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Proposed Re-evaluation Decision PRVD2019-05

Chlorpyrifos and Its Associated End-use Products: Updated Environmental Risk Assessment

Consultation Document

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Proposed Re-evaluation Decision

Under the authority of the *Pest Control Products Act*, all registered pesticides must be regularly re-evaluated by Health Canada's Pest Management Regulatory Agency (PMRA) to ensure that they continue to meet current health and environmental safety standards and continue to have value. The re-evaluation considers data and information from pesticide manufacturers, published scientific reports, and other regulatory agencies. Health Canada applies internationally accepted risk assessment methods as well as current risk management approaches and policies.

Chlorpyrifos is a broad spectrum organophosphate insecticide used to control insects in various settings. In 2000, Health Canada concluded a re-evaluation of chlorpyrifos, focused on non-agricultural uses including uses in and around residential areas (REV2000-05). As a result, most residential uses (except those applied using containerized baits) were removed from chlorpyrifos labels. In addition, mitigation measures were implemented for some agricultural uses including discontinuation of tomato use and lowered maximum residue limits for apples and grapes.

The re-evaluation of chlorpyrifos continued with the examination of agricultural and forestry uses. The health and environmental risk assessments, as well as the proposed decision for agricultural and forestry uses, were published for consultation in 2003 (PACR2003-03). Refinement of the environmental risk assessment presented in that consultation document was limited by a lack of sufficient surface water monitoring data and uncertainties related to the avian risk assessment. Following the consultation, Health Canada implemented measures in 2007 (REV2007-01) to further protect human health, including new engineering controls, personal protective equipment, and restricted-entry intervals. In addition, the environment was further protected by adding environmental precautions and spray buffer zones to the chlorpyrifos product labels. Health Canada has since received additional water monitoring data and updated the environmental risk assessment.

This document presents a summary of the updated environmental risk assessment and the proposed regulatory decision for chlorpyrifos. A value assessment was also conducted.

All products containing chlorpyrifos registered in Canada are subject to this proposed re-evaluation decision. This document is subject to a 90-day public consultation period, during which the public including the pesticide manufacturers and stakeholders may submit written comments and additional information to the PMRA. The final re-evaluation decision will be published taking into consideration the comments and information received.

Outcome of the Updated Environment Risk Assessment

Currently, chlorpyrifos is used in the commercial production of fruits, vegetables, cereals, grains, legumes, tree nuts, oilseeds, greenhouse and outdoor ornamentals and turf (golf courses, industrial sites, highway medians and sod farms). It is also applied in non-residential, outdoor areas to control mosquito larva in standing water and to reduce adult mosquito populations. Furthermore, it is used to manage certain destructive forest or urban tree insects, and as an indoor and outdoor, non-residential treatment to control insects found in and around buildings.

Chlorpyrifos is applied by growers and other certified users using ground equipment as a foliar, soil granular or drench application, and for some uses by aerial application.

An evaluation of available scientific information has not found acceptable risks to beneficial arthropods, birds, mammals and all aquatic biota in the environment for most current chlorpyrifos uses. Greenhouse ornamental, outdoor ornamentals (container stock only) for control of Japanese beetle larvae, indoor and outdoor structural, adult and larval mosquito uses of chlorpyrifos have been shown to be acceptable from the environmental perspective.

Chlorpyrifos is a broad spectrum insecticide that can manage several insect pests on a wide range of use sites, including horticultural, structural, and mosquito control uses. It is one of the most widely sold pesticides in Canada, and is one of the few insecticides registered to manage certain important pests, including invasive alien species, and mosquitoes. Chlorpyrifos has been found to have value to agriculture and other sectors.

Proposed Regulatory Decision for Chlorpyrifos

Under the authority of the *Pest Control Products Act* and based on the evaluation of currently available scientific information, Health Canada is proposing cancellation of all uses of chlorpyrifos except those listed below, due to risks to the environment (aquatic biota, beneficial arthropods, birds and mammals) that were not found to be acceptable. These uses that are proposed for cancellation include almost all agricultural uses of chlorpyrifos.

Only a small number of uses are acceptable for continued registration with required label changes:

- Standing water - temporary pools for larval mosquito control
- Outdoor adult mosquito control
- Structural indoor and outdoor (non-residential)
- Outdoor ornamentals (container stock only) for control of Japanese beetle larvae
- Greenhouse ornamentals

Registered pesticide product labels include specific instructions for use. Directions include risk reduction measures to protect human and environmental health. These directions must be followed by law. As a result of the re-evaluation of chlorpyrifos, additional required label changes are summarized below based on the current labelling standard. Refer to Appendix IV for details.

- Standard environmental hazard statements to inform users of the potential toxic effects to non-target species.
- Standard environmental advisory statements for prevention of contamination of aquatic systems and to reduce volatilization.

Status of Human Health Assessment

Chlorpyrifos is also under re-evaluation in other jurisdictions including the United States Environmental Protection Agency (USEPA) and the European Food Safety Authority. Due to the recent international reviews, new studies on human health have been generated. Health Canada will be requesting, in the near future, that the relevant new information be provided in order to update the existing human health risk assessment including the drinking water assessment. This update will be presented in a future publication.

International Context

Chlorpyrifos is currently authorized for use in other Organisation for Economic Co-operation and Development (OECD) member countries, including the United States, Australia and the European Union. The European Food Safety Authority, Australia Pesticides and Veterinary Medicines Authority, and the USEPA are currently reviewing chlorpyrifos.

No decisions by an OECD member country or other international agency to prohibit all uses of chlorpyrifos for health or environmental reasons have been identified.

Next Steps

The public, including the registrants and stakeholders may submit additional information that could be used to refine risk assessments during the 90-day public consultation period[1] upon publication of this proposed re-evaluation decision.

All comments received during the 90-day public consultation period will be taken into consideration in preparation of re-evaluation decision document,[2] which could result in revised risk mitigation measures. The re-evaluation decision document will include the final re-evaluation decision, the reasons for it and a summary of comments received on the proposed re-evaluation decision with Health Canada's responses.

Additional Scientific Information

There are no additional data requirements at this time for the environmental risk assessment.

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1 "Consultation statement" as required by subsection 28(2) of the *Pest Control Products Act*.

2 "Decision statement" as required by subsection 28(5) of the *Pest Control Products Act*.

Science Evaluation

1.0 Introduction

Chlorpyrifos is a broad spectrum organophosphate insecticide belonging to Insecticide Resistance Action Committee Mode of Action Group 1B, which disrupts nerve transmission by acting as a cholinesterase inhibitor. It works as a non-systemic insecticide with contact, ingestion and respiratory activity.

2.0 Technical Grade Active Ingredient

2.1 Identity of the Technical Grade Active Ingredient

Common name chlorpyrifos

Function insecticide

Chemical Family organophosphate

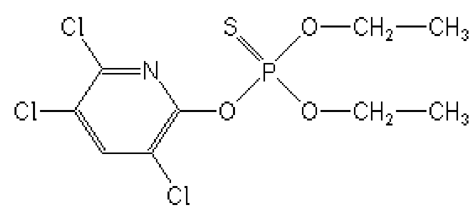
Chemical name

1. **International Union of Pure and Applied Chemistry (IUPAC)** *O*,*O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate
2. **Chemical Abstracts Service (CAS)** *O*,*O*-diethyl *O*-(3,5,6-trichloro-2-pyridinyl) phosphorothioate

CAS Registry Number 2921-88-2

Molecular Formula $C_9H_{11}Cl_3NO_3PS$

Structural Formula



Molecular Weight 350.6

Reg. No.	Product Name	Active Ingredient Content
19656	Dursban FM Insecticidal Chemical	97.0%
23621	Pyrinex Technical Chlorpyrifos Insecticide	97%
31417	Chlorpyrifos Agrogill Technical Grade Active Ingredient	98.6%
31418	Fosban Chlorpyrifos Technical	98.5%
32694	Sharda Chlorpyrifos Technical Insecticide	98.8%
33295	Newagco Chlorpyrifos Technical	98.9%

2.2 Physical and Chemical Properties of the Technical Grade Active Ingredient

Property	**Result**
Vapour pressure at 25°C	2.7 mPa
Ultraviolet (UV) / visible spectrum	λ_{max} = 230 nm
Solubility in water at 20-25°C	~1.4 mg/L
n-Octanol/water partition coefficient	log K_{ow} = 4.7
Dissociation constant	Does not dissociate at environmental pH

2.3 Description of Registered Chlorpyrifos Uses

Appendix I lists all chlorpyrifos products that are registered under the authority of the *Pest Control Products Act*.

Appendix II lists all the commercial uses for which chlorpyrifos is presently registered and were therefore considered in the environmental risk assessment of chlorpyrifos. In 2017, the residential containerized bait products expired and were not renewed by registrants. Therefore, there are no domestic class products of chlorpyrifos registered in Canada.

3.0 Environmental Assessment

3.1 Fate and Behaviour in the Environment

A summary of physical and chemical properties and environmental fate data for chlorpyrifos in terrestrial and aquatic environments can be found in Appendix III, Tables 1–9.

Chlorpyrifos enters the terrestrial environment when it is used as an insecticide on a variety of cereal, oilseed, fruit, tobacco, vegetable crops, shrubs, turf, and ornamentals for the control of insect pests. Although chlorpyrifos is also registered for structural, greenhouse and mosquito control, environmentally-relevant concentrations are not expected from these uses when used according to label directions.

In the environment, chlorpyrifos is expected to be non-persistent to moderately persistent in aerobic soil (half-life = 11–180 days), with persistence decreasing with increased soil alkalinity. Laboratory aerobic soil biotransformation studies identify only one major transformation product, 3,5,6-trichloro-2-pyridinol (TCP). Aerobic soil biotransformation of TCP in soil varies (half-life = 8–752 days) while phototransformation of TCP is an important route of degradation in soil (half-life = 2–14 days). Under anaerobic conditions, chlorpyrifos is expected to be slightly to moderately persistent in soil (half-life = 15–58 days), with TCP being the only major transformation product. Once transformed to TCP in anaerobic soils, TCP is persistent with a half-life greater than 500 days.

Terrestrial field dissipation half-lives were relatively consistent and indicate that chlorpyrifos is non-persistent to moderately persistent in Canadian or equivalent soils (DT_{50} = 2–56 days). Field study dissipation half-lives for TCP were found to be similar to that of chlorpyrifos. Dissipation of chlorpyrifos from plants appears to be biphasic, with rapid volatilization followed by photolysis and growth dilution, with half-lives ranging from 5 hours to 14 days. Laboratory studies indicate that volatilization is unlikely to contribute significantly to the dissipation of chlorpyrifos in the environment; however, field studies demonstrate that volatilization is significant (25–80% of applied chlorpyrifos).

Chlorpyrifos has low solubility in water (0.059–2 mg/L) and a high soil organic carbon partition coefficient (K_{oc} = 2785-31 000) which indicates that it is expected to be immobile to slightly mobile in soils. Laboratory adsorption data indicate that the more soluble transformation product TCP is much more mobile in soil than chlorpyrifos. The criteria of Cohen et al. (1984) and the groundwater ubiquity score (GUS) indicate that chlorpyrifos has limited potential to leach (GUS = 0.97), whereas, TCP has much more potential for leaching (GUS = 7.4). Soil column leaching experiments confirm that chlorpyrifos residues remains in the upper few centimeters of soil. No leaching of chlorpyrifos or TCP below 30 cm was observed in American agricultural field sites; however, leaching of TCP into drainage tiles below highly porous golf greens was demonstrated.

In aquatic systems, chlorpyrifos is non-persistent in the water column (DT_{50} values <15.2 days), with much of the dissipation in the water column being a result of partitioning to the sediment. Chlorpyrifos does not hydrolyze rapidly in water (half-life of 16–147 days); hydrolysis rates generally increase with increasing pH. TCP and O-ethyl O-(3,5,6-trichloro-2-pyridinol) phosphorothioate are major transformation products of hydrolysis, and they do not appear to undergo hydrolysis themselves. In water, phototransformation is not expected to be an important route of transformation of chlorpyrifos (laboratory half-life of 29.6–40 days), with transformation products accounting for <5% of applied radioactivity at the end of the 30-day study.

Aquatic field dissipation studies indicate that chlorpyrifos has a half-life of <7 days in water; the short persistence of chlorpyrifos in water under field conditions is likely due to volatility from water, low water solubility and strong affinity for sediments and suspended solids. Although the laboratory-based Henry’s Law Constant predicts a low potential for chlorpyrifos to volatilize from water or moist soil, volatilization of chlorpyrifos from aquatic systems has been shown to be significant, with up to 60% lost on the first day after treatment. Once chlorpyrifos enters the sediment, the rate of transformation is highly variable with half-lives ranging from 1.2–200 days in aquatic field studies, while TCP is expected to be non-persistent in water and sediment (half-life <13.3 days).

Based on the octanol-water partitioning coefficient, chlorpyrifos has the potential to bioaccumulate (log K_{ow} of 3.3-5.27), while TCP has a lower potential to bioaccumulate (log K_{ow} of 1.3-3.2), particularly under neutral conditions. Laboratory studies indicate that chlorpyrifos bioaccumulates in aquatic organisms; however, bioconcentration factors (BCFs) were generally below the TSMP Track 1 criteria of >5000 (Appendix III, Table 9). Although modelling suggests that chlorpyrifos should not be transported long distances, there is evidence indicating that chlorpyrifos is present in air, snow, seawater, precipitation, sediment and both aquatic and terrestrial Arctic biota; however, chlorpyrifos has not been shown to biomagnify in either terrestrial or marine organisms in studies from the Canadian Arctic.

3.2 Environmental Risk Characterization

The environmental risk assessment integrates the environmental exposure and ecotoxicology information to estimate the potential for adverse effects on non-target species. This integration is achieved by comparing exposure concentrations with concentrations at which adverse effects occur. Estimated environmental concentrations (EECs) are concentrations of pesticide in various environmental media, such as food, water, soil and air. The EECs are estimated using standard models which take into consideration the application rate(s), chemical properties and environmental fate properties, including the dissipation of the pesticide between applications. Ecotoxicology information includes acute and chronic toxicity data for various organisms or groups of organisms from both terrestrial and aquatic habitats including invertebrates, vertebrates, and plants. Toxicity endpoints used in risk assessments may be adjusted to account for potential differences in species sensitivity as well as varying protection goals (in other words, protection at the community, population, or individual level). A risk quotient (RQ) is calculated by dividing the exposure estimate by an appropriate toxicity value (RQ = exposure/toxicity), and the risk quotient is then compared to the level of concern (LOC).

Normally, a screening level risk assessment is performed to identify pesticides and/or specific uses that do not pose a risk to non-target organisms and to identify those groups of organisms for which there may be a potential risk. During previous screening level risk assessments, RQ values were very high (PACR 2003-03); therefore, the current review proceeded directly to a refined risk assessment.

A refined assessment takes into consideration more realistic exposure scenarios (such as drift and run-off to non-target habitats). Refinements may include further characterization of risk based on exposure modelling, monitoring data, results from field or mesocosm studies, and probabilistic risk assessment methods. Refinements to the risk assessment may continue until the risk is adequately characterized or no further refinements are possible.

Endpoints selected for the risk assessment were chosen on a hierarchical basis. Hazardous concentration to 5% of the species (HC_5) or hazardous dose to 5% of the species (HD_5) values from species sensitivity distributions (SSDs), when available either from the 2016 review conducted by the USEPA or as determined by Health Canada, were selected first as they take into consideration much of the available data from published literature and registrant submitted studies. For taxa where an HC_5 was not available, the most sensitive endpoint was selected from various international reviews (USEPA, Australia, European Commission, European Food Safety Agency and the previous Health Canada review conducted in 2000). The toxicological endpoints are provided in Appendix III, Table 10. The freshwater chronic laboratory invertebrate endpoint chosen for the risk assessment was a LOAEC, therefore, risk could be underestimated for freshwater invertebrates using this endpoint.

When multiple higher tier aquatic studies were available, risk was bracketed using lower and upper bound endpoints. For freshwater invertebrates both lower and upper bound acute endpoints were obtained from the same study and represent the measured concentration (lower bound) and nominal concentration (upper bound) for community level effects. The freshwater fish endpoints chosen for the acute risk assessment were the measured concentrations from two different studies with an uncertainty factor of 0.5 included with the LC_{50} for the upper bound endpoint.

Transformation products of chlorpyrifos were not considered in the environmental risk assessment because either their toxicity was orders of magnitude less than chlorpyrifos or environmental fate studies showed insignificant formation which would result in negligible exposure of the transformation products to biota.

3.2.1 Risks to Terrestrial Organisms

A summary of the endpoints selected for the risk assessment for terrestrial biota is presented in Appendix III, Table 10. The terrestrial risk assessment took into account the range of agricultural application rates that are registered for chlorpyrifos and the fact that there may be multiple applications of chlorpyrifos on the same field in a use season.

Terrestrial Invertebrates

Soil-Dwelling Invertebrates
The most-sensitive 14-day LC_{50} for *Lumbricus rubellus* is 104 mg a.i./kg dry soil. Taking into consideration the uncertainty factor of 0.5, the LC_{50} used in the risk assessment is 52 mg a.i./kg soil. At the highest cumulative application rate (3 360 g a.i./ha × 4 applications at 18-, 21- and 21-day intervals and a soil half-life of 179 days to account for dissipation between applications) for rutabaga, the EEC is 5.3 mg a.i./kg soil. The associated acute RQ based on the maximum application rate is 0.10 indicating that chlorpyrifos is not expected to pose an acute risk to earthworms (LOC = 1).

The NOEC for chronic effects to earthworms is 4.6 mg a.i./kg soil. The associated RQ based on the maximum application rate is 1.2; therefore, the LOC is slightly exceeded on a chronic basis. Given the conservative nature for determining the EEC in soil, a chronic risk is not expected for earthworms.

Pollinators
The pollinator risk assessment followed the framework developed jointly by Health Canada's Pest Management Regulatory Agency (PMRA), USEPA and the California Department of Pesticide Regulation (Guidance for Assessing Pesticide Risks to Bees, 2014). The tiered risk assessment framework consists of exposure characterization and effects characterization relative to bees, and moves from a highly conservative risk assessment at lower tiers to a more realistic assessment at higher tiers.

Screening Level Risk Assessment
Pollinators can be exposed to chlorpyrifos from contact and/or feeding on contaminated parts of plants, for example, pollen and nectar. In-hive bees, including immature bees, can be exposed via contaminated plant materials brought back by foraging bees. For the Tier I risk assessment for foliar application, the lowest single spray application rate was used to estimate the EEC. If risk is apparent at the lowest rate, risk will also be expected at higher application rates. The most

sensitive 48-h endpoints for acute contact and oral toxicity tests on adult bees were used in the risk assessment (0.059 and 0.04 µg a.i./adult bee, respectively) as well as acute larval toxicity (0.021 µg a.i./larval bee).

Contact exposure to adult bees (expressed as µg a.i./bee) was estimated by multiplying the application rate in kg a.i./ha by 2.4 µg a.i./bee per kg a.i /ha, the maximum residue value. The estimated residue per bee following the minimum single application of 12 g a.i./ha (various ornamentals) is 0.029 µg a.i./bee, respectively. The RQ value for adult bees resulting from acute contact exposure to chlorpyrifos at the minimum single application rate was 0.5 which exceeds the LOC of 0.4. As the lowest single application rate was used for this screening level risk assessment for adult bees, the LOC would also be exceeded for all other application rates and uses.

Dietary exposure to adult bees (in µg a.i./bee) was estimated by multiplying the application rate in kg a.i./ha by 29 µg a.i./bee per kg a.i/ha. The estimated dietary exposure was calculated to be 0.348 µg a.i./bee using the lowest single application rate of 12 g a.i./ha for various ornamentals, as above. The RQ for adult bees resulting from acute oral exposure was 8.7 which exceeds the LOC of 0.4. As the lowest single application rate was used for this screening level risk assessment for adult bees, the LOC would also be exceeded for all other application rates and uses.

Dietary exposure to larval bees (in µg a.i./bee) was estimated by multiplying the application rate in kg a.i./ha by 12 µg a.i./bee per kg a.i/ha. The estimated dietary exposure was calculated to be 0.144 µg a.i./bee. The RQ for bee larvae resulting from acute oral exposure was 6.9 which exceeds the LOC of 0.4 (RQ = 6.9). As the lowest single application rate was used for this screening level risk assessment for larval bees, the LOC would also be exceeded for all other application rates.

Chronic endpoints for adult and larval bees are not available; however, multiple higher tier studies at the colony level are available. Given the potential for risks to bees that was observed in the screening assessment, a higher-tiered risk assessment was conducted for bees.

Higher Tier Risk Assessment

The results from multiple tier II and III studies suggest that there are potential risks for bees, including honey bees and alfalfa leafcutting bees, for foliar applications during bloom at 1.12 kg/ha or greater on bee-attractive flowering plants. Risks may occur from applications made during the crop blooming period (risks may occur from applications made while bees are foraging on blooming crops, as well as from evening or morning applications made during the crop blooming period; risks cannot be mitigated by making applications during the evening when bees are not foraging). In addition, there is evidence of potential for risk to bees at application rates lower than 1.12 kg a.i./ha rate, with effects on bees from a microencapsulated formulation applied to flowering crops (800 g a.i./ha) and a foliar residue study where application at 280 g a.i./ha resulted in 100% mortality after 12-h of aging on leaves and <31% mortality after 48–96 h of aging on leaves.

Overall, there is the potential for risk to bees at all application rates when chlorpyrifos is applied by foliar spray during bloom to bee-attractive crops. Therefore, the potential for pollinator exposure through pollen and nectar routes was further considered for the crops to which chlorpyrifos is applied by foliar spray. The likelihood of pollinator exposure depends on crop attractiveness to pollinators, as well as other agronomic considerations (such as whether or not the crop is harvested before bloom).

Crops or Uses Posing Minimal Risk to Pollinators

Several crop groups or named crops on chlorpyrifos labels are expected to pose minimal risk to bees. These crops are either harvested before bloom, not attractive to pollinators, or are deflowered as standard practice.

The following registered crops are typically harvested before bloom. When harvested before bloom, there will be no exposure to pollinators through pollen and nectar. If these crops are grown for seed, they will not be harvested before bloom; however, very little, if any, of these crops are grown for seed in Canada:

- Crop Group 1: Root and tuber vegetables (only the following crops are registered: Asian radish, radish, sugar beets, carrots, rutabaga, does not include potato as it will have low/moderate exposure (see below)).
- Crop Group 3: Bulb vegetables (only the following crops are registered: onions, garlic)
- Crop group 4: Leafy vegetables (only the following crops are registered: pak-choi, celery)
- Crop group 5: Brassica (Cole) leafy vegetables (only the following crops are registered: Chinese broccoli, Chinese cabbage, broccoli, Brussel sprouts, cabbage, cauliflower)

The following registered crops are not attractive to pollinators:

- From Crop Group 15 Cereal grains: barley, oats, wheat

The following registered crop is normally deflowered as standard production practice (USDA 2015) so it will not pose a risk to pollinators:

- Tobacco

The following uses of chlorpyrifos should not result in exposure to pollinators:

- Forest Lodgepole Pine and Elm tree – the pesticide is applied to lower trunk of tree
- Turf (sod farms and golf courses – weeds are managed, therefore, flowering weeds are not expected to be present in sod farms or golf courses)
- Structural uses, including industrial and manufacturing plants, warehouses, meat packing plants, ships holds, railroad boxcars, food processing plants

- Ornamental uses: Coniferous evergreens (pine, fir, juniper, spruce, arborvitae, hemlock, cypress, yew, live Christmas trees) – coniferous evergreens are not attractive to pollinators

- Temporary pools/standing water for larval mosquito control

Crops or Uses Posing Potential Risk to Pollinators

Crops with High Pollinator Exposure:

- Crop Group 12: Stone fruit (registered crops include: nectarines, peaches)

- Crop Group 20: Oilseed (registered crops include: canola, sunflowers, flax)

- No Crop Group: Ornamentals (excluding coniferous evergreens)

- No Crop Group: Turf (industrial turf lawn sites and highway medians containing flowering plants/weeds; pollinator exposure can be variable from low to high depending on what types of flowering plants/weeds are present in the turf)

Crops with Low/Moderate Pollinator Exposure:

- From Crop Group 1: Root and Tuber Vegetables (registered crops include: potato)

- Crop Group 6: Legume vegetables (registered crop includes: lentils)

- Crop Group 8: Fruiting vegetables (registered crops include: peppers, cucumbers)

- From Crop Group 13: Small fruit and berry (registered crop includes: strawberry)

- From Crop Group 14: Tree Nuts (registered crop includes: filbert)

- From Crop Group 15: Cereals (registered crops include: Sweet corn, field corn, seed corn)

Based on the risk assessment and considering the potential for pollinator exposure, risk is acceptable for pollinators with the following application timing restrictions:

For the following crops application cannot be made during bloom:

- Crop Group 12: Stone fruit (nectarines, peaches)

- Crop Group 20: Oilseed (canola, sunflowers, flax)

- No Crop Group: Ornamentals, excluding Coniferous Evergreens (Coniferous evergreens: pine, fir, juniper, spruce, arborvitae, hemlock, cypress, yew, live Christmas trees)

- No Crop Group: Turf (industrial turf lawn sites and highway medians containing flowering plants/weeds)—when pollinator attractive flowering plants/weeds are present

For the following crops application during bloom should be avoided, but where necessary applying in the evening after bees are no longer foraging is acceptable; if managed bees are being used, application during bloom is prohibited.

- From Crop Group 1: Root and Tuber Vegetables (potato)

- Crop Group 6: Legume vegetables (lentils)

- Crop Group 8: Fruiting vegetables (peppers, cucumbers)

- From Crop Group 13: Small fruit and berry (strawberry)

- From Crop Group 14: Tree Nuts (Filbert)

- From Crop Group 15: Cereals (Sweet corn, field corn, seed corn)

The following crops/uses are acceptable without any application timing restrictions:

- Asian radish, radish, sugar beets, carrots, rutabaga, radish, onions, garlic, pak-choi, celery, Chinese broccoli, Chinese cabbage, broccoli, Brussel sprouts, cabbage, cauliflower, barley, oats, wheat, tobacco, Forest Lodgepole Pine, Elm trees, turf (golf courses and sod farms), Coniferous evergreens (pine, fir, juniper, spruce, arborvitae, hemlock, cypress, yew, live Christmas trees), Structural uses [including industrial and manufacturing plants, warehouses, meat packing plants, ships holds, railroad boxcars, food processing plants, temporary pools/standing water.

Beneficial Arthropods

The most sensitive acute endpoint for *Aphides colemani* (LC_{50} of 0.2 g a.i./ha) was considered in the risk assessment. Risk to beneficial arthropods is expected at all application rates, with the lowest single registered application rate for chlorpyrifos (12 g a.i./ha on ornamentals) producing an RQ of 60 (LOC = 2).

Field studies show reduction in abundance at application rates ≥180 g a.i./ha. Recovery to initial or control abundance can occur within 2–49 days, however, some arthropod species required approximately one year to fully recover from a single application at a rate of 720 g a.i./ha.

Registered single application rates in Canada range from 12–5000 g a.i./ha. Considering the effects observed in laboratory and field studies at application rates as low as 0.2 g a.i./ha and 180 g a.i./ha, respectively, and that recovery within a year occurred at rates up to 720 g a.i./ha, beneficial arthropods are expected to be at risk from exposure to chlorpyrifos at all registered application rates, and recovery within a year is uncertain at rates greater than 720 g a.i./ha.

Based on the available information, risks to beneficial arthropods were not shown to be acceptable for most outdoor uses of chlorpyrifos at rates above 720 g a.i./ha.

Vascular Plants

Non-target plants may be exposed to chlorpyrifos by direct overspray and spray drift. In a seedling emergence study the most sensitive species was lettuce with an IC_{25} of 2.275 kg a.i./ha. Based on the maximum proposed single application rate (drench application at 5.0 kg a.i./ha for use on rutabaga and cole crops) the RQ is 2.2 indicating that plants may be at risk at maximum application rates used for drenches (LOC = 1). Exposure to non-target seedlings, however, would be expected to be low via this application method.

In a vegetative vigour test, there were no effects observed at the highest application rate used in the study (6.39 kg a.i./ha). Therefore, vegetative vigour is not expected to be affected at the maximum registered single application rate.

Terrestrial Vertebrates

Foliar Applications

For the bird and mammal risk assessment, the ingestion of food items contaminated by spray droplets is considered to be the main route of exposure. The risk assessment is thus based on the estimated daily exposure which takes into account the expected concentration of chlorpyrifos on various food items immediately after the last application and the food ingestion rate of different sizes of birds and mammals. At the screening level, only the most conservative exposure estimates are used; in other words, the highest applicable cumulative application rate for agricultural uses (filbert - 2304 g a.i./ha ×3 applications; at 14-day intervals).

Screening level RQ values are shown in Table 11, Appendix III. The LOC is exceeded for all size classes and feeding guilds of birds and mammals on both an acute and reproductive basis. Given the conservative assumption made at the screening level (in other words, maximum food residue values), the risk to birds and mammals was further characterized by using the mean residue values for calculating EECs and EDEs instead of the upper bound residue values used in the screening level risk assessment. The EDEs were calculated for each bird and mammal size and feeding preference item using the cumulative crop application rate that results in the highest drift (filbert 2304 g a.i./ha × 3 applications) and therefore, the highest off-field EDEs. The risk associated with the consumption of food items contaminated from spray drifting off the treated field was assessed taking into consideration the projected spray drift deposition of spray quality of ASAE fine for early airblast application to filbert (74%) at 1 m downwind from the site of application and the 14-day foliar half-life based on an Ontario field study.

Appendix III, Table 12 indicates that all feeding guilds and size classes of birds are also at an acute and reproductive risk when using mean nomogram residue levels in food (except for acute risk to large granivores) both on-field and off-field due to drift.

As was the case for birds, all feeding guilds and size classes of mammals are also at an acute and reproductive risk when using mean nomogram residue levels in food, both on-field and off-field due to drift (except acute, off-field risk to large granivores) (Appendix III, Table 13).

Based on the available information, the risks to birds and mammals were not shown to be acceptable for many outdoor uses of chlorpyrifos. A label statement is required to inform the user of the potential hazard to both birds and mammals; however, this is unlikely to provide sufficient mitigation for protection of birds and mammals.

Granular Applications

Granular chlorpyrifos is registered for use on a number of crops. The inert carriers are composed of clay particles which can vary in size, weight and texture. Granules made using an inorganic base are usually not attractive as a food item, however, they may be ingested incidentally when birds are foraging for food, or they may be intentionally ingested by birds as grit. The risk assessment method for granular pesticides is similar to that of spray applications, except that the dietary items are granules rather than food items contaminated with pesticide spray. Because the granules in the end-use products are inert clay material it is unlikely they will be ingested by mammals; therefore, this risk will not be considered for mammals.

The same HC_5 and NOEL (reproduction endpoint) endpoints were used in the granular assessment as were used in the foliar risk assessment. Because there are two granular end use products with slightly different granule size, the granular risk assessment was conducted for each product.

As an initial worst-case scenario, in the screening level risk assessment, exposure is estimated based on the food ingestion rate typical of each size class at the highest granular application rate and an incorporation rate of 85%. The screening level risk assessment indicates that all size classes of birds are at risk (Appendix III, Table 14) for both granular products. The number of granules required to reach the acute endpoint for birds ranges from 7 to 431, depending on the size of the bird. The reproductive endpoint is reached with as few as 3–188 granules in birds. The required area to reach the endpoint is much less than 1 m^2 for all size classes of birds.

To refine the risk, the number of grit particles consumed by different bird species can be used to estimate the likelihood of consumption of chlorpyrifos granules. Additionally, the preferred size distribution of grit particles for different bird species is compared with the size distribution of granules in the pesticide product. The average number and size distribution of grit particles consumed by 27 different bird species are described in Luttik and deSnoo (2004[3]). These size distributions are used to determine if there are sufficient granules of the preferred size available to reach the toxicity level of concern through ingestion as grit.

When birds are searching for food and/or grit, the treated granules are mixed with soil particles on the surface. In order to determine the probability of birds consuming a formulated granule over a soil particle, the amount of soil particles on the soil surface needs to be known. Three soils have been assessed by Luttik and deSnoo (2004) and the mean number of all soil particles in the same size class as the granules was used in the assessment and was found to be 712 159 soil particles/m^2. This value was used for all probability calculations.

3 Luttik, R. and G.R. de Snoo (2004). Characterization of grit in arable birds to improve pesticide risk assessment. Ecotoxicology and Environmental Safety 57: 319-329.

The probability of birds consuming granules incidentally while searching for food was estimated using information on the characteristics of the granules, application rates, soil incorporation (85% as per Health Canada guidance), granule preference/avoidance and disappearance, the number of soil particles available and information on granule consumption by birds. As some information specific to the granules or bird behaviour is not available, certain conservative assumptions were made (assumed no preference or avoidance of the granules and that the granules did not disappear over time).

Taking these variables into consideration, it was determined that the probability of any size class of bird preferentially consuming enough granules of chlorpyrifos over actual soil particles to reach either the acute or chronic endpoint was negligible (Appendix III, Table 15).

Terrestrial Risk Assessment Conclusions

Following publication of PACR 2003-03, Health Canada explored probabilistic risk assessment approaches for birds to foliar applications of chlorpyrifos. At that time, probabilistic risk assessment methodology for birds employed models that were in development (Terrestrial Investigation Model (TIM v1) and LiquidPARAM) that had never been used in any type of regulatory assessment for a pesticide. The models remained in development throughout the period Health Canada explored the use of a probabilistic risk assessment approach (2007). Health Canada had concerns with some of the assumptions used in the model and these could not be resolved. As a result, the foliar probabilistic risk assessment that was conducted was not found to be scientifically defensible. The approach was not pursued and is not discussed further in the current assessment.

A probabilistic avian risk assessment conducted for granular formulations of chlorpyrifos determined that there was likely little probability that birds would consume sufficient granular chlorpyrifos to illicit an effect. Risks to birds from granular uses are not expected.

Based on the available information, the risks to beneficial arthropods, birds and mammals were not shown to be acceptable for most outdoor uses of chlorpyrifos.

3.2.2 Risks to Aquatic Organisms

A summary of the endpoints selected for the risk assessment for aquatic biota is presented in Appendix III, Table 10. The aquatic risk assessment takes into account the range of agricultural application rates that are registered for chlorpyrifos and the fact that there may be multiple applications of chlorpyrifos on the same field in a use season. A screening level risk assessment was not conducted as previous screening assessments indicated risk (PACR-2003-03); therefore, the risk characterization proceeded directly to a refined risk assessment.

3.2.2.1 Refined Aquatic Risk Assessment for Spray Drift

The risk to aquatic organisms from drift was characterized by taking into consideration the concentrations of chlorpyrifos that could be deposited in off-field aquatic habitats that are downwind and directly adjacent to the treated field through drift of spray.

Chlorpyrifos-containing end-use products can be applied by a variety of methods. The maximum amount of spray that is expected to drift one metre downwind from the application site during spraying using groundboom, airblast and aerial application methods was initially determined based on a fine spray droplet size: field sprayer – 11%, airblast – 74% (early), 59% (late), aerial – 26%.

Given the variation in percent drift off site for each of the application methods, the assessment of potential risk from drift was determined as a range using a minimum single airblast application to ornamentals (12 g a.i./ha) and the cumulative maximum airblast application rate for filbert (3 applications × 2304 g a.i./ha, at 14-day intervals). There are higher ground application rates; however, the filbert application provides the highest aquatic EECs due to drift because of the higher anticipated percentage of drift (74%) for the airblast application method compared to groundboom applications (11%).

The aquatic EEC for the cumulative application rate has been adjusted to take into consideration the dissipation between applications by using the whole system aquatic biotransformation half-life value of 29.5 days that was used in water modelling.

For airblast application, at the lowest single application rate of 12 g a.i./ha, most biota are at both an acute and chronic risk from spray drift, with the exception of acute risk to freshwater and marine algae, amphibians and freshwater vascular plants (Appendix III, Table 16). Depending on the toxicity endpoint of concern for fish, the lowest application rate also results in risk to freshwater and marine fish from spray drift.

For airblast application using the cumulative maximum application rate for filberts, all biota from both freshwater and marine environments (except freshwater vascular plants) show an acute and chronic risk (where chronic data is available) due to spray drift (Appendix III, Table 16).

3.2.2.2 Refined Aquatic Risk Assessment for Run-off

Aquatic Risk Assessment Using EECs from Water Modelling

Aquatic organisms can be exposed to chlorpyrifos as a result of runoff into a body of water. The Pesticide in Water Calculator (PWC) model was used to predict EECs resulting from runoff of chlorpyrifos following application. Details on modelling inputs and are provided in Appendix III, Table 17 and Table 18. In total, 39 different scenarios were modelled, taking into consideration a wide range of application rates and different regional scenarios.

Detailed results of the refined risk assessment for run-off using water modelling are presented in Appendix III, Tables19–22.

The aquatic ecoscenario modelling EEC values (Appendix III, Table 19 and Table 20) are 90th percentile concentrations at a number of time-frames including the yearly peak, 96-hr, 21-d, 60-d, 90-d and yearly average. The EEC values chosen for calculation of the acute and chronic RQ values are the highest values at the appropriate depth (80 or 15 cm) and appropriate time-frame.

Acute and chronic RQ values were calculated using an EEC for the time frame which most closely matched the exposure time used to generate the endpoint (for example, a 96-hour LC_{50} would use the 96-hour value generated by the model; a 21-day NOEC would use the 21-day EEC value).

Acute and chronic risk due to run-off at all EECs from modelled applications, are shown in Appendix III, Table 21 and Table 22, respectively. The LOC is exceeded for almost all freshwater and marine biota endpoints of concern at every modelled application rate and scenario. Risk was demonstrated at every modelled application rate with the exception of the endpoints for acute freshwater fish HC_5, upper bound fish mesocosm and amphibian HC_5, chronic fish, chronic amphibian and chronic marine fish. Risk is highest for invertebrates on a chronic basis and RQ values ranged from 13 to 3600 and 14 to 3913 for freshwater invertebrates and estuarine/marine invertebrate laboratory endpoints, respectively, at the modelled application rates (Appendix III, Table 22). However, marine biota are expected to be exposed to lower EECs than modelled for freshwater surface waters due to more significant dilution and water exchange in marine systems.

Higher tier invertebrate and fish aquatic field studies corroborate both the acute and chronic risk determined in the risk assessment conducted with laboratory derived endpoints, although RQ values are lower. The RQ values for the lower and upper bound acute invertebrate mesocosm endpoints range from 2.3–500 and 1.4–300, respectively. The RQ values for the lower and upper bound acute fish mesocosm endpoints range from 0.6–120 and 0.1–22, respectively, over all modelled application rates. Based on the lowest chronic invertebrate endpoint derived from mesocosm data, the RQ values range from 0.7–180 for all modelled uses. Only the lowest application rate for lentils falls below the LOC. It should be noted that the use of this chronic invertebrate mesocosm endpoint may not be protective for chronic risk to invertebrates because there were effects in higher tier aquatic studies observed at the lowest concentration tested (0.1 µg a.i./L).

Canadian Water Monitoring Data

A summary of available Canadian water monitoring data is presented in Appendix III, Table 23. Samples taken prior to the year 2000 were not considered relevant due to significant reductions to the registered use pattern around this time. Post year 2000, there were 12 431 Canadian surface water samples analyzed for chlorpyrifos that were considered to be relevant for determination of exposure to aquatic biota.

Monitoring data from New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Manitoba, Saskatchewan, Alberta and British Columbia was available but had limitations that made it difficult to use in the ecological risk assessment. These limitations included: 1) Temporally limited (insufficient number of samples taken at the same location during the growing season, long periods of time between samples where peak concentrations may have been missed), 2) Analytical LODs were higher than the aquatic toxicity endpoints of concern and/or 3) There was limited ancillary information provided with the data (location of sample, identification of crops up stream of the sampling site, pesticide use information), allowing confirmation that chlorpyrifos was in fact used in the watershed in cases where no detections were reported.

Chlorpyrifos was detected in 6% (798) of the post-2000 samples (Appendix III, Table 23). Overall, the provinces of British Columbia, Quebec, and Ontario had the highest detection frequencies of 36%, 18%, and 13%, respectively. The detection frequency in British Columbia is much higher than other regions because the analytical limit of detection (LOD) used was much more sensitive.

The highest surface water monitoring concentration found in Canada was detected in the Ruisseau Rousse, Quebec (44 µg/L; Appendix III, Table 23). This value is identical to the peak level 2 surface water modelling value at 80 cm depth, determined using application rates and timing for onions, (Appendix III, Table 19). This is considered to be a realistic peak concentration from areas of use. For a preliminary monitoring risk assessment, Health Canada determined risk associated with the peak concentration and the second highest concentration (4 µg a.i./L from the Saint-Zéphirin River in Quebec in 2005) found in Canadian monitoring studies.

A chronic EEC value could not be determined from the available monitoring data. Other methods are used in this assessment to determine chronic risk to aquatic organisms and are discussed below in the refined aquatic risk assessment sections. There was no monitoring data available for marine/estuarine systems; therefore, a refined risk assessment using monitoring data was not possible.

First Tier Refined Aquatic Risk Assessment Using EEC values from Canadian Water Monitoring

A summary of the assessment is presented in Appendix III, Table 24.

The two highest concentrations of chlorpyrifos reported in Canadian water monitoring studies were used as a first tier approach in the acute monitoring risk assessment to determine freshwater biota that may not be at risk at these measured concentrations.

The LOC was not exceeded for freshwater vascular plants using the two highest concentrations as acute exposure estimates. The LOC was also not exceeded using the second highest EEC using the fish HC_5 (5.94 µg a.i./L), amphibian HC_5 (20 µg a.i./L) and algae EC_{50} (32 µg a.i./L) toxicity endpoints of concern; using the highest concentration detected, the LOC was slightly exceeded for these same endpoints (RQ values 1.4 – 7.4, Appendix III, Table 24).

The LOC was exceeded for freshwater invertebrates using the HC_5 of 0.044 µg a.i./L (RQ values 91–1000). The LOC was also exceeded for freshwater invertebrates (RQ values 33–176) and freshwater fish (RQ values 2.9 – 16) using the lower and upper bound acute higher tier endpoints of concern for both groups.

As the LOC was exceeded for acute risks to aquatic invertebrates and freshwater fish, a second tier refined aquatic risk assessment using the available robust Canadian water monitoring data was conducted. In addition, chronic risk is examined in a second tier risk assessment.

Second Tier Refined Aquatic Risk Assessment Using EEC values from Canadian Water Monitoring

Available monitoring data on chlorpyrifos from New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Manitoba, Saskatchewan, Alberta and British Columbia were not robust; therefore, were not considered in the second tier monitoring risk assessment.

Robust and useful monitoring data was available from Quebec and Ontario. Two streams from Quebec (Ruisseau-Rousse and Gibeault-Delisle) were sampled during the growing season every 3–5 days over multiple years and had LOD values that were low enough to allow comparison of the detected concentrations to almost all toxicity endpoints of concern. The data from these watersheds were compared to available toxicological endpoints in the refined monitoring risk assessment.

The potential for both acute and chronic risk associated with EECs from monitoring data is analyzed in this second tier refined risk assessment. The monitoring data were considered as follows for the refined the risk assessment:

1. The maximum consecutive days chlorpyrifos concentrations exceed critical toxicity endpoints of concern was examined. Endpoint exceedances that are of short duration may indicate a lower risk relative to endpoints being exceeded for longer periods of time. This analysis can be particularly useful for determining chronic risk to aquatic biota. The maximum consecutive days that chlorpyrifos exceeded toxicity endpoints is calculated by counting the number of calendar days over which all samples taken exceeded the endpoint. In doing so, the assumption is made that on days when samples were not taken, concentrations remained above the endpoint. The assumption that concentrations exceeded the endpoint between consecutive sampling days was considered acceptable based on the short time period between samples (generally 3–4 days) and the general pattern of dissipation of chlorpyrifos in aquatic systems.

2. Comparison of the minimum cumulative (total) number of days over which an endpoint was exceeded during a sampling year to the total number of samples taken in that year. This gives a percent of the total samples taken in season that exceeded the toxicity endpoint of concern.

The following is a detailed analysis of the Ruisseau-Rousse and Gibeault-Delisle. Two other Quebec sites and one Ontario site are also briefly discussed.

a) Analysis of Data from the Ruisseau-Rousse

A large portion of the Rouisseu-Rousse watershed upstream of the sampling site is represented by orchards, vegetables as well as cereals, corn and soybeans. A detailed analysis of data from this sampling site is presented in Appendix III, Tables 25–28.

The lower bound acute invertebrate mesocosm toxicity endpoint of concern (0.06 µg/L) was exceeded in up to 30% of the samples taken during a sampling season over the four years of sampling (2010, 2011, 2015 and 2016) (Appendix III, Table 25). The more sensitive acute invertebrate HC_5 endpoint (0.044 µg/L) was exceeded in up to 42% of the samples taken during a sampling season. The acute fish mesocosm endpoint (0.25 µg/L) was exceeded in up to 7% of the samples taken during a sampling season.

The maximum consecutive days that concentrations of chlorpyrifos exceeded the lower bound acute invertebrate mesocosm endpoint was 26 days (Appendix III, Table 26). The acute invertebrate HC_5 endpoint was exceeded for up to 35 consecutive days, with two other consecutive periods of 12 and 25 days occurring in 2011. The most sensitive acute fish mesocosm endpoint was exceeded for up to 7 consecutive days over all sampling years. Other acute toxicity endpoints of concern (highest acute fish mesocosm and acute fish HC_5) were rarely exceeded and data are not shown in the tables.

The analytical LOD was too high to accurately estimate the frequency of detections higher than the LOC for the chronic laboratory invertebrate toxicity endpoint of concern (0.005 µg/L). For this risk assessment, acknowledging that there is uncertainty in the assumptions made, a value of half the LOD was used for non-detections, which results in 100% of the samples taken over the four sampling seasons having concentrations equal to, or exceeding, the most sensitive chronic invertebrate toxicity endpoint of concern. The chronic invertebrate mesocosm endpoint (0.1 µg/L) and the chronic fish endpoint (0.14 µg/L) were exceeded for up to 15% of the samples taken during a sampling season (Appendix III, Table 27).

The maximum consecutive days, using a value equivalent to half the LOD for non-detections, that exceed the chronic laboratory invertebrate endpoint of concern ranged from 99 to 106 days (the entire sampling period for all years). Concentrations of chlorpyrifos exceeded the chronic invertebrate mesocosm and chronic fish endpoints of concern for up to 15 consecutive days (Appendix III, Table 28).

b) Analysis of Data from the Gibeault-Delisle

The Gibeault-Delisle is a natural waterbody, certain section of which have been historically straightened or reprofiled for agricultural purposes (for example, drainage). At the sampling site, the Gibeault-Desisle is a third-order stream and, although it is a small stream, many of the smaller streams in the area drain into larger rivers. The importance of smaller streams to the ecological health of downstream areas should not be disregarded. A detailed analysis of data from this sampling site is presented in Appendix III, Tables 29–32.

Acute invertebrate mesocosm toxicity endpoints of concern were exceeded for up to 100% of the samples during the four years of sampling in this watershed (2006, 2007, 2013 and 2014) (Appendix III, Table 29). The acute invertebrate HC_5 endpoint was exceeded in up to 100% of samples taken during a sampling season. The lowest acute fish mesocosm toxicity endpoint was exceeded in up to 21% of the samples taken during a sampling season (Appendix III, Table 29).

The maximum consecutive days concentrations of chlorpyrifos exceeded the lower bound acute invertebrate mesocosm endpoints was 106 days (Appendix III, Table 30). In 2006 there were three periods of 24, 20 and 17 consecutive days when concentrations exceeded the upper bound acute invertebrate mesocosm endpoint (NOAEC of 0.1 µg/L). The acute invertebrate HC_5

endpoint was exceeded up to 105 consecutive days and the most sensitive acute fish mesocosm toxicity endpoint was exceeded for up to 12 consecutive days (Appendix III, Table 30). Other acute toxicity endpoints of concern (upper bound acute fish mesocosm and acute fish HC_5) were rarely exceeded and data are not shown in the tables.

In 2006 and 2007 all samples from this watershed contained measureable concentrations of chlorpyrifos (all above the LOD). The data shows that for the entire sampling seasons in 2006 and 2007, chlorpyrifos concentrations were above the chronic invertebrate toxicity endpoint of concern (Appendix III, Table 31). In 2013 and 2014, some non-detections were reported, and the LOD is above the toxicity endpoint of concern. As a value of half the LOD was used in the analysis for 2013 and 2014 non-detections, there is some uncertainty in interpreting these results. The chronic invertebrate mesocosm toxicity endpoint of concern was exceeded for up to 100% of the entire sampling seasons in 2006, 2007, 2013 and 2014. The chronic fish toxicity endpoint of concern was exceeded for up to 70% of the sampling season (Appendix III, Table 31).

The maximum consecutive days (estimated for 2013 and 2014 using half the LOD for non-detections in those years) that exceeded the chronic laboratory invertebrate toxicity endpoint of concern comprised the entire sampling season in all years (Appendix III, Table 32). Concentrations of chlorpyrifos exceeded the chronic invertebrate mesocosm endpoint for up to 82 consecutive days; in 2006 there were three periods of 24, 20 and 17 consecutive days when concentrations exceeded the NOAEC of 0.1 µg/L. The chronic toxicity fish endpoint of concern was exceeded for a maximum of 19 consecutive days (Appendix III, Table 32) in all years, with two separate periods of 15 days each that exceeded this endpoint in 2006. In 2007 there were also periods of 13, 11 and 12 consecutive days that exceeded the chronic fish toxicity endpoint of concern.

c) Analysis of Data from Other Sites

The Saint- Régis and Saint-Zéphirin rivers in Quebec had detection frequencies of 21 and 9%, respectively. The number of detections that exceeded the toxicity endpoints of concern are reported in Appendix III, Tables 33-36.

Detection frequency in Prudhomme Creek, Ontario was 55% between 2005 and 2015, with a total of 69 samples taken. The number of detections that exceeded the toxicity endpoints of concern is reported in Appendix III, Tables 37–38.

Aquatic Risk Assessment Conclusions

Refined modelling, using region-specific scenarios and a wide range of crops across Canada also identified potential acute and chronic risks of concern for aquatic organisms for all modelled scenarios. Recent robust water monitoring data from Quebec indicates that chlorpyrifos is being detected in surface waters at concentrations that frequently exceed the level of concern for both acute and chronic adverse effects to invertebrates and fish. Concentrations that may impact individual species and invertebrate communities occurred for extended periods (weeks to months). Monitoring data for other regions of Canada was not robust and was not useful for determination of acute or chronic risks and consequently risks were assessed based on exposure concentrations determined using modelling.

A probabilistic risk assessment was not conducted for aquatic biota because sufficient, relevant and recent Canadian surface water monitoring data were recently received to compare to SSD endpoints for aquatic invertebrates and fish.

Based on the available information, risks to aquatic invertebrates and fish were not shown to be acceptable for most outdoor uses of chlorpyrifos.

3.2.3 Environmental Incident Reports

Environmental incident reports are obtained from two main sources; the Canadian pesticide incident reporting system (including both mandatory reporting from the registrant and voluntary reporting from the public and other government departments) and the USEPA Ecological Incident Information System (EIIS).

Canadian Incident Reports

Since 26 April 2007, registrants have been required by law to report pesticide incidents to Health Canada that are related to their products. In addition, the general public, medical community, government and non-governmental organizations are able to report pesticide incidents directly to Health Canada. Table 39 (Appendix III) summarizes the incidents that were reported to Health Canada where a causal link to chlorpyrifos was assessed. Between 2012 and 2015, a total of 15 possible incidents were reported to Health Canada: one with fish and 14 with pollinators.

An analysis of a 2015 incident involving fish determined that the application of chlorpyrifos was probably the cause. In this incident, a tank mix of two products containing chlorpyrifos and penthiopyrad was aerially applied to a sunflower field located near a pond. Mortality of fish, birds, dragonflies, frogs and other insects in and around the pond was reported. Although the incident was considered to have high plausibility due to chlorpyrifos exposure, there were uncertainties (for example, it was unknown if the buffer zones were observed, two products were used and could have had synergistic effects). The tank mix was also applied during bloom in contravention of chlorpyrifos label directions.

In 2012, 11 different bee keeping yards were potentially exposed to chlorpyrifos when it and/or the pesticide dimethoate were applied via aerial or ground application to registered Canadian crops. Health Canada has determined that nine of the 11 incidents in 2012 were considered to be possibly related to chlorpyrifos application and two were considered to be unlikely due to chlorpyrifos (Appendix III, Table 39). A total of three incidents with pollinators in 2014 and 2015 were found to be unlikely due to chlorpyrifos application (Appendix III, Table 39).

American Incident Reports

The USEPA's Ecological Incident Information System (EIIS) was also queried for environmental incidents related to chlorpyrifos that were available in that database from 1974 to 5 October 2015; there were 302 cases.

Since 2001, the year after most residential uses were phased out in the United States and Canada, the number of incidents decreased significantly. Only the incidents after 2001 are discussed below.

Aquatic Incidents

Fifteen unique aquatic incidents were reported in the United States. Four were a result of registered use. Two were determined to be unlikely due to chlorpyrifos with the remaining classified as possible, probable and highly probable due to chlorpyrifos. Five cases were a result of runoff, three due to drift and in one case the route of exposure could not be determined. For the remaining cases there was no information reported or the route of exposure was a result of direct treatment.

Plant Incidents

Twenty unique plant incidents were reported in the United States. Twelve of the incidents were due to registered use with only one rated as being unlikely due to chlorpyrifos use. Of these 20 cases, 18 were a result of direct treatment and one was a result of drift. Six of the 20 incidents were due to registered use on citrus which is not a registered use in Canada. Other incidents occurred on crops that chlorpyrifos is registered for use in Canada (corn and onion) or on crops that are not registered for use in Canada (soybean).

Terrestrial Incidents

Twenty two unique terrestrial incidents were reported in the United States. Ten of the terrestrial incidents involved birds. The legality of the use of chlorpyrifos was undetermined for most bird incidents; however, most incidents were possible, probable or highly probable due to chlorpyrifos. The route of exposure was primarily through ingestion (unspecified) with one secondary poisoning of a red-tailed hawk. One incident involved the incapacitation of 41 pigs. The remaining incidents were all related to bees or honey bees, with only one incident having an unlikely certainty level. One honey bee incident was a result of a registered use with the majority of incidents having an undetermined legality and two were a result of misuse.

Incidents Involving Both Terrestrial and Aquatic Species

One incident in the United States involved both terrestrial and aquatic habitats. This incident was possibly due to chlorpyrifos as a result of a spill.

Incident Report Conclusions

Chlorpyrifos was determined to be the cause (possible to highly probable) for the majority of the incidents. Although information is lacking on the route of exposure for many incidents, it is clear that registered uses of chlorpyrifos were the cause of some incidents; however, it is unclear if labelled risk mitigation measures (for example, buffer zones, timing) were followed.

3.2.4 Interactions with the Endocrine System

The USEPA concluded that, based on the weight of evidence, chlorpyrifos does not demonstrate potential interaction with the estrogen, androgen, or thyroid pathways. Health Canada concurs with this conclusion.

3.3 Uncertainties Identified in the Risk Assessment

Health Canada believes that the risk conclusions presented in this assessment are sound on the basis of the weight-of-evidence available with the acute and chronic laboratory and higher tier aquatic and terrestrial toxicity data, extensive surface water modelling that was conducted, and relevant Canadian environmental monitoring data that were available. However, the following uncertainties in assessing chlorpyrifos risk are noted.

Exposure Uncertainties

In the risk assessment, Health Canada uses a tiered approach to estimating exposure, moving from an assumption of potential risk at the highly conservative screening level, to the use of modelling estimates and finally to real-world Canadian monitoring data. Uncertainties for each are outlined below.

Modelling Uncertainties

Higher-tiered surface water runoff modelling was conducted for 39 different application rate/crop and regional scenarios. Uses were chosen to ensure that runoff potential was assessed for the highest application rates as well as lower rates for important crops across the country. Although modelling is generally considered to provide a conservative estimate of concentrations in water, in the case of chlorpyrifos, the peak EEC from modelling matches the highest concentration measured in Canadian water bodies.

Monitoring Uncertainties

Monitoring data likely underestimates short-term exposure to chlorpyrifos, as most sampling regimes are unlikely to capture peak concentrations. Sampling protocols differ across the country, with some watersheds being sampled only a few times during the growing season, resulting in uncertainty as to the duration of exposure. There is variation in the analytical methods used. In some cases, such as with data from British Columbia, a very low LOD was achieved resulting in a high detection frequency, where as in other regions (such as Saskatchewan), the LOD is much higher, making the interpretation of detection frequency and analysis of non-detections challenging. The usefulness of the BC monitoring data was hampered by the paucity of samples that were taken during the growing season when chlorpyrifos would be expected to be used.

The lack of ancillary information (use of chlorpyrifos in the watershed, crops grown) further complicates the interpretation of non-detections, which could be related to chlorpyrifos not being transported from the site of application or be a result of chlorpyrifos not being used in the watershed.

In areas where chlorpyrifos is used, but monitoring data are lacking or sporadic, there is no reason to believe that detection patterns would differ compared to those observed in areas where robust water monitoring data are available. With the lack of ancillary information available for almost all sampling sites, it is very difficult to relate chlorpyrifos concentrations at a particular site to use on a specific crop.

Endpoint Uncertainties

The endpoints chosen for the risk assessment are in general agreement with recent evaluations conducted by other regulatory agencies and with recent reviews available in the public literature (for example, Giddings et al. 2014). Uncertainty can be reduced by bracketing endpoints using upper and lower bound values where possible. In doing so, the range of potential risks for biota at environmentally relevant concentrations is described and considered.

Health Canada typically selects NOAEC or NOEC endpoints for chronic effects to freshwater invertebrates. In the case of chlorpyrifos, the most sensitive species endpoint available was an LOAEC (0.005 µg a.i./L). An NOAEC could not be determined from this study because of effects at all treatment concentrations. Health Canada selected this endpoint because the results demonstrated statistically significant effects at this concentration and because it was lower than other available NOAEC/NOECs. The use of the LOAEC in the risk assessment may underestimate the potential chronic risk to freshwater invertebrates and may not be protective for chronic exposures to freshwater invertebrates

The higher tier aquatic toxicity endpoints chosen for the acute invertebrate and fish risk assessments were lower and upper bound NOAECs or the LC_{50} with an uncertainty factor applied, where recovery may have been observed but was delayed until the end of the study or for significant time periods after exposure. There is uncertainty as to whether recovery would be expected in the environment as these toxicity studies were single exposures and the concentrations of chlorpyrifos decreased relatively quickly within the exposure systems. This is in contrast to monitoring data that clearly demonstrates chlorpyrifos concentrations can remain well above toxicity endpoints of concern for extended periods of time (up to the entire summer season).

3.4 Acceptable Use Pattern Based on the Environmental Assessment

Risk from chlorpyrifos has not been shown to be acceptable to aquatic biota, beneficial arthropods, birds and mammals. From an environmental perspective, only uses that minimize or eliminate exposure to these groups are acceptable for continued registration.

Although use of chlorpyrifos to control mosquitoes will result in release to the environment, environmental risk was deemed to be acceptable. Larval mosquito control is restricted to temporary pools and standing water and the presence of aquatic biota in these systems is expected to be limited. Chlorpyrifos can be applied by ultra-low volume (ULV) applicators for adult mosquito control. Spray droplets from ULV applications are very small and do not deposit onto soil or water as quickly as larger droplets and are very likely to dissipate or evaporate while suspended in air. Risk from ULV applications is considered to be acceptable to non-target terrestrial and aquatic biota.

Risk from greenhouse ornamental, outdoor ornamentals (container stock), indoor and outdoor structural, adult and larval mosquito uses of chlorpyrifos are acceptable from an environmental perspective.

4.0 Value Assessment

Chlorpyrifos is a broad spectrum insecticide that can manage several insect pests on a wide range of use sites, including horticultural, structural, and mosquito control uses. It is one of the most widely sold pesticides in Canada, and is one of the few insecticides registered to manage certain important pests, including invasive alien species, and mosquito larvae. With respect to those uses that have been found to be acceptable from an environmental perspective, chlorpyrifos is of value for the management of Japanese beetle, an invasive alien species regulated by the Canadian Food Inspection Agency. Both adults and larvae cause damage requiring control of both life stages. Alternative active ingredients are registered to control adults; however, these are limited to specific ornamental crops. While there are alternatives registered to control the larval stage, Japanese beetles have known resistance issues, and as such chlorpyrifos is an important tool to manage this pest.

Chlorpyrifos is valued in mosquito larval control programs for rotation with other insecticides to delay the development of insecticide resistance, since mosquitos have been documented to develop resistance. Alternative active ingredients to chlorpyrifos are available for use as a fog to control adult mosquitoes.

There are a limited number of alternatives registered for use as a perimeter barrier spray when applied to non-residential structures for the control of carpenter ants, crickets, earwigs and boxelder bugs. For other insect pests, there are several alternatives to chlorpyrifos. Alternative products to chlorpyrifos are available for use to control insect pests inside non-residential structures.

5.0 Pest Control Product Policy Considerations

5.1 Toxic Substances Management Policy Considerations

In accordance with the PMRA Regulatory Directive DIR99-03,[4] the assessment of chlorpyrifos against Track 1 criteria of Toxic Substances Management Policy (TSMP) under *Canadian Environmental Protection Act* was conducted. Health Canada has reached the conclusions that:

[4] DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*

- Chlorpyrifos does not meet all Track 1 criteria, and is not considered a Track 1 substance (refer to Appendix III, Table 40).

- Chlorpyrifos does not form any transformation products that meet all Track 1 criteria.

5.2 Formulants and Contaminants of Health or Environmental Concern

During the review process, contaminants in the technical grade active ingredient and formulants and contaminants in the end-use products are compared against the *List of Pest control Product Formulants and Contaminants of Health or Environmental Concern* maintained in the *Canada Gazette.*[5] The list is used as described in the Health Canada Notice of Intent NOI2005-01[6] and is based on existing policies and regulations including DIR99-03 and DIR2006-02[7], and taking into consideration the Ozone-depleting Substance Regulations, 1998, of the *Canadian Environmental Protection Act* (substances designated under the Montreal Protocol). Health Canada has reached the following conclusions:

- No contaminants of human health or environmental concern are expected to be present in the technical active ingredient.

- The use of formulants in registered pest control products is assessed on an ongoing basis through PMRA formulant initiatives.

6.0 Conclusion of Science Evaluation

Environment

An evaluation of available scientific information found that environmental risks were not shown to be acceptable for beneficial arthropods, birds, mammals and all aquatic biota for most of the current chlorpyrifos uses. Greenhouse ornamental, outdoor ornamentals (container stock only) for control of Japanese beetle larvae, indoor and outdoor structural, adult and larval mosquito uses of chlorpyrifos are considered to be acceptable from the environmental perspective due to the limited potential for environmental exposure.

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5 *Canada Gazette*, Part II, Volume 139, Number 24, SI/2005-114 (2005-11-30) pages 2641–2643: *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern* and in the order amending this list in the *Canada Gazette*, Part II, Volume 142, Number 13, SI/2008-67 (2008-06-25) pages 1611-1613. *Part 1 Formulants of Health or Environmental Concern, Part 2 Formulants of Health or Environmental Concern that are Allergens Known to Cause Anaphylactic-Type Reactions and Part 3 Contaminants of Health or Environmental Concern.*

6 NOI2005-01, *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern under the New Pest Control Products Act.*

7 DIR2006-02, *Formulants Policy and Implementation Guidance Document.*

Value

With respect to those uses that have been found to be acceptable from an environmental perspective, chlorpyrifos is valued as a broad spectrum insecticide that can manage several insect pests on a wide range of use sites. Chlorpyrifos is used in several ornamental crops to control the larval stage of the Japanese beetle, an invasive alien species regulated in Canada for which there are limited alternatives registered. It is valued as an effective outdoor perimeter spray on non-residential structures for the control of carpenter ants, crickets, earwigs and boxelder bugs, for which there are limited alternatives available. Alternative products to chlorpyrifos are available to control pests inside non-residential structures. Chlorpyrifos can be used in rotation with other insecticides to delay the development of insecticide resistance in susceptible species, including mosquito larvae. Alternative products to chlorpyrifos are available for use as a fog to control adult mosquitoes.

List of Abbreviations

%	percent
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
°C	degrees Celsius
AEROWIN	program within EPISuite that determines the fraction of airborne substances sorbed to airborne particulates
a.i.	active ingredient
AOPWIN	model that estimates atmospheric oxidation potential
ASAE	American Society of Agricultural Engineers
atm	atmosphere
BAF	bioaccumulation factor
BCF	bioconcentration factor
BCPC	British Crop Production Council
bw	body weight
CEPA	*Canadian Environmental Protection Act*
cm	centimetre(s)
cm^3	centimetre(s) cubed
Co.	Company
d	day(s)
DACO	data code
DFOP	double first-order in parallel
DT_{50}	dissipation time 50% (the dose required to observe a 50% decline in concentration)
dw	dry weight
EC_{50}	effective concentration on 50% of the population
EDE	estimated daily exposure
EEC	Estimated environmental concentration
EFSA	European Food Safety Authority
EIIS	USEPA Ecological Incident Information System
E/M	estuarine/marine
EUP	end-use product
fw	fresh weight
FW	freshwater
g	gram(s)
GUS	groundwater ubiquity score
h	hour(s)
ha	hectare(s)
HC_5	hazardous concentration to 5% of the species
HD_5	hazardous dose to 5% of the species
IC_{25}	inhibitory concentration on 25% of the population
Inc.	Incorporated
Invert.	invertebrate

IORE	indeterminate order rate equation
K_d	soil-water partition coefficient
kg	kilogram(s)
K_H	Henry's Law Constant
km	kilometre(s)
K_{oa}	octanol-air partition coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	n–octanol-water partition coefficient
L	litre(s)
LC_{50}	lethal concentration 50%
LD_{50}	lethal dose 50%
LOAEC	lowest observed adverse effect concentration
LOD	limit of detection
LOEC	low observed effect concentration
LOQ	limit of quantitation
Ltd.	Limited
lw	lipid weight
m	metre(s)
m^2	square metre(s)
m^3	cubic metre(s)
M/E	marine/estuarine
mg	milligram(s)
mL	millilitre(s)
mm	millimetre(s)
mmHg	millimetres of mercury
mol	mole(s)
mPa	milliPascal(s)
MS	most sensitive
n	number
NA	not available
ND	not detected
ng	nanogram(s)
No.	number
NOAEC	no observed adverse effect concentration
NOAEL	no observable adverse effect level
NOEC	no observed effect concentration
OECD	Organization for Economic Cooperation and Development
OH	hydroxide
PACR	Proposed Acceptability for Continuing Registration
pg	picogram(s)
pK_a	dissociation constant
PMRA	Pest Management Regulatory Agency
PWC	Pesticide in Water Calculator
RQ	risk quotient
SFO	single first-order
SSD	species sensitivity distribution
SW	saltwater

$t_{1/2}$	half-life
$t_{1/2}$rep	representative half-life
TSMP	Toxic Substances Management Policy
UF	uncertainty factor
µg	micrograms
µL	micro litre(s)
ULV	Ultra-low volume
U.S.A.	United States of America
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
Vol.	volume
WHO	World Health Organization

Appendix I Registered Chlorpyrifos Products, As Of January 2019 Excluding Discontinued Products Or Products With A Submission For Discontinuation.

Registration Number	Marketing Class	Registrant	Product Name	Formulation Type	Guarantee
23621	Technical Grade Active Ingredient	Adama Agricultural Solutions Canada Ltd	Pyrinex Technical Chlorpyrifos Insecticide	Solid	97%
31417		Agrogill Chemicals PTY Ltd	Chlorpyrifos Agrogill Technical Grade Active Ingredient	Solid	98.6 %
31418		Agromarketing Co. Inc.	Fosban Chlorpyrifos Technical	Solid	98.5 %
19656		Dow Agrosciences Canada Inc.	Dursban FM Insecticidal Chemical	Liquid	97%
32694		Sharda Cropchem Limited	Sharda Chlorpyrifos Technical Insecticide	Solid	98.81%
33295		Newagco Inc.	Newagco Chlorpyrifos Technical	Solid	98.9%
20320	Manufacturing concentrate	Dow Agrosciences Canada Inc.	Dursban HF Insecticidal Concentrate	Solution	720 g/L
20407			Dursban W Insecticidal Concentrate	Dust or Powder	50%
14879	Commercial & Restricted	Dow Agrosciences Canada Inc.	Lorsban 4E Insecticide	Emulsifiable Concentrate	480g /L
20944			Lorsban 50W Insecticide	Wettable Powder	50%
29650			Lorsban NT Insecticide	Emulsifiable Concentrate	452 g/L
23704		Adama Agricultural Solutions Canada Ltd.	Pyrate 480 EC Insecticide	Emulsifiable Concentrate	480 g/L
32768		Sharda Cropchem Limited	Sharphos Insecticide	Emulsifiable Concentrate	480 g /L
16458	Commercial	Dow Agrosciences Canada Inc.	Lorsban* 15G Insecticide	Granular	15%
21997			Dursban Water Soluble Insecticide	Soluble Powder	50%

Registration Number	Marketing Class	Registrant	Product Name	Formulation Type	Guarantee
23705	Commercial	Adama Agricultural Solutions Canada Ltd.	Pyrinex 480EC For Food Crops	Emulsifiable Concentrate	480 g/L
33113			Pyrinex 450 LV EC		450 g/L
25831		FMC Corporation	Nufos 4E Insecticide	Emulsifiable Concentrate	480 g/L
27479		Interprovincial Cooperative Limited	Citadel 480EC Insecticide	Emulsifiable Concentrate	480 g/L
29849		Interprovincial Cooperative Limited	Chlorpyrifos 480 EC Insecticide	Emulsifiable Concentrate	480 g/L
24648		Loveland Products Canada Inc.	Pyrifos 15G Insecticide	Granular	15%
29984		Loveland Products Inc.	Warhawk 480 EC Insecticide	Emulsifiable Concentrate	480 g/L
30985		Newagco Inc.	MPOWER Krypton	Emulsifiable Concentrate	480 g/L
31891		Agromarketing Co. Inc.	Fosban 480 EC	Emulsifiable Concentrate	480 g/L

Appendix II Registered Commercial and/or Restricted Class Uses of Chlorpyrifos in Canada as of January 2019.

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
Standing water Temporary Pools	Mosquitoes (larvae)	Emulsifiable Concentrate	Ground application	13-53	Not stated	14 days
Outdoors	Mosquitoes (adults)	Emulsifiable Concentrate	Ground application	26-53	Not stated	Not stated
Forest: lodgepole pine	Mountain pine beetle	Emulsifiable Concentrate	Ground application: surface spray to trunks	20 kg a.i. per 1000 L	Not stated	Not stated
Canola	Armyworms, alfalfa looper	Emulsifiable Concentrate	Ground or aerial application: foliar spray	360–480	1	Not applicable
	Diamondback moth (larvae)			480–720		
	Lygus bugs			240–480		
	Cutworms			420–576		
	Grasshoppers			278–420		
Flax	Armyworms	Emulsifiable Concentrate	Ground or aerial application: foliar spray	360–480	1	Not applicable
	Cutworms			420–576		
Lentil	Cutworms	Emulsifiable Concentrate	Ground or aerial application: foliar spray	420–576	1	Not applicable
	Grasshoppers			278–576		
Corn (field, sweet)	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152	1	Not applicable
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment	562–1152		
Corn (field, seed, sweet)	Cutworms, Rootworms	Granular	Ground application: row treatment	11.25 g a.i. per 100 m row		

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
Peach, nectarine	Oriental fruit moth	Wettable Powder	Ground application: airblast sprayer.	1725	2	Not stated
Strawberry	Strawberry cutworm (crown borer)	Emulsifiable Concentrate, Wettable Powder	Ground application: foliar spray	562.5–576	1	Not applicable
Asian radish (lo bok, Daikon)	Cabbage maggot	Emulsifiable Concentrate	Ground application: soil drench	100.8 g a.i. per 1000 m row	3	13 days
Radish	Cabbage maggot	Emulsifiable Concentrate	Ground application: soil drench	40.8 g a.i. per 1000 m row	1	Not applicable
Celery, cucumber, Pepper	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152	1	Not applicable
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment	562–1152		
Pak choi, broccoli, Brussels sprout, cabbage, Chinese cabbage, cauliflower	Cabbage maggot (broccoli, Brussels sprout, cabbage, cauliflower)	Granular	Ground application: in-furrow	90–150 g a.i. per 1000 m of row.	1	Not applicable
	Cabbage maggot	Emulsifiable Concentrate	Ground application: at planting drench	100.8 g a.i. per 1000 m of row.	Brussel sprouts 3 (2 if a granular treatment has been used); all other crops 2 (1 if a granular treatment has been used)	21 days (after transplanting drench); 28 days (after seeding drench)
		Emulsifiable Concentrate	Ground application: post planting drench	806 g a.i. per 1000 L (10.1 g a.i. per 100 m of row)		

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
	Cabbage maggot (cabbage only)	Wettable Powder	Ground application: transplant water treatment	16.25 g a.i./100 L (0.0325 g a.i. per plant)	1	Not applicable
	Cutworms (broccoli, Brussel sprout, cabbage, cauliflower, Chinese cabbage)	Emulsifiable Concentrate	Ground application: soil treatment	1152	Brussel sprouts 3 (2 if a granular treatment has been used); all other crops 2 (1 if a granular treatment has been used)	21 days (after transplanting drench); 28 days (after seeding drench)
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment	562–1152	1	Not applicable
Chinese broccoli	Cabbage maggot	Emulsifiable Concentrate	Ground application: row treatment	72 g a.i. per 1000 m of row	1	Not applicable
Garlic	Onion maggot	Emulsifiable Concentrate	Ground application: soil drench	1680	2	Not stated
	Cutworms		Ground application: soil treatment	1152		
			Ground application: seedling treatment	576–1152		
Rutabaga	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152	1	Not applicable
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment	562–1152		
	Cabbage maggot	Granular	Ground application: in-furrow	90–150 g a.i. per 1000 m of row	1	Not applicable
		Emulsifiable Concentrate	Ground application: soil drench	100.8 g a.i. per 1000 m of row.	4 (3 if a granular treatment has been used)	18 days

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
Carrot	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152–2304	1	Not applicable
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment			
Potato	Colorado potato beetle, potato flea beetle, tarnished plant bug	Emulsifiable Concentrate; Wettable powder	Ground application: foliar spray	480	1	Not applicable
	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152		
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment	562-1152		
	Wireworms	Emulsifiable Concentrate	Ground application: in furrow at planting	1152 (based upon a 90 cm row spacing)		
		Granular		1700 (based upon a 90cm row spacing)		
Sunflower	Cutworms	Emulsifiable Concentrate	Ground application- foliar spray	576	1	Not applicable
	Seed weevil		Ground or aerial application- foliar spray			
Sugarbeet	Cutworms	Emulsifiable Concentrate	Ground application	576–1152	1	Not applicable
Barley, wheat, oats	Armyworms, Cutworms	Emulsifiable Concentrate	Ground or aerial application: soil treatment and foliar spray	420–576	1	Not applicable
	Grasshoppers		Ground or aerial application: foliar spray	278.4–420		
	Brown wheat mite			300		
	Russian wheat aphid			240		
	Orange wheat blossom midge			398–480 (ground application)		

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
	(wheat only)			480 (aerial application)		
Shallot (dry bulb) Onion (bulb, pickling)	Onion maggot	Granular	Ground application: in-furrow at planting	1200-2400 (based upon a row spacing from 2.5 to 15 cm)	1	Not applicable
	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152–2304		
		Emulsifiable Concentrate, Wettable Powder	Ground application: seedling treatment	1125–2304		
Onion (green)	Onion maggot	Emulsifiable Concentrate, Wettable Powder	Ground application: soil drench	67.8 g a.i. per 1000 m of row (1763-2215 g a.i./ha at row spacing of 30-38 cm)	1	Not applicable
Filbert	Filbert aphid	Emulsifiable Concentrate, Wettable Powder	Ground application: airblast sprayer	2016–2304	3	Not stated
Tobacco	Cutworms	Emulsifiable Concentrate	Ground application: soil treatment	1152–2304	1	Not applicable
			Ground application: cover crop treatment	540–576		
	Seedcorn maggot	Wettable Powder	Ground application: transplant water treatment	68.75 g a.i. per 1000 L (0.01375 g a.i. per plant)		
Structural (non-residential): outdoor perimeter and exterior surface	Ants including carpenter ants, crickets, earwigs, millipedes, sowbugs (pillbugs)	Soluble Powder	Exterior perimeter, broadcast treatment and spot treatment	112 g/1000 m^2	Not stated	Not stated

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
Structural (non-residential): indoors	Cockroaches, ants including carpenter ants, crickets, firebrats, silverfish, spiders	Emulsifiable Concentrate	Crack and crevice and spot treatment	0.24% or 0.48% chlorpyrifos spray (2.4 or 4.8 g /L of spray mixture)	2	14 days
Structural indoor (non-residential)	Lesser mealworms		Broadcast surface and crack and crevice spray	21.2 g/75 to 100 m^2		
Greenhouse and outdoor ornamentals	Spittlebugs	Emulsifiable Concentrate	Ground application	39.8-72 g /1000 L	Not stated	7 days
		Soluble Powder		168 g /1000 L		
	Mealybugs	Emulsifiable Concentrate		90.4-96 g /1000 L		
		Soluble Powder		112 g /1000 L		
	Grasshoppers, thrips, whiteflies	Emulsifiable Concentrate		226-240 g /1000 L		
		Soluble Powder		224 g /1000 L		
	Leafhoppers	Emulsifiable Concentrate		452-480 g /1000 L		
		Soluble Powder		448 g /1000 L		
	Scale insects	Emulsifiable Concentrate		904-960 g /1000 L		
		Soluble Powder		896 g /1000 L		
Greenhouse and outdoor ornamentals	Japanese beetle (larvae)	Emulsifiable Concentrate	Ground application: surface spray irrigated into soil and root ball immersion	2034-2160 g /1000 L	Not stated	Not stated
Outdoor ornamentals	Aphids	Emulsifiable Concentrate	Ground application	169.5-180 g /1000 L	Not stated	7 days
		Soluble Powder		168 g /1000 L		
	Mites	Emulsifiable Concentrate		169.5-240 g /1000 L		
		Soluble Powder		224 g /1000 L		
	Borers	Emulsifiable Concentrate		226-240 g /1000 L		

Site(s)[1]	Pests	Formulation Type	Application Methods and Equipment	Single App. Rate (g a.i./ha)	Max. No. Apps. per Season	Typical Number of Days Between Applications
		Soluble Powder		224 g /1000 L		
	Tent caterpillars	Emulsifiable Concentrate		226-240 g /1000 L		
		Soluble Powder		224 g /1000 L		
	Pine sawflies	Emulsifiable Concentrate		226-240 g /1000 L		
		Soluble Powder		224 g /1000 L		
Elm	Native elm bark beetle	Emulsifiable Concentrate	Ground application: trunk surface spray (Restricted use)	4800 g /1000 L	1	Not stated
		Soluble Powder		4704 g /1000 L		
Turf (golf courses, industrial sites, highway medians and sod farms)	Crane fly larvae (leatherjackets)	Emulsifiable Concentrate, Soluble Powder	Ground application	904-1130	1	Not applicable
	Ants, chinch bugs, cutworms			1017-1120	2	Not stated
	turfgrass and bluegrass weevil					
	Sod webworms				Not stated	

[1]Not for use at homes and other residential structures.

Appendix III Fate, Toxicity and Risk to the Environment

Table 1 Physical and Chemical Properties of Chlorpyrifos and the Transformation Product, TCP, Relevant to the Environment

Type of the Study	Endpoint (units)	Value	Comments
Chlorpyrifos			
Melting Point	ºC	42 - 43.5	PACR2003-03
Vapour Pressure	mPa	2.49	At 25°C. High volatility.
		3.35	At 25°C. High volatility. PMRA 2776696
		1.43	At 20°C. High volatility. PMRA 2776696
Volatilization	half-life (days)	NA	Not a major route of dissipation in the laboratory; 10% volatilized in 30 days, conflicts with volatilization rates observed in field dissipation studies (25-80%)
Solubility	mg/L at 25°C	2	Low solubility (PACR2003-03)
	mg/L at 20°C	0.941	Sparingly solubility (PMRA 2776700)
		0.588	
	mg/L at 20°C	1.05	Low solubility PMRA 2776696
Henry's Law Constant K_H	atm•m^3/mol	4.2 $\times 10^{-6}$ 6.2 $\times 10^{-6}$	Low potential to volatilize from water or moist soil (PMRA 2824695), conflicts with volatilization rates observed in field dissipation studies (25-80%)
Octanol-Water Partition Coefficient,	log k_{OW}	4.70	PACR2003-03, High potential to bioaccumulate.
		3.31 - 5.27	PMRA 2776695
Dissociation Constant	pK_a	No Value	Does not dissociate. PACR2003-03
Octanol-Air Partition Coefficient	Log Koa	8.882	Potential bioaccumulation in terrestrial food chains Estimated with EPISuite v. 3.20 PMRA 2776927
TCP (3,5,6-trichloro-2-pyridinol) (PACR2003-03)			
Melting point	ºC	174-175	
Vapour Pressure	mPa	3.3	At 25°C high volatility
Solubility	mg/L at 25°C	117 pH 2.5 49 100 pH7	Very soluble. Increases at higher pH
Octanol-Water Partition Coefficient	log k_{ow}	3.2 at pH 3 1.3 at pH 7	K_{OW} = 1600 at pH 3 K_{OW} = 22 at pH 7 Less potential for bioaccumulation than chlorpyrifos
Dissociation Constant	pKa	4.55	Potentially mobile in more acidic pH

Table 2 Summary of Abiotic Transformation Properties of Chlorpyrifos and TCP

Type of the Study	Half-life (days)	Comments	Reference
Chlorpyrifos			
Hydrolysis	73 at pH 5 72 at pH 7 16 at pH 9	At 25ºC. Not an important route of transformation at neutral or acidic conditions. Not an important route of transformation.	PACR2003-03 PMRA 2824695 PMRA 2776789 PMRA 2776695 PMRA 2776700 PMRA 2776696
	72 at pH 4 40 at pH 7 24 at pH 9	At 30ºC. Not an important mode of transformation at neutral or acidic conditions. Not an important route of transformation.	PMRA 2776700
	81 at pH 7		PMRA 2824697
	63 at pH 4.7 35 at pH 6.9 23 at pH 8.1	Not important in acidic and neutral. Not an important route of transformation.	PMRA 2776789
	147 at pH 5 116 at pH 7 75 at pH 9	At 25ºC. Not an important route of transformation.	PMRA 1139246
Phototransformation - soil	Stable	Not an important route of transformation.	PACR2003-03
Phototransformation - air	2 hours (indirect) 5 hours (direct)	A significant route of transformation.	PMRA 2824697
Photochemical oxidative transformation in air	0.058	Atmospheric Oxidation Program (DT_{50} = 1.4 hours)	PMRA 2776696
Photochemical oxidative transformation in air	0.117 1.4 hours	12 hour day, 1.56×10^6 OH/cm^3 Long range transport should not be a concern	AOPWIN EPISuite V.4.0
Percent fraction absorbed to particulates in air • Junge-Pankow • Mackay • Octanol/air (K_{oa})	 2.65 5.68 1.47	Fraction (%) sorbed to particulates in air indicates that transport via particulate matter would not increase long-range transport potential	AEROWIN EPISuite V.4.0
Phototransformation - water (sterile)	29.6 at pH 7	Not an important route of transformation	PACR2003-03 PMRA 2824697 PMRA 2776789 PMRA 2776696
Phototransformation – water (nonsterile)	39.9	Natural river water under natural sunlight.	PMRA 2776696

Type of the Study	Half-life (days)	Comments	Reference
TCP (3,5,6-trichloro-2-pyridinol)			
Hydrolysis	>30 at pH 5, 7 and 9	Not an important route of transformation.	PACR2003-03
Phototransformation - soil	14.1	Important route of transformation for TCP.	PACR2003-03
Phototransformation – soil	2 at pH 7	Important route of transformation.	PMRA 2776748
Phototransformation - water	Stable	Information not available, assumed to be stable.	Current evaluation
Photochemical oxidative transformation in air	60.5	Atmospheric Oxidation Program; Fraction (%) sorbed to particulates in air (range = 0.02 to 4.0%) indicates that transport via particulate matter should not increase long-range transport potential	PMRA 2776696 Same as determined in AEROWIN/AOPWIN (EPISuite v 4.0) by PMRA; however, model version not provided in PMRA 2776696

Table 3 Summary of Biotic Transformation Properties of Chlorpyrifos and TCP

Parameter	Test System or Soil Characteristic	NAFTA Representative Half-life Values (fitted model)	$t_{1/2}$ (days)	Persistence Categorization	PMRA No. Study ID
Chlorpyrifos					
Aerobic Soil biotransformation	Commerce loam	19 days (IORE)	11	Non-persistent	PMRA 2824697 PMRA 2684171
	Barnes loam	36.7 days (IORE)	22	Slightly persistent	
	Miami silt loam	31.1 days (IORE)	24	Slightly persistent	
	Catlin silty clay loam	33.4 days (SFO)	34	Slightly persistent	
	Norfolk loamy sand	156 days (DFOP)	102	Moderately persistent	
	Stockton Clay	297 days (IORE)	107	Moderately persistent	
	German sandy loam	193 (IORE)	141	Moderately persistent	
	Sandy loam	185 days (DFOP)	180	Moderately persistent	PMRA 1139264
Anaerobic Soil biotransformation	Commerce, loam	78 (IORE)	15	Slightly persistent	PMRA 2824697 PACR2003-03
	Stockton, clay	171 days (SFO) anaerobic phase only	58	Moderately persistent	

Parameter	Test System or Soil Characteristic	NAFTA Representative Half-life Values (fitted model)	$t_{1/2}$ (days)	Persistence Categorization	PMRA No. Study ID
Aerobic Aquatic Biotransformation	Whole system	30.4 days (SFO)	30.4	Slightly persistent	PMRA 2824697
	Whole system	-	29.5	Slightly persistent	PMRA 2684174
	Whole system Water	-	22-51 3-6	Slightly to moderately persistent Non-persistent	PMRA 2776696
	Water	-	5.5-15.2	Non-persistent	PMRA 2824697
Anaerobic Aquatic Biotransformation	Commerce loam	50.2 days (IORE)	39	Slightly persistent	PMRA 2684171
	Stockton clay	125 days (SFO)	51	Moderately persistent	PMRA 2824697
	No information	-	39-200	Moderately persistent to persistent	PACR2003-03
	Sediment	-	41-53	Slightly to moderately persistent	PMRA 2824697
TCP					
Aerobic Soil biotransformation	Sandy Loam	2560 (DFOP)	752	Persistent	PMRA 1139256
		-	10-67	Non-persistent to moderately persistent	PMRA 2776696
		-	8 - 279	Non persistent to persistent	PMRA 2776789
Anaerobic Soil Biotransformation	No information	-	>500, >1500	Persistent	PACR2003-03

Table 4 Comparison of the Properties of Chlorpyrifos with the Leaching Criteria of Cohen et al. (1984)

Property	Criteria of Cohen *et al.* (1984) Indicating a Potential for Leaching	Chorpyrifos	Meets Criterion for Leaching
Solubility in water	>30 mg/L	0.588 to 2 mg/L at 20°C and 25°C	No
K_d	<5 and usually <1 or 2	23-295	No
K_{oc}	<300	2785 – 31 000	No
Henry's law constant	$<10^{-2}$ atm m^3/mol	$4.2\text{-}6.2 \times 10^{-6}$ atm m^3/mol	Yes
pK_a	Negatively charged (either fully or partially) at ambient pH	Does not dissociate	No
Hydrolysis half-life	>20 weeks (>140 days)	16-147	Yes
Soil	>1 week	Stable	Yes

Property	Criteria of Cohen *et al.* (1984) Indicating a Potential for Leaching	Chorpyrifos	Meets Criterion for Leaching
phototransformation half-life	(>7 days)		
Half-life in soil	>2 to 3 weeks (>14 to 21 days)	11-180 days	Yes

Table 5 Comparison of the Properties of TCP with the leaching criteria of Cohen et al. (1984)

Property	Criteria of Cohen *et al.* (1984) Indicating a Potential for Leaching	TCP	Meets Criterion for Leaching
Solubility in water	>30 mg/L	117 – 49 100 mg/L at 25ºC	Yes
K_d	<5 and usually <1 or 2	0.53-1.95	Yes
K_{oc}	<300	27-389	Yes
Henry's law constant	$<10^{-2}$ atm m^3/mol	No information	-
pK_a	Negatively charged (either fully or partially) at ambient pH	4.55	Yes
Hydrolysis half-life	>20 weeks (>140 days)	>30 days (stable)	Yes
Soil phototransformation half-life	>1 week (>7 days)	14 days	Yes
Half-life in soil	>2 to 3 weeks (>14 to 21 days)	8-752 days	Yes

Table 6 Summary of Mobility Characteristics of Chlorpyrifos and TCP

Type of the study	Endpoint (units)	Value	Comments
Chlorpyrifos			
Volatilization	-	<10% of applied 25-80% of applied	Laboratory: Not an important route of transformation (PACR2003-03) Field Studies: Very important route (PACR2003-03, PMRA 2824697)
Adsorption, K_{OC}	mL/g	3680 – 31 000 Average = 6070	Sandy loam - clay loam (OC = 0.2 - 5.1%). Slightly mobile - immobile.
		2785-31000 Average = 8151	No information on soils, slightly mobile to mobile (PMRA 2776696)
		4960 – 7300	Slightly mobile to mobile PMRA 2824697
Adsorption Coefficient, K_d	mL/g	50-260	Sandy loam - clay loam. Slightly immobile to immobile (PMRA 2824697)
		22.76-295	No information on soils, slightly mobile to mobile (PMRA 2776696)
		49.9 – 99.7	Slightly mobile to mobile (PMRA 2824697)
Leaching	-	NA	Leaching studies indicate that chlorpyrifos does not leach beyond 15 cm depth. PACR2003-03
TCP (3,5,6-trichloro-2-pyridinol)			
Adsorption, K_{OC}	mL/g	77 - 242 27 - 389	Moderate to high mobility. PACR2003-03

Type of the study	Endpoint (units)	Value	Comments
		67.2 – 315	Moderate to high mobility (PMRA 2776696)
Adsorption Coefficient, K_d	mL/g	0.53 – 13.6	Low to high mobility (PMRA 2776696)

Table 7 Summary of Terrestrial Field Dissipation of Chlorpyrifos

Location	Canadian Equivalent Ecoregion	Half-life[1] or DT_{50} (days)	Persistence Category	Endpoint Reference/ Site Location reference
Illinois	Yes	56	Moderately	PMRA 2824697
Michigan	Yes	33	Slightly	
Canada	Yes	14	Non-persistent	PMRA 2776789/ PMRA 2776747
Canada	Yes	56	Moderately	
Herford, Germany	Yes	51	Moderately	
Lauter, Germany	Yes	40	Slightly	
France	Yes	11	Non-persistent	PMRA 2776696/ PMRA 2776747
Spain	Yes	2	Non-persistent	

[1] the half-life reported in these studies would be equivalent to a DT_{50} because they took into consideration other dissipation processes such as volatilization and leaching.

Table 8 Summary of Aquatic Field Dissipation Studies on Chlorpyrifos

Location	Half-life or DT_{50} (days)	Persistence Category	Reference
Canada, United States and The Netherlands	Water: <1 - 3 Sediment: 1.2 - 34	Non-persistent Non-persistent to Slightly persistent	PMRA 2776695
United Kingdom	Whole system: 20	Slightly persistent	PMRA 2824697
Illinois	Water: 3 Sediment: 200	Non-persistent Persistent	PMRA 2776789
Brazil	Water: 5 Sediment: 7	Non-persistent	PMRA 2776747
Kenya	Sediment: 10.3	Non-persistent	
North Vietnam	Water: 7	Non-persistent	
TCP			
United States	Water: 4 to 10 Sediment: 3.8 to 13.3	Non-persistent	PMRA 2795251

Table 9 Bioconcentration Factors in Biota

Organism	Study Type	Comments	Reference
Laboratory Studies			
Rainbow trout	BCF Edible tissue: 1280 Non-edible: 3903 Whole: 2729 Whole fish excluding transformation products: 2183	Chlorpyrifos accounted for 80% of the total radioactivity in fish $t_{1/2}$ = 2-3 days (PMRA 2776789)	PMRA 2824697
Guppy	BCF_k = 1600-1700		
Fathead minnow	BCF = 1700	Full life-cycle study	
Inland silverside	BCF = 440	ELS study	
Tidewater silverside	BCF = 580	ELS study	
California grunion	BCF = 450 and 1000	ELS study	
Gulf toadfish	BCF = 650 and 5100	ELS study, increased BCF with increased exposure concentration	
Larval zebrafish	BCF_k = 3548 and 6918	Increased BCF with increased exposure concentration	
Eastern oyster	BCF Whole oyster: 1900 Tissue: 2500 Liquor: 87 Whole oyster parent only: 874	Chlorpyrifos accounted for 46% of the radioactivity	
Marine mollusc	BCF = 400		
Marine mollusc	BCF = 482		
Freshwater amphipod	BCF_k = 412	Based on chlorpyrifos only Chlorpyrifos-oxon formed in amphipod	
	BCF = 1660	Based on total ^{14}C residues	
Sea Bass	BCF = 0.6		PMRA

Organism	Study Type	Comments	Reference
Tilapia	BCF = 116 - 3313		2776747
Eel	BCF_k = 400		
Atlantic silverside	BCF = 420		
Mosquito fish	BCF = 472	Microcosm	
Carp	BCF = 550		
Rainbow trout	BCF = 1374		
Fathead minnow	BCF = 1673		
Sheepshead minnow	BCF = 1830		
Marine mollusc	BCF = 3.4		
Marine mollusc	BCF = 4.1		
Mosquito larvae	BCF = 45	Microcosm	
Oligochaete	BCF = 57		
Algae	BCF = 72	Microcosm	
FW amphipod	BCF = 412		
Oyster	BCF = 565		
Snail	BCF = 691	Microcosm	
Water lettuce	BCF = 3000		
Salamander	BCF = 3632		
Duckweed	BCF = 5700		
Field Studies			
Bluegill	BAF = 100 - 1115	Field	PMRA 2776747
Fathead minnow	BAF = 780	Field	
Largemouth bass	BAF = 1344	Field	
Biomagnification Studies			
Spanish toothcarp	BMF = 0.3 – 0.7	BMF decreased over time	PMRA 2824695
Catfish	BMF = 0.045	$t_{1/2}$ = 3.5 days	
TCP			
Mosquito Fish	BCF = 3.1	$T_{1/2}$ = 3 days	PMRA 2776789

Table 10 Selected Toxicity Endpoints for Terrestrial and Aquatic Risk Assessments

Organism	Exposure	Species	Endpoint Reported (µg a.i./L)	Endpoint for RA[1] (µg a.i./L)	Source of Endpoint
Aquatic Freshwater					
Invertebrate	Acute	SSD[2]	HC_5 = 0.044	0.044	PMRA 2824698
	LB[3] acute mesocosm	Community Effects	NOAEC = 0.06	0.06	PMRA 2876898
	UB[4] acute mesocosm	Community Effects	NOAEC = 0.1	0.1	PMRA 2876898
	Chronic	*Daphnia carinata*	LOAEC = 0.005	0.005	PMRA 2824698
	Chronic mesocosm	Community Effects	NOAEC = 0.1	0.1[2]	PMRA 2933946
Fish	Acute	SSD	HC_5 = 5.94	5.94	PMRA 2824698
	Chronic	*Pimephales promelas*	NOEC = 0.14	0.14	PMRA 2776696
	LB acute mesocosm	*Lepomis macrochirus*	NOAEC = 0.25	0.25	PMRA 2933940
	UB Acute mesocosm	*Lepomis macrochirus*	LC_{50} = 2.67	1.34	PMRA 2776789
Amphibian	Acute	SSD	HC_5 = 20	20	Current review.
	Chronic	*Xenopus laevis*	NOEC = 0.88	0.88	PMRA 2272830
Algae	Acute	*Selenastrum capricornutum*	EC_{50} = 64	32	PMRA 2776789
Vascular plant	Acute	*Pistia stratiotes* and *Lemna minor*	LOAEC = 1000	1000	PMRA 2824698
Aquatic Marine					
Invertebrate	Acute	SSD	HC_5 = 0.034	0.034	PMRA 2824698
	Chronic	*Americamysis bahia*	NOEC = <0.0046	0.0046	PMRA 2824698 PMRA 2776789 PACR2003-03
Fish	Acute	SSD	HC_5 = 0.79	0.79	PMRA 2824698
	Chronic	*Menidia menidia*	NOAEC = 0.28	0.28	PMRA 2824698 PACR2003-03
Algae	Acute	*Isochrysis galbans*	EC_{50} = 140	70	PMRA 2824698 PACR2003-03
Terrestrial Biota				**Multiple Units**	
Earthworm	Acute	*Lumbricus rubellus*	LC_{50} = 104 mg a.i./kg dry soil	52	PACR2003-03
	Chronic		NOEC = 4.6 mg a.i./kg dry soil	4.6	

Organism	Exposure	Species	Endpoint Reported (µg a.i./L)	Endpoint for RA[1] (µg a.i./L)	Source of Endpoint
Pollinators	Acute contact	*Apis mellifera*	LD_{50} = 0.059 a.i./bee	0.059	PMRA 2824698 PMRA 2776696 PACR2003-03
	Acute oral		LD_{50} = 0.04 µg a.i./bee	0.04	PMRA 2776789 PACR2003-03
	Acute oral larvae		LD_{50} = 0.021 µg a.i./larvae	0.021	PMRA 2648538
Beneficial Arthropods	Acute	*Aphides colemani*	LC_{50} = 0.2 g a.i./ha	0.2	PMRA 2776696
Birds	Acute oral	*SSD*	HC_5 = 6.6 mg a.i./kg bw	6.6	PMRA 2824698
	Reproductive	*Anas platyrhynchos*	NOAEC = 25 mg a.i./kg-diet (2.88 mg/kg bw/d)	25 (2.88)	PMRA 2824698 PMRA 2776696 PACR2003-03 PMRA 2776789 PMRA 2776697
Mammals	Acute oral	*Mus musculus*	LD_{50} = 60 mg/kg bw	6	PMRA 2824698
	Reproductive	*Rattus norvegicus*	NOAEL = 1 mg/kg bw	1	PMRA 2824698 PMRA 2776696 PACR2003-03 PMRA 2776789 PMRA 2776697
Vascular Plants	Seedling emergence	Lettuce Onion	Dicot IC_{25} =2.275 kg/ha Monocot IC_{25} = >6.490 kg/ha	Dicot: IC_{25} =2.275 Monocot: IC_{25} = >6.490	PMRA 2824698
	Vegetative Vigour	Cucumber Oat	Dicot IC_{25} = >6.39 kg a.i./ha Monocot IC_{25} = 6.39 kg a.i./ha	Dicot: IC_{25} = >6.39 Monocot: IC_{25} = 6.39	PMRA 2824698

[1] Risk Assessment.
[2] May not be protective.
[3] LB = lower bound
[4] UB = upper bound

Table 11 Screening Level Risk Assessment for Chlorpyrifos for Birds and Mammals Using the Highest Applicable Cumulative Application Rate for Agricultural Uses (filbert – 2304 g a.i./ha × 3 applications)

	Toxicity (mg ai/kg bw/d)	Feeding Guild (food item)	EDE (mg ai/kg bw)	RQ
Small Bird (0.02 kg)				
Acute	6.60	Insectivore	328.22	**49.73**[1]
Reproduction	2.88	Insectivore	328.22	**113.9**
Medium Sized Bird (0.1 kg)				
Acute	6.60	Insectivore	256.14	**38.81**
Reproduction	2.88	Insectivore	256.14	**88.94**
Large Sized Bird (1 kg)				
Acute	6.60	Herbivore (short grass)	165.45	**25.07**
Reproduction	2.88	Herbivore (short grass)	165.45	**57.45**
Small Mammal (0.015 kg)				
Acute	6.00	Insectivore	188.78	**31.46**
Reproduction	1.00	Insectivore	188.78	**188.8**
Medium Sized Mammal (0.035 Kg)				
Acute	6.00	Herbivore (short grass)	366.13	**61.02**
Reproduction	1.00	Herbivore (short grass)	366.13	**366.1**
Large Sized Mammal (1 kg)				
Acute	6.00	Herbivore (short grass)	195.64	**32.61**
Reproduction	1.00	Herbivore (short grass)	195.64	**195.6**

[1] Bold indicates LOC was exceeded.

Table 12 Avian Risk Assessment Using Mean Chlorpyrifos Food Residue Values Based on the Crop Application Rate that Provides Highest Estimated Daily Exposures (EDE) Due to Drift (air blast application to filbert at 3 × 2304 g a.i./ha with 14-day intervals and 14-day foliage dissipation half-life)

			Mean Nomogram Residues			
			On-field		**Off-Field**	
	Toxicity (mg ai/kg bw/d)	**Food Guild (food item)**	**EDE (mg a.i./kg bw)**	**RQ**	**EDE (mg a.i./kg bw)**	**RQ**
Small Bird (0.02 kg)						
Acute	6.60	Insectivore	226.6	**34.3**[1]	167.7	**25.4**
	6.60	Granivore (grain and seeds)	24.23	**3.67**	17.93	**2.72**
	6.60	Frugivore (fruit)	48.45	**7.34**	35.85	**5.43**
Reproduction	2.88	Insectivore	226.6	**78.7**	167.7	**58.2**

			Mean Nomogram Residues			
			On-field		Off-Field	
	Toxicity (mg ai/kg bw/d)	Food Guild (food item)	EDE (mg a.i./kg bw)	RQ	EDE (mg a.i./kg bw)	RQ
	2.88	Granivore (grain and seeds)	24.23	**8.41**	17.93	**6.22**
	2.88	Frugivore (fruit)	48.45	**16.82**	35.85	**12.5**
Medium Sized Bird (0.1 kg)						
Acute	6.60	Insectivore	176.8	**26.8**	130.9	**19.8**
	6.60	Granivore (grain and seeds)	18.91	**2.86**	13.99	**2.12**
	6.60	Frugivore (fruit)	37.81	**5.73**	27.98	**4.24**
Reproduction	2.88	Insectivore	176.9	**61.4**	130.9	**45.4**
	2.88	Granivore (grain and seeds)	18.91	**6.56**	13.99	**4.86**
	2.88	Frugivore (fruit)	37.81	**13.1**	27.98	**9.72**
Large Sized Bird (1 kg)						
Acute	6.60	Insectivore	51.64	**7.82**	38.2	**5.79**
	6.60	Granivore (grain and seeds)	5.52	0.84	4.08	0.62
	6.60	Frugivore (fruit)	11.04	**1.67**	8.17	**1.24**
	6.60	Herbivore (short grass)	58.76	**8.90**	43.5	**6.59**
	6.60	Herbivore (long grass)	32.99	**5.00**	24.4	**3.70**
	6.60	Herbivore (Broadleaf plants)	50.60	**7.67**	37.5	**5.67**
Reproduction	2.88	Insectivore	51.64	**17.9**	38.2	**13.3**
	2.88	Granivore (grain and seeds)	5.52	**1.92**	4.08	**1.42**
	2.88	Frugivore (fruit)	11.04	**3.83**	8.17	**2.84**
	2.88	Herbivore (short grass)	58.76	**20.4**	43.5	**15.1**
	2.88	Herbivore (long grass)	32.99	**11.5**	24.4	**8.48**
	2.88	Herbivore (Broadleaf plants)	50.60	**17.6**	37.4	**13.0**

[1] Bold indicates LOC was exceeded.

Table 13 Mammalian Risk Assessment Using Mean Chlorpyrifos Food Residue Values Based on the Crop Application Rate that Provides Highest Estimated Daily Exposures (EDE) Due to Drift (air blast application to filbert at 3 × 2304 g a.i./ha with 14-day intervals and 14-day foliage dissipation half-life)

			Mean Nomogram Residues			
			On-Field		Off-Field	
	Toxicity (mg ai/kg bw/d)	Food Guild (food item)	EDE (mg a.i./kg bw)	RQ	EDE (mg a.i./kg bw)	RQ
Small Sized Mammal (0.015 kg)						
Acute	6.00	Insectivore	130.4	**21.7**[1]	96.46	**16.1**
	6.00	Granivore (grain and seeds)	13.9	**2.3**	10.31	**1.72**
	6.00	Frugivore (fruit)	27.9	**4.65**	20.62	**3.43**
Reproduction	1.00	Insectivore	130.4	**130**	96.46	**96.5**
	1.00	Granivore (grain and seeds)	13.9	**13.9**	10.31	**10.3**

			Mean Nomogram Residues			
			On-Field		Off-Field	
	Toxicity (mg ai/kg bw/d)	Food Guild (food item)	EDE (mg a.i./kg bw)	RQ	EDE (mg a.i./kg bw)	RQ
	1.00	Frugivore (fruit)	27.9	**27.9**	20.62	**20.6**
Medium Sized Mammal (0.035 kg)						
Acute	6.00	Insectivore	114.3	**19.0**	84.56	**14.1**
	6.00	Granivore (grain and seeds)	12.21	**2.04**	9.04	**1.51**
	6.00	Frugivore (fruit)	24.43	**4.07**	18.08	**3.01**
	6.00	Herbivore (short grass)	130.0	**21.7**	96.22	**16.0**
	6.00	Herbivore (long grass)	73.00	**12.2**	54.02	**9.0**
	6.00	Herbivore (forage crops)	111.9	**18.7**	82.87	**13.8**
Reproduction	1.00	Insectivore	114.3	**114**	84.56	**84.6**
	1.00	Granivore (grain and seeds)	12.21	**12.2**	9.04	**9.04**
	1.00	Frugivore (fruit)	24.43	**24.4**	18.08	**18.1**
	1.00	Herbivore (short grass)	130.0	**130**	96.22	**96.2**
	1.00	Herbivore (long grass)	73.00	**72.9**	54.02	**54.0**
	1.00	Herbivore (Broadleaf plants)	111.9	**112**	82.87	**82.9**
Large Sized Mammal (1 kg)						
Acute	6.00	Insectivore	61.06	**10.2**	45.18	**7.5**
	6.00	Granivore (grain and seeds)	6.53	**1.09**	4.83	0.81
	6.00	Frugivore (fruit)	13.05	**2.18**	9.66	**1.61**
	6.00	Herbivore (short grass)	69.48	**11.6**	51.41	**8.57**
	6.00	Herbivore (long grass)	39.00	**6.50**	28.86	**4.81**
	6.00	Herbivore (Broadleaf plants)	59.84	**9.97**	44.28	**7.38**
Reproduction	1.00	Insectivore	61.06	**61.1**	45.18	**45.2**
	1.00	Granivore (grain and seeds)	6.53	**6.53**	4.83	**4.83**
	1.00	Frugivore (fruit)	13.05	**13.1**	9.66	**9.67**
	1.00	Herbivore (short grass)	69.48	**69.5**	51.41	**51.4**
	1.00	Herbivore (long grass)	39.00	**39.0**	28.86	**28.9**
	1.00	Herbivore (Broadleaf plants)	59.84	**59.8**	44.28	**44.3**

[1] Bold indicates LOC was exceeded.

Table 14 Granular Risk Assessment for Birds - Pyrifos 15G (PCP No. 24648) and Lorsban 15G (PCP No. 16458)

	Study Endpoint (mg a.i./kg bw/day/ UF)	EDE (mg a.i./kg bw/day)	Screening Level RQ	Number of Granules Needed to Reach Endpoint (Pyrifos 15G/Lorsban 15G)	Area Required to Reach Endpoint (m^2) Both EUPs	
					No soil Incorporation	With Soil Incorporation Rate of 85%
Small bird (0.02 kg)						
Acute	6.60	38091	5771	7/9	0.0003	0.0018
Reproduction	2.88	38091	13226	3/4	0.0001	0.0008
Medium bird (0.10 kg)						
Acute	6.60	29921	4533	33/43	0.0013	0.0089
Reproduction	2.88	29921	10389	14/19	0.0006	0.0039
Large bird (1.00 kg)						
Acute	6.60	8723	1322	330/431	0.013	0.089
Reproduction	2.88	8723	3029	144/188	0.006	0.039

Table 15 Probability of Birds Eating the Required Granules to Reach Acute and Reproductive Endpoints – Pyrifos 15G (PCP No. 24648) and Lorsban 15G (PCP No. 16458)

End-use Product	Pyrifos 15G (PCP No. 24648)		Lorsban 15G (PCP No. 16458)	
	Number of Granules Needed to Reach Endpoint	Probability of Consuming Enough Granules to Reach Endpoints	Number of Granules Needed to Reach Endpoint	Probability of Consuming Enough Granules to Reach Endpoints
Small Bird (0.02 kg)				
Acute	6.60	<0.001	8.63	<0.001
Reproduction	2.88	<0.001	3.76	<0.001
Medium Sized Bird (0.1 kg)				
Acute	33.0	<0.001	43.1	<0.001
Reproduction	14.4	<0.001	18.8	<0.001
Large Sized Bird (1 kg)				
Acute	330	<0.001	431	<0.001
Reproduction	144	<0.001	188	<0.001

Table 16 Spray Drift Risk Assessment for Aquatic Non-target Organisms

Organism	Exposure	Species	Endpoint for RA (µg a.i./L)	Lowest Single Application (Airblast to Ornamentals) Drift EEC[1] (µg a.i./L)	RQ	Airblast Application to Filbert Drift EEC[2] (µg a.i./L)	RQ
Freshwater							
Invertebrate	Acute	SSD	0.044	1.11	**25.2**	476.9	**10 839**[3]
	Lower Bound Acute mesocosm	Community Effects	0.06	1.11	**18.5**	476.9	**7 948**
	Upper Bound Acute mesocosm	Community Effects	0.1	1.11	**11.1**	476.9	**4 769**
	Chronic	*Daphnia*	0.005	1.11	**222**	476.9	**95 380**
	Chronic mesocosm	Community Effects	0.1	1.11	**11.1**	476.9	**4 769**
Fish	Acute	SSD	5.94	1.11	0.2	476.9	**80**
	Lower Bound Acute mesocosm	*Lepomis macrochirus*	0.25	1.11	**4.4**	476.9	**1 908**
	Upper Bound Acute mesocosm	*Lepomis macrochirus*	1.34	1.11	0.83	476.9	**356**
	Chronic	*Pimephales promelas*	0.14	1.11	**7.9**	476.9	**3 406**
Amphibian	Acute	SSD	20	5.92	0.3	2544	**127**
	Chronic	*Xenopus laevis*	0.88	5.92	**6.7**	2544	**2 890**
Algae	Acute	*Selenastrum capricornutum*	32	1.11	0.03	476.9	**14.9**
Vascular plant	Acute	*Pistia stratiotes* and *Lemna minor*	1000	1.11	0.001	476.9	0.48
Marine/Estuarine							
Invertebrate	Acute	SSD	0.034	1.11	**32.6**	476.9	**14 027**
	Chronic	*Americamysis bahia*	0.0046	1.11	**241**	476.9	**103 675**
Fish	Acute	SSD	0.79	1.11	**1.4**	476.9	**604**
	Chronic	*Menidia menidia*	0.28	1.11	**4.0**	476.9	**1 703**
Algae	Acute	*Isochrysis galbans*	70	1.11	0.02	476.9	**6.8**

[1] 12 g a.i./ha × 1 application
[2] 3 applications × 2304 g a.i./ha, at 14-day intervals
[3] **BOLD** values indicate LOC is exceeded.

Table 17 Water Model Inputs for Chlorpyrifos

Crop	Modelled Use Pattern	Dates of First Application [1]
Garlic	2 × 1680 g a.i./ha, with a 7-d interval (seasonal: 3360 g a.i./ha)	Feb 15 - Jun 25
Onion	1 × 2400 g a.i./ha	Apr 20 - Jul 26
Corn	1 × 1476 g a.i./ha	Apr 18 - Aug 15
Turf	2 × 1120 g a.i./ha, with a 7-d interval (seasonal: 2240 g a.i./ha)	Apr 15 - Nov 15
Barley, oats, wheat	1 × 576 g a.i./ha	Mar 1 - Oct 20
	1 × 240 g a.i./ha	
Canola	1 × 720 g a.i./ha	Apr 1 - Aug 12
	1 × 240 g a.i./ha	
Lentils	1 × 576 g a.i./ha	Jun 1- Jul 19
	1 × 278 g a.i./ha	

[1] Initial application dates are dependent on the modelled crop and region; information presented here is for all regions combined

Table 18 Water Modelling Environmental Fate Inputs for Chlorpyrifos

Input Parameter	Chlorpyrifos
Molecular weight	350.6
Vapour pressure (mmHg)	1.87E-5
Solubility in water (mg/L)	2
Adsorption K_{OC} (mL/g)	5320 [1]
Hydrolysis half-life at pH 7 (days)	116
Photolysis half-life in water (days)	29.6
Aerobic soil biotransformation half-life (days)	179 [2]
Aerobic aquatic biotransformation half-life (days)	29.5
Anaerobic aquatic biotransformation half-life (days)	125 [3]

[1] 20th percentile of 3 K_{OC} values for chlorpyrifos
[2] 90th percentile confidence bound on mean of 8 half-lives adjusted to 25°C
[3] Longest of two half-lives adjusted to 25°C

Table 19 Level 1 Aquatic Ecoscenario Modelling EECs (μg a.i./L) for Chlorpyrifos in a Water Body 0.8-m deep, Excluding Spray Drift

Use Pattern	Region	Peak	96-h	21-d	60-d	90-d	Yearly	Pore water	
								Peak	21-d
Garlic: 2 × 1680 g a.i./ha @ 7d	BC	5.1	3.1	1.2	0.78	0.67	0.38	0.52	0.51
Onion: 1 × 2400 g a.i./ha	ON	11	6.3	2.7	2.1	1.9	1.2	1.6	1.6
	QC	8.9	5.5	2.8	2.1	2.0	1.5	1.8	1.8
	Atlantic	44	30	18	11	9.6	5.1	7.5	7.4
Corn: 1 × 1476 g a.i./ha	Prairies	11	6.4	2.8	2.0	1.7	1.0	1.6	1.6
Turf: 2 × 1120 g a.i./ha @ 7-d	BC	5.9	3.7	1.8	1.3	1.1	0.62	0.93	0.93
	ON	9.5	5.5	2.5	1.8	1.7	1.1	1.5	1.4
	QC	10	7.1	4.0	2.5	2.2	1.4	1.9	1.9
	Atlantic	37	27	17	10	8.9	5.5	7.1	7.1
Cereals: 1 × 576 g a.i./ha	BC	0.61	0.36	0.19	0.12	0.11	0.059	0.087	0.086
	MB	1.6	0.91	0.42	0.25	0.22	0.14	0.19	0.19
	SK	1.6	1.0	0.43	0.23	0.21	0.11	0.18	0.17
	ON	2.0	1.1	0.50	0.38	0.36	0.22	0.30	0.30
	QC	3.0	2.2	1.2	0.78	0.68	0.38	0.60	0.59
	Atlantic	7.9	5.5	3.3	2.1	1.8	0.99	1.4	1.4
Cereals: 1 × 240 g a.i./ha	BC	0.47	0.28	0.12	0.081	0.070	0.042	0.060	0.059
	MB	0.67	0.38	0.17	0.10	0.094	0.056	0.080	0.080
	SK	0.65	0.43	0.18	0.096	0.088	0.044	0.073	0.072
	ON	0.81	0.47	0.21	0.16	0.15	0.091	0.13	0.13
	QC	1.3	0.92	0.48	0.32	0.28	0.16	0.25	0.25
	Atlantic	3.3	2.3	1.4	0.87	0.75	0.41	0.60	0.59
Canola: 1 × 720 g a.i./ha	BC	1.5	0.87	0.35	0.23	0.20	0.13	0.17	0.17
	Prairies	3.8	2.3	1.2	0.75	0.66	0.39	0.61	0.60
	ON	2.5	1.4	0.63	0.48	0.45	0.28	0.38	0.38
	QC	3.4	2.6	1.4	0.97	0.85	0.47	0.73	0.72
	Atlantic	11	6.7	3.3	2.0	1.7	1.0	1.5	1.5
Canola: 1 × 240 g a.i./ha	BC	0.49	0.29	0.12	0.077	0.066	0.043	0.058	0.057
	Prairies	1.3	0.75	0.40	0.25	0.22	0.13	0.20	0.20
	ON	0.82	0.47	0.21	0.16	0.15	0.092	0.13	0.13
	QC	1.1	0.86	0.48	0.32	0.28	0.16	0.28	0.24

Use Pattern	Region	Peak	96-h	21-d	60-d	90-d	Yearly	Pore water	
								Peak	21-d
	Atlantic	3.5	2.2	1.1	0.68	0.58	0.34	0.49	0.49
Lentils: 1 × 576 g a.i./ha	BC	0.47	0.30	0.14	0.092	0.083	0.051	0.067	0.067
	Prairies	3.4	2.0	0.97	0.68	0.60	0.34	0.57	0.56
	ON	2.1	1.2	0.50	0.35	0.34	0.23	0.31	0.31
	QC	1.7	1.0	0.51	0.39	0.37	0.29	0.35	0.34
Lentils: 1 × 278 g a.i./ha	BC	0.23	0.14	0.066	0.044	0.040	0.024	0.032	0.032
	Prairies	1.7	0.96	0.47	0.33	0.29	0.17	0.27	0.27
	ON	0.99	0.57	0.24	0.17	0.16	0.11	0.15	0.15
	QC	0.81	0.48	0.25	0.19	0.18	0.14	0.17	0.16

Table 20 Level 1 Aquatic Ecoscenario Modelling EECs (μg a.i./L) for Chlorpyrifos in a Water Body 0.15-m Deep, Excluding Spray Drift

Use Pattern	Region	Peak	96-h	21-d	60-d	90-d	Yearly	Pore water	
								Peak	21-d
Garlic: 2 × 1680 g a.i./ha @ 7d	BC	22	4.5	1.4	0.88	0.76	0.46	0.59	0.58
Onion: 1 × 2400 g a.i./ha	ON	56	9.2	3.2	2.5	2.3	1.5	2.0	1.9
	QC	42	7.9	3.4	2.6	2.4	1.9	2.2	2.2
	Atlantic	151	47	21	13	11	6.3	8.9	8.8
Corn: 1 × 1476 g a.i./ha	Prairies	52	8.7	3.5	2.3	2.0	1.2	1.8	1.8
Turf: 2 × 1120 g a.i./ha @ 7-d	BC	29	5.0	2	1.5	1.2	0.76	1.1	1.1
	ON	44	8.4	2.9	2.2	2.0	1.4	1.8	1.7
	QC	46	11	4.6	3.0	2.6	1.7	2.2	2.2
	Atlantic	144	42	19	12	11	6.7	8.4	8.4
Cereals: 1 × 576 g a.i./ha	BC	5.6	1.0	0.37	0.23	0.20	0.13	0.18	0.17
	MB	7.7	1.2	0.47	0.29	0.26	0.17	0.24	0.24
	SK	6.9	1.5	0.49	0.26	0.25	0.13	0.20	0.20
	ON	9.7	1.7	0.60	0.46	0.42	0.28	0.36	0.35
	QC	11	3.1	1.4	0.91	0.81	0.48	0.70	0.69
	Atlantic	28	8.5	3.9	2.5	2.2	1.2	1.7	1.7
Cereals: 1 × 240 g a.i./ha	BC	2.3	0.43	0.15	0.094	0.081	0.055	0.073	0.071
	MB	3.2	0.51	0.20	0.12	0.11	0.070	0.098	0.098
	SK	2.9	0.61	0.20	0.11	0.10	0.053	0.084	0.082
	ON	4.1	0.70	0.25	0.19	0.18	0.11	0.15	0.15

Use Pattern	Region	Peak	96-h	21-d	60-d	90-d	Yearly	Pore water	
								Peak	21-d
	QC	4.6	1.3	0.57	0.38	0.34	0.20	0.29	0.29
	Atlantic	12	3.5	1.6	1.0	0.90	0.51	0.71	0.70
Canola: 1 × 720 g a.i./ha	BC	7.4	1.3	0.41	0.27	0.23	0.16	0.21	0.21
	Prairies	20	3.2	1.4	0.89	0.78	0.50	0.70	0.69
	ON	12	2.1	0.75	0.58	0.53	0.35	0.46	0.45
	QC	14	3.8	1.7	1.1	1.0	0.59	0.85	0.84
	Atlantic	36	10	3.9	2.4	2.1	1.3	1.8	1.8
Canola: 1 × 240 g a.i./ha	BC	2.5	0.44	0.14	0.091	0.078	0.055	0.071	0.069
	Prairies	6.5	1.1	0.46	0.30	0.26	0.17	0.24	0.23
	ON	4.1	0.71	0.25	0.19	0.18	0.12	0.15	0.15
	QC	4.7	1.3	0.55	0.38	0.33	0.20	0.28	0.28
	Atlantic	12	3.5	1.3	0.81	0.70	0.43	0.60	0.59
Lentils: 1 × 576 g a.i./ha	BC	2.3	0.42	0.16	0.11	0.096	0.063	0.078	0.078
	Prairies	17	2.8	1.2	0.79	0.70	0.43	0.65	0.64
	ON	11	1.7	0.59	0.42	0.40	0.28	0.38	0.37
	QC	8.0	1.5	0.62	0.48	0.46	0.36	0.43	0.41
Lentils: 1 × 278 g a.i./ha	BC	1.1	0.20	0.076	0.051	0.046	0.030	0.038	0.037
	Prairies	8.1	1.4	0.56	0.38	0.34	0.21	0.32	0.31
	ON	5.1	0.83	0.28	0.20	0.19	0.14	0.18	0.18
	QC	3.9	0.71	0.30	0.23	0.22	0.18	0.21	0.20

Table 21 Acute Risk (RQ values) Associated with Modelled Runoff EECs at all Currently Modelled Regional Scenarios and Use-sites for Freshwater (FW) Invertebrates and Fish, Amphibians, and Estuarine/Marine (E/M) Invertebrates and Fish

Use Pattern	Region	96-h EEC (80/15 cm) µg a.i./L	FW Invertebrate SSD HC_5 = 0.044 µg a.i./L	FW Invertebrate Most Sensitive Mesocosm NOEC = 0.06 µg a.i./L (measured concentration)	FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L (nominal concentration)	FW Fish SSD HC_5 = 5.94 µg a.i./L	FW Fish Mesocosm NOEC = 0.25 µg a.i./L	FW Fish Mesocosm 1/2 LC_{50} = 1.34 µg a.i./L	Amphibian SSD HC_5 = 20 µg a.i./L	E/M Invertebrate SSD HC_5 = 0.034 µg a.i./L	E/M Fish SSD HC_5 = 0.79 µg a.i./L
Onion	Atlantic	30/47	**682**	**500**	**300**	**5.05**	**120**	**22.4**	**2.4**	**882**	**38.0**
Turf	Atlantic	27/42	**614**	**450**	**270**	**4.55**	**108**	**20.1**	**2.1**	**794**	**34.2**
Turf	QC	7.1/11	**161**	**118**	**71**	**1.20**	**28.4**	**5.3**	0.6	**209**	**9.0**
Cereals	Atlantic	5.5/8.5	**125**	**91.7**	**55**	**0.93**	**22.0**	**4.1**	0.4	**162**	**7.0**
Canola	Atlantic	6.7/10	**152**	**112**	**67**	**1.13**	**26.8**	**5.0**	0.5	**197**	**8.5**
Onion	QC	5.5/7.9	**125**	**91.7**	**55**	**0.93**	**22.0**	**4.1**	0.4	**162**	**7.0**
Corn	Prairies	6.4/8.7	**145**	**107**	**64**	**1.08**	**25.6**	**4.8**	0.4	**188**	**8.1**
Onion	ON	6.3/9.2	**143**	**105**	**63**	**1.06**	**25.2**	**4.7**	0.5	**185**	**8.0**
Turf	ON	5.5/8.4	**125**	**91.7**	**55**	0.93	**22.0**	**4.1**	0.4	**162**	**7.0**
Turf	BC	3.7/5.0	**84**	**61.7**	**37**	0.62	**14.8**	**2.8**	0.3	**109**	**4.7**
Cereals	Atlantic	2.3/3.5	**52**	**38.3**	**23**	0.39	**9.2**	**1.7**	0.2	**68**	**2.9**
Canola	QC	2.6/3.8	**59**	**43.3**	**26**	0.44	**10.4**	**1.9**	0.2	**76**	**3.3**
Garlic	BC	3.1/4.5	**70**	**51.7**	**31**	0.52	**12.4**	**2.3**	0.2	**91**	**3.9**
Cereals	QC	2.2/3.1	**50**	**36.7**	**22**	0.37	**8.8**	**1.6**	0.2	**65**	**2.8**
Canola	Prairies	2.3/3.2	**52**	**38.3**	**23**	0.39	**9.2**	**1.7**	0.2	**68**	**2.9**
Canola	Atlantic	2.2/3.5	**50**	**36.7**	**22**	0.37	**8.8**	**1.6**	0.2	**65**	**2.8**
Lentils	Prairies	2.0/2.8	**45**	**33.3**	**20**	0.34	**8.0**	**1.5**	0.1	**59**	**2.5**

Use Pattern	Region	96-h EEC (80/15 cm) µg a.i./L	FW Invertebrate SSD HC_5 = 0.044 µg a.i./L	FW Invertebrate Most Sensitive Mesocosm NOEC = 0.06 µg a.i./L (measured concentration)	FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L (nominal concentration)	FW Fish SSD HC_5 = 5.94 µg a.i./L	FW Fish Mesocosm NOEC = 0.25 µg a.i./L	FW Fish Mesocosm 1/2 LC_{50} = 1.34 µg a.i./L	Amphibian SSD HC_5 = 20 µg a.i./L	E/M Invertebrate SSD HC_5 = 0.034 µg a.i./L	E/M Fish SSD HC_5 = 0.79 µg a.i./L
Canola	ON	1.4/2.1	**32**	**23.3**	**14**	0.24	**5.6**	**1.0**	0.1	**41**	**1.8**
Lentils	QC	1.0/1.5	**23**	**16.7**	**10**	0.17	**4.0**	0.7	0.1	**29**	**1.3**
Cereals	ON	1.1/1.7	**25**	**18.3**	**11**	0.19	**4.4**	0.8	0.1	**32**	**1.4**
Lentils	ON	1.2/1.7	**27**	**20.0**	**12**	0.20	**4.8**	0.9	0.1	**35**	**1.5**
Cereals	QC	0.92/1.3	**21**	**15.3**	**9.2**	0.15	**3.7**	0.7	0.1	**27**	**1.2**
Canola	QC	0.86/1.3	**20**	**14.3**	**8.6**	0.14	**3.4**	0.6	0.1	**25**	**1.1**
Lentils	Prairies	0.96/1.4	**22**	**16.0**	**9.6**	0.16	**3.8**	0.7	0.1	**28**	**1.2**
Cereals	SK	1.0/1.5	**23**	**16.7**	**10**	0.17	**4.0**	0.7	0.1	**29**	**1.3**
Cereals	MB	0.91/1.2	**21**	**15.2**	**9.1**	0.15	**3.6**	0.7	0.1	**27**	**1.2**
Canola	Prairies	0.75/1.1	**17**	**12.5**	**7.5**	0.13	**3.0**	0.6	0.1	**22**	0.9
Canola	BC	0.87/1.3	**20**	**14.5**	**8.7**	0.15	**3.5**	0.6	0.1	**26**	**1.1**
Lentils	QC	0.48/0.71	**11**	**8.0**	**4.8**	0.08	**1.9**	0.4	0.04	**14**	0.6
Lentils	ON	0.57/0.83	**13**	**9.5**	**5.7**	0.10	**2.3**	0.4	0.04	**17**	0.7
Cereals	ON	0.47/0.70	**11**	**7.8**	**4.7**	0.08	**1.9**	0.4	0.04	**14**	0.6
Canola	ON	0.47/0.71	**11**	**7.8**	**4.7**	0.08	**1.9**	0.4	0.04	**14**	0.6
Cereals	BC	0.36/1.0	**8.2**	**6.0**	**3.6**	0.06	**1.4**	0.3	0.1	**11**	0.5
Cereals	SK	0.43/0.61	**9.8**	**7.2**	**4.3**	0.07	**1.7**	0.3	0.03	**13**	0.5
Cereals	MB	0.38/0.51	**8.6**	**6.3**	**3.8**	0.06	**1.5**	0.3	0.03	**11**	0.5
Lentils	BC	0.3/0.42	**6.8**	**5.0**	**3**	0.05	**1.2**	0.2	0.02	**8.8**	0.4
Cereals	BC	0.28/0.43	**6.4**	**4.7**	**2.8**	0.05	**1.1**	0.2	0.02	**8.2**	0.4
Canola	BC	0.29/0.44	**6.6**	**4.8**	**2.9**	0.05	**1.2**	0.2	0.02	**8.5**	0.4

Use Pattern	Region	96-h EEC (80/15 cm) µg a.i./L	FW Invertebrate SSD HC_5 = 0.044 µg a.i./L	FW Invertebrate Most Sensitive Mesocosm NOEC = 0.06 µg a.i./L (measured concentration)	FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L (nominal concentration)	FW Fish SSD HC_5 = 5.94 µg a.i./L	FW Fish Mesocosm NOEC = 0.25 µg a.i./L	FW Fish Mesocosm 1/2 LC_{50} = 1.34 µg a.i./L	Amphibian SSD HC_5 = 20 µg a.i./L	E/M Invertebrate SSD HC_5 = 0.034 µg a.i./L	E/M Fish SSD HC_5 = 0.79 µg a.i./L
Lentils	BC	0.14/0.20	**3.2**	**2.3**	**1.4**	0.02	0.6	0.1	0.01	**4.1**	0.2

Bold values indicate the LOC is exceeded.

Table 22 Chronic Risk (RQ values) Associated With Modelled Runoff EECs at all Currently Modelled Regional Scenarios and Use-sites for Freshwater (FW) Invertebrates and Fish, Amphibians, and Estuarine/Marine (E/M) Invertebrates and Fish

Use Pattern	Region	21-d EEC (80/15 cm) µg a.i./L	Chronic FW Invert. LOEC = 0.005 µg a.i./L	Chronic FW Invert. Mesocosm NOEC = 0.1 µg a.i./L (may not be protective)1	Chronic FW Fish NOEC = 0.14 µg a.i./L	Chronic Amphibian NOEC = 0.88 µg a.i./L	Chronic E/M Invert. LOEC = <0.0046 µg a.i./L	Chronic E/M Fish NOEC = 0.28 µg a.i./L
Onion	Atlantic	18/21	3600	180	129	23.9	3913	64.3
Turf	Atlantic	17/19	3400	170	121	21.6	3696	60.7
Turf	QC	4.0/4.6	800	40	29	5.2	870	14.3
Canola	Atlantic	3.3/3.9	660	33	24	4.4	717	11.8
Cereals	Atlantic	3.3/3.9	660	33	24	4.4	717	11.8
Corn	Prairies	2.8/3.4	560	28	20	3.9	609	10.0
Onion	QC	2.8/3.5	560	28	20	4.0	609	10.0
Onion	ON	2.7/3.2	540	27	19	3.6	587	9.6
Turf	ON	2.5/2.9	500	25	18	3.3	543	8.9
Turf	BC	1.8/2.0	360	18	13	2.3	391	6.4
Canola	QC	1.4/1.6	280	14	10	1.8	304	5.0
Cereals	Atlantic	1.4/1.7	280	14	10	1.9	304	5.0
Canola	Prairies	1.2/1.4	240	12	8.6	1.6	261	4.3
Cereals	QC	1.2/1.4	240	12	8.6	1.6	261	4.3
Garlic	BC	1.2/1.4	240	12	8.6	1.6	261	4.3

Use Pattern	Region	21-d EEC (80/15 cm) µg a.i./L	Chronic FW Invert. LOEC = 0.005 µg a.i./L	Chronic FW Invert. Mesocosm NOEC = 0.1 µg a.i./L (may not be protective)1	Chronic FW Fish NOEC = 0.14 µg a.i./L	Chronic Amphibian NOEC = 0.88 µg a.i./L	Chronic E/M Invert. LOEC = <0.0046 µg a.i./L	Chronic E/M Fish NOEC = 0.28 µg a.i./L
Canola	Atlantic	1.1/1.3	220	11	7.9	1.5	239	3.9
Lentils	Prairies	0.97/1.2	194	9.7	6.9	1.4	211	3.5
Canola	ON	0.63/0.75	126	6.3	4.5	0.9	137	2.3
Lentils	QC	0.51/0.62	102	5.1	3.6	0.7	111	1.8
Cereals	ON	0.5/0.60	100	5	3.6	0.7	109	1.8
Lentils	ON	0.5/0.59	100	5	3.6	0.7	109	1.8
Canola	QC	0.48/0.57	96	4.8	3.4	0.6	104	1.7
Cereals	QC	0.48/0.55	96	4.8	3.4	0.6	104	1.7
Lentils	Prairies	0.47/0.56	94	4.7	3.4	0.6	102	1.7
Cereals	SK	0.43/0.49	86	4.3	3.1	0.6	93	1.5
Cereals	MB	0.42/0.47	84	4.2	3.0	0.5	91	1.5
Canola	Prairies	0.40/0.46	80	4	2.9	0.5	87	1.4
Canola	BC	0.35/0.41	70	3.5	2.5	0.5	76	1.3
Lentils	QC	0.25/0.30	50	2.5	1.8	0.3	54	0.9
Lentils	ON	0.24/0.28	48	2.4	1.7	0.3	52	0.9
Canola	ON	0.21/0.25	42	2.1	1.5	0.3	46	0.8
Cereals	ON	0.21/0.25	42	2.1	1.5	0.3	46	0.8
Cereals	BC	0.19/0.37	38	1.9	1.4	0.4	41	0.7
Cereals	SK	0.18/0.20	36	1.8	1.3	0.2	39	0.6
Cereals	MB	0.17/0.20	34	1.7	1.2	0.2	37	0.6
Lentils	BC	0.14/0.16	28	1.4	1.0	0.2	30	0.5
Canola	BC	0.12/0.15	24	1.2	0.9	0.2	26	0.4
Cereals	BC	0.12/0.14	24	1.2	0.9	0.2	26	0.4
Lentils	BC	0.066/0.076	13	0.66	0.5	0.1	14	0.2

Bold values indicate the LOC is exceeded.

Table 23 Summary of All Available, Relevant Canadian Chlorpyrifos Water Monitoring Data (post-2000) for Determining Potential Aquatic Biota Exposure

Province, Year(s) Sampled	LOD Range (µg/L)	Number of Detections	Total Samples	Detection Frequency (%)[1]	Maximum Detection (µg/L)
New Brunswick[2], 2003	-	0	25	0	ND
Nova Scotia, 2014	0.1 (LOQ)	0	1	0	ND
Québec, 2002-2016	0.01-0.1 (LOQ)	373	2 038	18	44
Ontario, 2002-2015	0.0001-0.1 (LOQ)	289	1 422	20	0.52
Ontario, 2007[2]	-	0	13	0	ND
Manitoba, 2001-2014	0.02-0.1	1	801	< 1	0.02
Saskatchewan, 2000-2011	0.01-2	1	425	< 1	0.96
Alberta[3], 2000-2016	0.005-0.04	25	7 433	< 1	0.781
British Columbia, 2003-2014	0.0000005-0.1	82	229	36	0.74
British Columbia[2], 2003-2004	-	9	10	90	0.000045
British Columbia[2], 2003-2004	-	18	34	53	0.75
Overall Canada	0.0000005-10	798	12 431	6	44

1 Detection frequency is calculated based on the number of detections divided by the number of samples available. Calculations were rounded to the nearest whole number. If the detection frequency was below 0.5%, '<1' was reported.

2 These data sources only provided detection frequency, but did not include LOD.

3 This source reported number of detections (22) but not their concentrations and included samples from 1995-2002; the data could not be separated into pre- and post-2000 data; however, it was included in this table.

Table 24 First Tier Refined Acute Aquatic Risk Associated with two Highest Chlorpyrifos Concentrations Detected in Canadian Water Monitoring Studies

Organism	Endpoint for Risk Assessment (µg a.i./L)	Second Highest Monitoring Acute EEC (4 µg a.i./L)	RQ	LOC Exceeded	Highest Monitoring EEC (44 µg a.i./L) (acute)	RQ	LOC Exceeded
Invertebrate	0.044	4	**91**	Yes	44	**1000**	Yes
	0.06	4	**67**	Yes	44	**733**	Yes
	0.1	4	**40**	Yes	44	**440**	Yes
Fish	5.94	4	0.67	No	44	**7.4**	Yes
	0.25	4	**16**	Yes	44	**176**	Yes
	1.34	4	**2.9**	Yes	44	**32.8**	Yes
Amphibian	20	4	0.2	No	44	**2.2**	Yes
Algae	32	4	0.13	No	44	**1.4**	Yes
Vascular plant	1000	4	0.004	No	44	0.044	No

Table 25 Minimum Number of Days Exceeding Acute Endpoints of Concern (and Percent of Entire Sampling Season) in the Ruisseau-Rousse, Québec

Year	Total Sampling Season (days)	Minimum Cumulative Days Exceeding Endpoint (Percent (rounded to nearest 1%) of Entire Sampling Season)			
		Acute Invert. Mesocosm (NOAEC = 0.06 µg/L)	Acute Invert. Mesocosm (NOAEC = 0.1 µg/L)	Acute Invert. (HC_5 = 0.044 µg/L)	Acute Fish Mesocosm (NOAEC = 0.25 µg/L)
2010	106	32 (30)	15 (14)	41 (39)	6 (6)
2011	102	29 (27)	15 (15)	43 (42)	5 (5)
2015	99	17 (17)	15 (15)	21 (21)	7 (7)
2016	102	10 (10)	1 (1)	10 (10)	0 (0)

Table 26 Maximum Consecutive Days Chlorpyrifos Concentrations Exceeded Acute Risk Assessment Endpoints in the Ruisseau-Rousse, Québec

Year	Total Sampling Season (days)	Maximum Consecutive Days Exceeding the Endpoint			
		Acute Invert. Mesocosm (NOAEC = 0.06 µg/L)	Acute Invert. Mesocosm (NOAEC = 0.1 µg/L)	Acute Invert. (HC_5 = 0.044 µg/L)	Acute Fish Mesocosm (NOAEC = 0.25 µg/L)
2010	106	26	8	35	5
2011	102	15	8	25	3
2015	99	15	15	19	7
2016	102	8	1	8	0

Table 27 Minimum Number of Days Exceeding Chronic Endpoints of Concern (and Percent of Entire Sampling Season) in the Ruisseau-Rousse, Québec

Year	Total Sampling Season (Days)	Minimum Cumulative Days Exceeding Endpoint (Percent (rounded to nearest 1%) of Entire Sampling Season)		
		Chronic Invert. (LOAEC = 0.005 µg/L)	Chronic Invert. Mesocosm (NOAEC = 0.1 µg/L) (may not be protective)[1]	Chronic Fish (NOEC = 0.14 µg/L)
2010	106	106 (100)*	15 (14)	11 (10)
2011	102	102 (100)*	15 (15)	10 (10)
2015	99	99 (100)*	15 (15)	15 (15)
2016	102	102 (100)*	1 (1)	1 (1)

* Uncertainty due to high LOQ.

[1] One study reported an NOEC of 0.1 µg a.i./L, however, three other studies reported NOEC of <0.1 µg a.i./L, indicating that this concentrations may not be protective for entire communities.

Table 28 Maximum Consecutive Days Chlorpyrifos Concentrations Exceeded Chronic Risk Assessment Endpoints in the Ruisseau-Rousse, Québec

Year	Total Sampling Season (days)	Maximum Consecutive Days Exceeding the Endpoint		
		Chronic Invert. LOAEC = 0.005 µg/L	Chronic Invert. Mesocosm NOAEC = 0.1 µg /L (may not be protective)[1]	Chronic Fish NOEC = 0.14 µg/L
2010	106	106*	8	5
2011	102	102*	8	8
2015	99	99*	15	15
2016	102	102*	1	1

* Uncertainty due to high LOQ

[1] One study reported an NOEC of 0.1 µg a.i./L, however, three other studies reported NOEC of <0.1 µg a.i./L, indicating that this concentrations may not be protective for entire communities

Table 29 Minimum Number of Days Exceeding Acute Endpoints of Concern (and Percent of Entire Sampling Season) in the Gibeault-Delisle, Québec Watershed

Year	Total Sampling Season (days)	Minimum Cumulative Days Exceeding Endpoint (Percent (Rounded to Nearest 1%) of Entire Sampling Season)			
		Acute Invert. Mesocosm (NOAEC = 0.06 µg/L)	Acute Invert. Mesocosm (NOAEC = 0.1 µg/L)	Acute Invert. (HC_5 = 0.044 µg/L)	Acute Fish Mesocosm (NOAEC = 0.25 µg/L)
2006	108	97 (90)	68 (63)	105 (97)	22 (20)
2007	82	82 (100)	82 (100)	82 (100)	17 (21)
2013	104	9 (9)	4 (4)	9 (9)	0 (0)
2014	103	0 (0)	0 (0)	1 (1)	0 (0)

Table 30 Maximum Consecutive Days Chlorpyrifos Concentrations Exceeded Acute Risk Assessment Endpoints in the Gibeault-Delisle, Québec Watershed

Year	Total Sampling Season (days	Maximum Consecutive Days Exceeding the Endpoint			
		Acute Invert. Mesocosm (NOAEC = 0.06 µg a.i./L)	Acute Invert. Mesocosm (NOAEC = 0.1 µg a.i./L)	Acute Invert. (HC_5 = 0.044 µg a.i./L	Acute Fish Mesocosm (NOAEC = 0.25 µg a.i./L)
2006	108	106	24	105	8
2007	82	82	82	82	12
2013	104	8	4	8	0
2014	103	1	0	1	0

Table 31 Minimum Number of Days Exceeding Chronic Endpoints of Concern (and Percent of Entire Sampling Season) in the Gibeault-Delisle, Québec Watershed

Year	Total Sampling Season (days)	Minimum Cumulative Days Exceeding Endpoint (Percent of Entire Sampling Season)		
		Chronic Invert. (LOAEC = 0.005 µg/L)	Chronic Invert. Mesocosm (NOAEC = 0.1 µg/L) (may not be protective)[1]	Chronic Fish (NOEC = 0.14 µg/L)
2006	108	108 (100)	68 (63)	44 (41)
2007	82	82 (100)	82 100)	57 (70)
2013	104	104*	4 (4)	0 (0)
2014	103	103*	0 (0)	0 (0)

* Uncertainty due to high LOQ
[1] One study reported an NOEC of 0.1 µg a.i./L, however, three other studies reported NOEC of <0.1 µg a.i./L, indicating that this concentrations may not be protective for entire communities

Table 32 Maximum Consecutive Days Chlorpyrifos Concentrations Exceeded Chronic Risk Assessment Endpoints in the Gibeault-Delisle, Québec Watershed

Year	Total Sampling Season (days)	Maximum Consecutive Days Exceeding the Endpoint		
		Chronic Invert. (LOAEC = 0.005 µg/L)	Chronic Invert. Mesocosm (NOAEC = 0.1 µg/L) (may not be protective)[1]	Chronic Fish (NOEC = 0.14 µg/L)
2006	108	108	24	15
2007	82	82	82	19
2013	104	104*	4	0
2014	103	103*	0	0

* Uncertainty due to high LOQ
[1] One study reported an NOEC of 0.1 µg a.i./L, however, three other studies reported NOEC of <0.1 µg a.i./L, indicating that this concentrations may not be protective for entire communities

Table 33 Summary of the Number of Water Samples (Percent of Sample Days) from the Saint-Régis River from 2002-2014 that Exceeded Acute Freshwater Toxicity Endpoints of Concern

Acute FW Invertebrate HC_5 = 0.044 µg a.i./L	Acute FW Invertebrate Mesocosm NOEC = 0.06 µg a.i./L	Acute FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L	Acute FW Fish Mesocosm NOEC = 0.25 µg a.i./L	Acute FW Fish Mesocosm 1/2 LC_{50} = 1.34 µg a.i./L	Acute FW Fish HC_5 = 5.94 µg a.i./L
39 (10%)	31 (8%)	17 (4%)	8 (2%)	1 (< 1%)	0 (0%)

Table 34 Summary of the Number of Water Samples (Percent of Sample Days) from the Saint-Régis River from 2002-2014 that Exceeded Chronic Freshwater Toxicity Endpoints of Concern

Chronic FW Invertebrate LOEC = 0.005 µg a.i./L	Chronic FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L (may not be protective)[1]	Chronic FW Fish NOEC = 0.14 µg a.i./L	Chronic Amphibian NOEC = 0.88 µg a.i./L
403 (100%)*	17 (4%)	12 (3%)	1 (< 1%)

*Uncertainty due to substitution of ½ LOD for non-detections
[1] One study reported an NOEC of 0.1 µg a.i./L, however, three other studies reported NOEC of <0.1 µg a.i./L, indicating that this concentrations may not be protective for entire communities

Table 35 Summary of the Number of Water Samples (Percent of Sample Days) from the Saint-Zéphirin River (2005-2008) that Exceeded Acute Freshwater Toxicity Endpoints of Concern

Acute FW Invertebrate HC_5 = 0.044 µg a.i./L	Acute FW Invertebrate Mesocosm NOEC = 0.06 µg a.i./L	Acute FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L	Acute FW Fish Mesocosm NOEC = 0.25 µg a.i./L	Acute FW Fish Mesocosm 1/2 LC_{50} = 1.34 µg a.i./L	Acute FW Fish HC_5 = 5.94 µg a.i./L
13 (8%)	12 (7%)	10 (6%)	4 (2%)	1 (1%)	0 (0%)

Table 36 Summary of the Number of Water Samples (Percent of Sample Days) from the Saint-Zéphirin River (2005-2008) that Exceeded Chronic Freshwater Toxicity Endpoints of Concern

Chronic FW Invertebrate LOEC = 0.005 µg a.i./L	Chronic FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L (may not be protective)[1]	Chronic FW Fish NOEC = 0.14 µg a.i./L	Chronic Amphibian NOEC = 0.88 µg a.i./L
166 (100%)*	10 (6%)	8 (5%)	1 (1%)

*Uncertainty due to substitution of ½ LOD for non-detections
[1] One study reported an NOEC of 0.1 µg a.i./L, however, three other studies reported NOEC of <0.1 µg a.i./L, indicating that this concentrations may not be protective for entire communities

Table 37 Summary of the Number of Samples (Percent of Sample Days) from Prudhomme Creek in Ontario (2005-2015) that Exceeded Acute Freshwater Toxicity Endpoints of Concern

Acute FW Invertebrate HC_5 = 0.044 µg a.i./L	Acute FW Invertebrate Mesocosm NOEC = 0.06 µg a.i./L	Acute FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L	Acute FW Fish Mesocosm NOEC = 0.25 µg a.i./L	Acute FW Fish Mesocosm 1/2 LC_{50} = 1.34 µg a.i./L	Acute FW Fish HC_5 = 5.94 µg a.i./L
5 (7%)	4 (6%)	2 (3%)	1 (1%)	0 (0%)	0 (0%)

Table 38 Summary of the Number of Samples (Percent of Sample Days) from Prudhomme Creek in Ontario (2005-2015) that Exceeded Chronic Freshwater Toxicity Endpoints of Concern

Chronic FW Invertebrate LOEC = 0.005 µg a.i./L	Chronic FW Invertebrate Mesocosm NOEC = 0.1 µg a.i./L (may not be protective)[1]	Chronic FW Fish NOEC = 0.14 µg a.i./L	Chronic Amphibian NOEC = 0.88 µg a.i./L
27 (39%)	2 (3%)	2 (3%)	0 (0%)

Table 39 Canadian Incident Reports

Year	Organism	Number of Incidents	Causality
2015	Fish, birds, frogs, insects	1	Probable
2012	Pollinators	9	Possible
	Pollinators	2	Unlikely
2014	Pollinators	2	Unlikely
2015	Pollinators	1	Unlikely

Table 40 Toxic Substances Management Policy Considerations – Comparison to TSMP Track 1 Criteria

TSMP Track 1 Criteria	TSMP Track 1 Criterion value		Chlorpyrifos Are Criteria Met?
CEPA-toxic or CEPA-toxic equivalent[1]	Yes		Yes
Predominantly anthropogenic[2]	Yes		Yes
Persistence[3]:	Soil	Half-life ≥ 182 days	No: 11-180 days
	Water	Half-life ≥ 182 days	No: 3 – 15 days
	Whole system (Water + Sediment)	Half-life ≥ 365 days	No: 30 days
	Air	Half-life ≥ 2 days or evidence of long range transport	No: $t_{1/2}$ <8 hours But evidence of long range transport
Bioaccumulation[4]	Log $K_{OW} \geq 5$		Yes: 3.31-5.27
	BCF ≥ 5000		No: weight of evidence indicates not Track 1 (Table 12).
	BAF ≥ 5000		No: <1344
Is the chemical a TSMP Track 1 substance (all four criteria must be met)?			**No, does not meet all TSMP Track 1 criteria.**

[1] All pesticides will be considered CEPA-toxic or CEPA toxic equivalent for the purpose of initially assessing a pesticide against the TSMP criteria. Assessment of the CEPA toxicity criteria may be refined if required (in other words, all other TSMP criteria are met).

[2] The policy considers a substance "predominantly anthropogenic" if, based on expert judgment, its concentration in the environment medium is largely due to human activity, rather than to natural sources or releases.

[3] If the pesticide and/or the transformation product(s) meet one persistence criterion identified for one media (soil, water, sediment or air) than the criterion for persistence is considered to be met.

[4] The BCF and/or BAF are preferred over log K_{OW}.

Appendix IV Proposed Label Amendments for Products Containing Chlorpyrifos

The label amendments presented below do not include all label requirements for individual end-use products, such as first aid statements, disposal statements, precautionary statements and supplementary protective equipment. Additional information on labels of currently registered products should not be removed unless it contradicts the label statements given below.

Note: The following information is divided according to product type.

Label Amendments for Technical Class Products

a) Environmental Hazards/Precautions

The following statements are to be added to the "Environmental Hazards/Precautions" section of the chlorpyrifos Technical Insecticide labels:

- TOXIC to aquatic organisms.
- DO NOT discharge effluent containing this product into sewer systems, lakes, streams, ponds, estuaries, oceans or other waters.

b) Disposal

The following statements are required under the "Disposal" Section of the chlorpyrifos Technical Insecticide label:

- Canadian manufacturers should dispose of unwanted active ingredients and containers in accordance with municipal or provincial regulations. For additional details and cleanup of spills, contact the manufacturer or the provincial regulatory agency.

Label Amendments for Commercial and Restricted Class Products Containing Chlorpyrifos

a) Acceptable uses

Only the following chlorpyrifos uses are proposed for continued registration, any references to other uses must be removed from all **Commercial and Restricted Class** end-use product labels:

- Standing water - temporary pools for larval mosquito control
- Outdoor adult mosquito control
- Structural indoor and outdoor (non-residential)
- Outdoor ornamentals (container stock only) for control of Japanese beetle larvae
- Greenhouse ornamentals

b) Environmental Precautions

The following statements are to be added to the "Environmental Precautions" section of all product labels:

- Toxic to aquatic and terrestrial organisms.

- Toxic to birds.
- Toxic to small wild mammals.
- Toxic to bees.
- Toxic to certain beneficial insects.
- Toxic to non-target terrestrial plants.

For all product labels with Greenhouse uses:

- Greenhouse uses: Toxic to bees and other beneficial insects. May harm bees and other beneficial insects, including those used in greenhouse production. Do not apply when bees or other beneficial insects are foraging in the treatment area.
- DO NOT allow effluent or runoff from greenhouses containing this product to enter lakes, streams, ponds or other waters.

For all product labels with outdoor surface spray or fogging application uses (adult mosquito control and outdoor structural uses), include:

- Outdoor areas: Toxic to bees. Avoid application around blooming plants. Toxic to beneficial insects. Minimize exposure to non-target areas.
- To minimize the release of chlorpyrifos into the environment due to volatilization, chlorpyrifos should only be applied on cool mornings and evenings when air temperatures are 15°C or lower.

c) Direction for Use

The following statements are required under the “Directions for Use” Section on all product labels:

- DO NOT contaminate irrigation or drinking water supplies or aquatic habitats by cleaning of equipment or disposal of wastes.

For all product labels with outdoor surface spray or fogging application uses (adult mosquito control and outdoor structural uses), include:

- Outdoor areas: Toxic to bees. Avoid application around blooming plants. Toxic to beneficial insects. Minimize exposure to non-target areas.

For Greenhouse uses, include:

- Toxic to bees and other beneficial insects. May harm bees and other beneficial insects, including those used in greenhouse production. Do not apply when bees or other beneficial insects are foraging in the treatment area.
- DO NOT allow effluent or runoff from greenhouses containing this product to enter lakes, streams, ponds or other waters.

For all products that are not registered to control larval mosquitoes, add the following:

- As this product is not registered for the control of pests in aquatic systems, DO NOT use to control aquatic pests.

d) Storage

The following statement is required under the STORAGE heading:

- To prevent contamination, store this product away from food and feed.

e) Disposal

The following relevant statements are required under the “Disposal” Section on all product labels, where necessary:

The following statements should be used for commercial and restricted class products other than agriculture and non-crop land, where non-recyclable, non-returnable or non-refillable containers are used:

- Triple- or pressure-rinse the empty container. Add the rinsings to the spray mixture in the tank.
- Follow provincial instruction for any required additional cleaning of the container prior to its disposal.
- Make the empty container unsuitable for further use.
- Dispose of the container in accordance with provincial requirements.
- For information on disposal of unused, unwanted product, contact the manufacturer or the provincial regulatory agency. Contact the manufacturer and the provincial regulatory agency in case of a spill, and for clean-up of spills.

For recyclable containers:

The following statement would apply to plastic or metal containers that contain agricultural and non-crop land uses (for example, forestry) pesticide products, and that are designed to contain 23 L or less of product.

- Disposal of Container:
  - DO NOT reuse this container for any purpose. This is a recyclable container, and is to be disposed of at a container collection site. Contact your local distributor/dealer or municipality for the location of the nearest collection site. Before taking the container to the collection site:
    - Triple- or pressure-rinse the empty container. Add the rinsings to the spray mixture in the tank.
    - Make the empty, rinsed container unsuitable for further use.
  - If there is no container collection site in your area, dispose of the container in accordance with provincial requirements.

For returnable containers:

- Disposal of Container:
  - DO NOT reuse this container for any purpose. For disposal, this empty container may be returned to the point of purchase (distributor/dealer).

For containers that can be refilled for the user by the distributor/dealer:

- Disposal of Container:
    - For disposal, this container may be returned to the point of purchase (distributor/dealer). It must be refilled by the distributor/dealer with the same product. Do not reuse this container for any other purpose.

Disposal of unused, unwanted product

- For information on disposal of unused, unwanted product, contact the manufacturer or the provincial regulatory agency. Contact the manufacturer and the provincial regulatory agency in case of a spill, and for clean-up of spills.

For all domestic products the label should state:

- DO NOT reuse the empty containers. Dispose in household garbage. Unused or partially used products should be disposed at provincially or municipally designated hazardous waste disposal sites.

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Chemistry

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