scouting activities.
oriental fruit moth	**Restricted Use** NATURE OF RESTRICTION: To be used only in the Oriental Fruit Moth Resistance Management Program in the Regional Municipality of Niagara and Essex County, coordinated by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). OMAFRA will provide growers with information/training; application training and pest management program advice. WP formulation: Apply 1725 g a.i. in 1000–2000 L water/ha. RESISTANCE MANAGEMENT: Best results will be obtained when application of this insecticide is timed for egg hatch or first instar larvae of first generation Oriental fruit moth, usually around shuck to shuck-split. Growers should consult a local OMAFRA pest management specialist for exact timing of applications. Make 1–2 applications as needed. Apply as ground application only using an airblast sprayer. Direct nozzles of air blast sprayer into the targeted peach or nectarine tree orchard when spraying border rows.
STRAWBERRY	EC and WP formulations: Do not apply more than once per season. Ground application only (do not apply by aircraft). Do not apply within 20 days of harvest. Do not enter treated fields until 1 day after application.
strawberry cutworm (crown borer)	EC and WP formulations: Apply 562.5–576 g a.i. in 2000 L/ha. Apply once as a foliar spray between June 1 and June 15. Large volumes of water are desirable to ensure full wetting of the crown area of the plants.
ASIAN RADISHES (LO BOK, DAIKON)	EC formulation: Do not apply more than 3 times per season. Ground application only (do not apply by aircraft). Do not apply within 32 days of harvest. Do not enter treated fields until 1 day after application.
cabbage maggot	EC formulation: Apply 100.8 g a.i. in 1000 L of water per 1000 m row. Apply as a drench over seeded rows at 7, 20 and 35 days after seeding.
RADISH	EC formulation: Do not apply more than once per season. Ground application only (do not apply by aircraft). Do not apply within 21 days of harvest. Do not enter treated fields until 1 day after application.
cabbage maggot	EC formulation: Apply 40.8 g a.i. in 380 L of water per 1000 m row. Apply as a drench with seed at planting time.

Sites and pests	Rates (as active) and directions
CELERY, CUCUMBER	EC and WP formulations: Do not apply more than once per season. Do not apply within 70 days of harvest for celery, or 60 days of harvest for cucumber. Ground application only (do not apply by aircraft). Do not enter treated fields until 1 day after application.
black cutworm, darksided cutworm, redbacked cutworm	SOIL TREATMENT EC formulation: Apply 1152 g a.i. in 200–400 L/ha. Apply once as a soil treatment 3–7 days before transplanting. Do not incorporate. Also apply to a 15-m strip into adjacent fence rows. SEEDLING TREATMENT EC and WP formulations: Apply 562–1152 g a.i. in 200–400 L/ha. Apply once as a broadcast spray at the 2- to 5-leaf stage of the crop.
PAK CHOI, BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER, CHINESE CABBAGE	GR, EC and WP formulations: Ground application only (do not apply by aircraft). Do not enter treated fields until 1 day after application for pak choi and Chinese cabbage. Do not enter treated fields until 10 days after application for cauliflower, 1 day after application for all other crops. [See also below.] GR formulation: Do not apply more than once per season. EC formulation: If no granular chlorpyrifos treatment has been used, do not apply more than twice per season to broccoli, cabbage, cauliflower, Chinese cabbage and pak choi, or 3 times per season to Brussels sprouts. If granular treatment has been used, do not apply more than once per season to broccoli, cabbage, cauliflower, Chinese cabbage and pak choi, or twice per season to Brussels sprouts. Do not apply within 32 days of harvest for broccoli, Brussels sprouts, cabbage, cauliflower, or Chinese cabbage; or within 15 days of harvest for pak choi. WP formulation: Do not apply more than once per season. Do not apply within 32 days of harvest to cabbage.
cabbage maggot (BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER only)	GR formulation: Apply 90–150 g a.i. per 1000 m of row. Apply as an in-furrow at-plant treatment. Application rates for different row spacings are as follows: Row spacing — kg a.i./ha 30 cm — 3–5 60 cm — 1.5–2.5 75 cm — 1.2–2 80 cm — 1.125–1.875 90 cm — 1–1.7 105 cm — 0.86–1.42

Sites and pests	Rates (as active) and directions
cabbage maggot	EC formulation: AT-PLANTING TREATMENT: Apply 100.8 g a.i./1000 m row. Apply one drench spray in 1000 L/ha spray solution, 10 cm on each side of the plant, 7–10 days after seeding or 3 days after transplanting. POST PLANTING DRENCH: Mix 806 g a.i. in enough water to make 1000 L of finished spray. Apply 12.5 L of this solution per 100 m of row on soil, 10 cm on each side of the plant. Do not apply to harvestable portions of the crop. **If no granular treatment was used at seeding:** For broccoli, Brussels sprouts, cabbage and cauliflower apply a drench treatment within 3 days of transplanting (after plant recovery) or 7–10 days after seeding. Repeat 21 days after the transplanting drench or 28 days after the seeding drench.
cabbage maggot (CABBAGE only)	WP formulation: Apply 16.25 g a.i./100 L. TRANSPLANT WATER TREATMENT: Apply 200 mL of solution with each plant. Do not use starter fertilizers with this product.
CHINESE BROCCOLI	EC formulation: Do not apply more than once per season. Ground application only (do not apply by aircraft). Do not apply within 21 days of harvest. Do not enter treated fields until 1 day after application.
cabbage maggot	EC formulation: Apply 72 g a.i. in 800 L/1000 m row. Apply once per season banded over the row 5–7 days after seeding.
GARLIC	EC formulation: Do not apply more than 2 applications per season. Do not apply within 50 days of harvest. Ground application only (do not apply by aircraft). Do not enter treated fields until 1 day after application.
onion maggot	EC formulation: Apply 1680 g a.i. in 1000 L/ha. Apply as a drench to the soil over the seedling row.
black cutworm, darksided cutworm, redbacked cutworm	SOIL TREATMENT EC formulation: Apply 1152 g a.i. in 200–400 L/ha. Apply once 3–7 days before transplanting. Do not incorporate. Also apply to a 15-m strip into adjacent fence rows. SEEDLING TREATMENT EC formulation: Apply 576–1152 g a.i. in 200–400 L/ha Apply once as a broadcast spray at the 2- to 5-leaf stage of the crop.

Sites and pests	Rates (as active) and directions
ONION (Bulb, Pickling)	GR formulation: Do not apply more than once per season. Do not apply within 109 days of harvest for bulb onions, or 97 days of harvest for pickling onions. Ground application only (do not apply by aircraft). Do not enter treated fields until 1 day after application.
onion maggot	GR formulation: Apply 1.2–2.4 kg a.i./ha, as follows: Row spacing — kg a.i./ha 2.5–5 cm — 1.2 7.5 cm — 1.8 10–15 cm — 2.4 Apply as an in-furrow at-plant treatment.
RUTABAGA	GR, EC and WP formulations: Ground application only (do not apply by aircraft). Do not enter treated fields until 1 day after application. Do not apply within 30 days of harvest. [See also below.] GR formulation: Do not apply more than once per season. EC formulation: If no granular chlorpyrifos treatment has been used, do not apply more than 4 times per season. If granular chlorpyrifos treatment has been used, do not apply more than 3 times per season. WP formulation: Do not apply more than once per season.
black cutworm, darksided cutworm, redbacked cutworm	SOIL TREATMENT EC formulation: Apply 1152 g a.i. in 200–400 L/ha. Apply once 3–7 days before transplanting. Do not incorporate. Also apply to a 15-m strip into adjacent fence rows. SEEDLING TREATMENT EC and WP formulations: Apply 562–1152 g a.i. in 200–400 L/ha. Apply once as a broadcast spray at the 2- to 5-leaf stage of the crop.
cabbage maggot	GR formulation: Apply 90–150 g a.i. per 1000 m of row. Apply as an in-furrow at-plant treatment. Application rates for different row spacings are as follows: Row spacing — kg a.i./ha 30 cm — 3–5 60 cm — 1.5–2.5 75 cm — 1.2–2 80 cm — 1.125–1.875 90 cm — 1–1.7 105 cm — 0.86–1.42

Sites and pests	Rates (as active) and directions
cabbage maggot	EC formulation: Apply 100.8 g a.i. in 125 L/1000 m row. Apply as a post-planting drench to soil 10 cm on each side of the plant. Application rates for different row spacings are as follows: Row spacing — kg a.i./ha 30 cm — 3.36 60 cm — 1.68 75 cm — 1.34 80 cm — 1.26 90 cm — 1.12 105 cm — 0.96 Do not apply to harvestable portions of the crop. If no granular treatment was used at seeding, apply drench treatments at 10, 28, 49 and 70 days after seeding. If granular treatment with a chlorpyrifos insecticide was used at seeding, apply drench treatments at 28, 49 and 70 days after seeding.
CARROT	EC and WP formulations: Ground application only (do not apply by aircraft). Do not apply more than once per season. Do not apply within 60 days of harvest. Do not enter treated fields until 1 day after application.
black cutworm, darksided cutworm, redbacked cutworm	SOIL TREATMENT EC formulation: Apply 1152–2304 g a.i. in 200–400 L/ha. Apply once per season before planting or transplanting. May also be applied to a 15 m strip adjacent to fence rows. Use the low rate except under conditions of low soil moisture. Use the high rate if the top 1 cm of soil is dry. Do not incorporate on muck soils. SEEDLING TREATMENT EC and WP formulations: Apply 1152–2304 g a.i. in 200–400 L/ha. Apply as a broadcast spray at the 2 to 5 leaf stage. Use the low rate except under conditions of low soil moisture. Use the high rate if the top 1 cm of soil is dry.
POTATO	EC formulation: Ground application only (do not apply by aircraft). Do not apply more than once per season. Do not apply within 7 days of harvest. Do not enter treated fields until 1 day after application to conduct scouting, hand weeding or irrigation activities.
Colorado potato beetle (larvae)	EC formulation: Apply 480 g a.i. in 400–800 L/ha as a foliar spray.
SUNFLOWER	EC formulation: Ground application only (do not apply by aircraft). Do not apply more than once per season. Do not apply within 42 days of harvest. Do not enter treated fields until 1 day after application.
army cutworm, pale western cutworm, redbacked cutworm	EC formulation: Apply 576 g a.i. in 50–200 L/ha. Apply as a broadcast spray when damage first appears.
seed weevil	EC formulation: Apply 576 g a.i. in at least 20 L/ha. Apply in late July to early August when populations of weevils are observed in the sunflower heads.

Sites and pests	Rates (as active) and directions
BARLEY, WHEAT	EC Formulation: Do not apply more than once per season to barley or wheat. Do not apply within 60 days of harvest. Application by aircraft is permitted only for control of orange wheat blossom midge on wheat. Do not enter treated fields until 1 day after application.
army cutworm, darksided cutworm, pale western cutworm, redbacked cutworm	EC formulation: Ground application only (do not apply by aircraft). Apply 420–576 g a.i. in 50–200 L/ha. Apply to soil or foliage.
grasshoppers	EC formulation: Ground application only (do not apply by aircraft). Apply 278.4–420 g a.i. in 50–200 L/ha. Apply as a broadcast foliar spray. Use the low rate for juvenile grasshoppers and the high rate for adults. Treat adjacent ungrazed and unoccupied areas such as roadsides, rights-of-way and fence lines at the first sign of infestation.
orange wheat blossom midge (WHEAT only)	EC formulation: Apply 398–480 g a.i. in 50–200 L/ha for ground application. Apply 480 g a.i. in 10–30 L/ha for aerial application. Apply when adults reach the economic threshold and when 25% of the wheat heads have emerged from the boot, but preferably delay spraying until 30% of the crop is flowering. Timing is critical to ensure good control. Applications should be made in the late afternoon or early evening when temperatures exceed 15°C and wind speed is less than 10 km/h.
ONION (bulb, pickling)	GR, EC and WP formulations: Ground application only (do not apply by aircraft). Do not apply more than once per season. Do not enter treated fields until 1 day after application. Do not apply to bunching onions. [See also below.] GR formulation: Do not apply within 109 days of harvest for bulb onions, or 97 days of harvest for pickling onions. EC and WP formulations: Do not apply within 60 days of harvest.
onion maggot	GR formulation: Apply 1.2–2.4 kg a.i./ha, as follows: Row spacing — kg a.i./ha 2.5–5 cm — 1.2 7.5 cm — 1.8 10–15 cm — 2.4 Apply as an in-furrow at-plant treatment.

Sites and pests	Rates (as active) and directions
black cutworm, darksided cutworm, redbacked cutworm	SOIL TREATMENT EC formulation: Apply 1152–2304 g a.i. in 200–400 L/ha. Apply once per season before planting or transplanting. Application is also permitted on a 15 m strip adjacent to fence rows. Use the low rate except under conditions of low soil moisture. Use the high rate if the top 1 cm of soil is dry. Do not incorporate on muck soils. SEEDLING TREATMENT EC and WP formulations: Apply1125–2304 g a.i. in 200–400 L/ha. Apply as a broadcast spray at the 2 to 5 leaf stage. Use the low rate except under conditions of low soil moisture. Use the high rate if the top 1 cm of soil is dry.

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