UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

September 30, 2016

MEMORANDUM

SUBJECT: Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and the Pyrethrins

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The U.S. Environmental Protection Agency has developed a pyrethroid registration review risk assessment strategy that would assess the pyrethroids as a class with regard to ecological risks, rather than conducting assessments by individual chemical. The high toxicity of pyrethroids to aquatic animals is well established. As such, risks to aquatic animals are expected to be a dominant

[1] ERB1 to ERB6 refers to Environmental Risk Branches 1 to 6 in EFED.

concern with currently registered uses of pyrethroids; therefore, this comparative risk assessment focuses on the risks to aquatic animals (although aquatic plants were also included). This assessment also focuses on the pyrethroids for which the Pyrethroid Working Group (PWG), a consortium of registrants representing a number of pyrethroids, has conducted multiple environmental fate and ecological effects studies, and for which ample monitoring data is available. These include the synthetic pyrethroids bifenthrin, cypermethrin (cypermethrin, *zeta*-cypermethrin, *alpha*-cypermethrin), cyfluthrin (cyfluthrin, *beta*-cyfluthrin), deltamethrin, esfenvalerate, fenpropathrin, cyhalothrin (*lambda*-cyhalothrin, *gamma*-cyhalothrin), and permethrin, with the addition of the pyrethrins.

This preliminary risk assessment (PRA) is organized in five parts, including the Tier I risk assessment for bees, *and* seven attachments as follows:

Parts of the PRA

Part I. Assessing Pyrethroid Releases to POTWs of Pyrethroids and Pyrethrins (DP Barcode D425791);
Part II. Assessing Outdoor Residential, Commercial, Turf, and Nursery Uses of Pyrethroids and Pyrethrins (DP Barcode D429461);
Part III. Assessing Agricultural Uses of Pyrethroids and Pyrethrins (DP Barcode D433338);
Part IV. Assessing the Mosquito Adulticide Uses of Pyrethroids and Pyrethrins (DP Barcode D433339);
Part V. Tier 1 Risk Assessment of Agricultural Uses of Pyrethroids and Pyrethrins for Bees (DP Barcode D435888).

Attachments of the PRA

Attachment I. Structures, CAS Numbers and Nomenclature of Synthetic Pyrethroids and Pyrethrins;
Attachment II. Ecological Effects Summary Tables of Most Sensitive Endpoints for Synthetic Pyrethroids and Pyrethrins;
Attachment III. Environmental Fate Assessments for Eight Synthetic Pyrethroids and Pyrethrins;
Attachment IV. Comprehensive Aquatic Toxicity Profiles for Pyrethroids and Pyrethrins;
Attachment V. Pyrethroid and Pyrethrin Usage Data to Support the Down the Drain Assessment (Memorandum by the Biological and Economic Analysis Division);
Attachment VI. Pyrethroid and Pyrethrins Aquatic Incident Database Review;
Attachment VII. Pyrethroid and Pyrethrins Pollinator Incident Database Review.

These seven attachments are associated with DP Barcode D425791; however, they may apply to any part of the PRA.

This assessment concludes that the down-the-drain, non-agricultural outdoor, agricultural, and adulticide use patterns of synthetic pyrethroids and pyrethrins may result in multiple exceedances of acute and chronic LOCs for freshwater and estuarine/marine fish, and for freshwater and

estuarine/marine invertebrates, resulting in a potential reduction in survival, growth and reproduction to non-target aquatic animals. In general, the RQs for aquatic plants were below the LOCs and are considered at less risk. For further details on the conclusions of each part of the PRA, refer to the Executive Summary of each part attached.

In addition to aquatic taxa, EFED also assessed Tier 1 risks of the pyrethroids and pyrethrins to honey bees resulting from selected agricultural uses. The Tier 1 risk assessment considers default (high end) exposures through direct contact and consumption of contaminated pollen and nectar. It is also based on effects to individual bees determined from laboratory studies. Results of the Tier 1 assessment indicate that the assessed uses of all pyrethroids and pyrethrins pose a potential risk to bees at the individual level. Additional data, such as measurement of residues in pollen and nectar and effects studies at the colony level, would be needed in order to refine the Tier 1 estimates of risk.

As an additional line of evidence, a review of the OPP Incident Data System (IDS) which now incorporates the Ecological Incident Information System (EIIS) database was conducted. The IDS and EIIS databases contained numerous aquatic and pollinator incidents for the pyrethroids and pyrethrins. The number of reports listed in the EIIS database is believed to be only a small fraction of the total incidents involving non-target organism mortality and damage caused by pesticides. These incidents appear to support the findings of the PRA.

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Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins

Part I. Assessing Pyrethroid Releases to POTWs

Chemical Names	PC Codes
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

Date: September 30, 2016 **DP Barcode:** D425791

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Part I. Assessing Pyrethroid Releases to POTWs

1 Executive Summary

1.1 Purpose

The preliminary risk assessment (PRA) examines the potential ecological risks associated with labeled uses of a pesticide, based on the best available scientific and commercial information on the use, environmental fate and transport, and effects of the chemical on non-target organisms. The U.S. Environmental Protection Agency (U.S. EPA, USEPA, EPA, or the Agency) has developed a pyrethroid registration review risk assessment strategy that will assess the pyrethroids as a class with regard to ecological risks, rather than conducting assessments by individual chemical. The toxicity of pyrethroids to aquatic animals is well established, and expected to drive the risk conclusions; therefore the single, streamlined assessment will focus on the risks to aquatic organisms. The assessment focuses on the pyrethroids for which the Pyrethroid Working Group (PWG), a consortium of registrants representing a number of pyrethroids, has conducted multiple studies and for which there is ample monitoring data. These include bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins, and permethrin, with the addition of the pyrethrins. With refinements, this approach is intended to cover all of the pyrethroids currently undergoing registration review. The assessment will be organized according to the use categories of indoor down-the-drain, outdoor residential, agricultural, and wide area mosquito adulticide uses. **Part I** of the comparative assessment deals with assessing pyrethroids and pyrethrins indoor down-the-drain releases to/from POTWs.[1]

1.2 Risk Conclusions

This comparative PRA examines the potential ecological risks associated with labeled uses of the insecticides bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins, permethrin, and the pyrethrins, based on the best available scientific and commercial information on the use, environmental fate and transport, and ecological effects of these chemicals on non-target aquatic animals. This section of the PRA deals solely on the potential exposure from indoor down-the-drain releases to, and subsequently from, wastewater treatment plants (WWTPs) and/or publicly owned treatment works (POTWs) to freshwater and estuarine/marine bodies of water.[2]

The pyrethrins and synthetic pyrethroids are highly hydrophobic compounds, showing low solubility in water. Their octanol/water partition coefficients (K_{OW}'s) for the pyrethroids are high. For example, the range of *Log* K_{OW} values across chemicals, from

[1] Portions of this PRA are based on, or are citations from Shamim, *et al.*, 2014.

[2] Fenpropathrin, *beta*-cyfluthrin, *alpha*-cypermethrin, and tefluthrin, four of the chemicals supported by the PWG, do not have any down-the-drain uses.

Laskowski (2002) is 4.53 – 7.00; however, in a recently submitted study the range is even higher (6.40 – 7.48; MRID 49314702). Based on these properties, there would be a potential to bioconcentrate in fish tissue; however, their fish bioconcentration factors (BCFs) for the majority of these compounds are lower than would be predicted based on K_{OW} alone. It appears that these compounds undergo metabolism in fish tissue and, with certain exceptions, undergo relatively rapid depuration. The pyrethroids and pyrethrins, show high organic carbon partition coefficients K_{OC}s in laboratory experiments, suggesting a high tendency to sorb with organic carbon in soil, water and sediments and dissolved organic carbon, or particulate matter in the water environment. A comprehensive review about the physicochemical and environmental fate properties of several pyrethroids was published in 2002 (Laskowski, 2002). Since then, during the Registration Review process, new environmental fate studies were requested and submitted to the Agency. Given that the results of the environmental fate studies are not used in modeling POTW releases of pesticides (other than the optional fish bioconcentration factor (BCF)), no further fate discussion will be provided in this first part of the comparative assessment.

In order to address the issue of releases to domestic wastewater, the Office of Pesticide Programs' (OPP) Environmental Fate and Effects Division (EFED) relied on the consumer exposure model, *Exposure and Fate Assessment Screening Tool* (E-FAST 2014) that was developed for assessing industrial chemicals in EPA's Office of Pollution Prevention and Toxics (USEPA 2015b). For further information about the model, refer to **Section 5.3**.

Synthetic pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} are <0.1 mg/L). Freshwater fish appear to be generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates appeared to be more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis (cyfluthrin is an example of an exception). Meanwhile, on a chronic basis, there is no clear trend in the comparison of freshwater and estuarine/marine invertebrates. Aquatic invertebrates (freshwater and estuarine/marine) are usually orders of magnitude more sensitive to pyrethroids and pyrethrins than fish (freshwater and estuarine/marine).

Risk determinations for the indoor down-the-drain uses of pyrethroid and pyrethrins are summarized in **Table 1**. The assessment concludes that the use of bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, cyhalothrins, and permethrin, plus the pyrethrins, in accordance with registered labels, results for acute and/or chronic risk Levels of Concern (LOCs) exceedances for freshwater and estuarine/marine invertebrates, from the indoor down-the-drain exposure to POTWs which in turn result in releases to bodies of water. Additionally, it results in acute risk LOC exceedances for freshwater fish for bifenthrin, *lambda*-cyhalothrin, cypermethrin and esfenvalerate, plus chronic risk LOC exceedances to freshwater fish for bifenthrin. There are no potential acute or chronic risk LOC exceedances for estuarine/marine fish from the down-the-drain uses for bifenthrin, cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, *lambda*-cyhalothrin, permethrin, and the pyrethrins. Since it has no residential indoor down-the-drain uses, for fenpropathrin there is no potential risk to freshwater or estuarine/marine aquatic animals. The reader is

directed to the risk characterization section for further details about risk estimation (*i.e.*, risk quotients) and risk description (**Sections 7.1** and **7.2**, respectively).

Table 1. Summary of Risk Determinations for Down-the-Drain Uses of Pyrethroids and Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates

Chemical	LOC Exceedances[1]							
	FW Fish		E/M Fish		FW Inverts		E/M Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	*X*	**X**			**X**	**X**	**X**	**X**
Cyfluthrin					*X*	**X**	**X**	**X**
Lambda-Cyhalothrin	*X*				**X**	**X**	*X*	**X**
Cypermethrin	*X*				**X**	**X**	**X**	**X**
Deltamethrin					**X**	**X**	**X**	**X**
Esfenvalerate	*X*				**X**	**X**	**X**	**X**
Fenpropathrin	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
Permethrin					**X**	**X**	**X**	**X**
Pyrethrins					*X*	**X**	*X*	

[1] A light shaded and italics "*X*" means it exceeds the listed species LOC. A dark shaded and bolded "**X**" represents LOC exceedances of the listed species and non-listed species LOCs.
[2] n/a = There are no applicable down-the-drain uses for fenpropathrin.

1.3 Data Gaps and Uncertainties

For details about the uncertainties in this assessment, refer to **Section 7.2.6** of the Risk Description. In short, the uncertainties lie in the following four major categories:

i. Uncertainties in the usage information, which provided high end usage based on adjustment factors. The usage information was provided by the Biological and Economic Analysis Division (BEAD). For esfenvalerate production volume was available from the registrant, and these estimates were also high end values.
ii. Uncertainties in the wastewater treatment plant removal efficiencies, which are based on EPI Suite modelling.
iii. Uncertainties related to the E-FAST 2014's Down-the-Drain (DtD) module, which assumes no degradation or partitioning on its way to the treatment plant or in the body of water. Comparison of modelled and maximum monitored concentrations from California POTWs shows similar concentrations, within an order of magnitude (with the exception of permethrin).
iv. Ecological effects data gaps and uncertainties.

2 Introduction

In the context of ecological risk assessment of conventional pesticides at USEPA, the issue of household wastewater releases of pesticides was first raised by public stakeholders from California during the Re-registration Eligibility Decision (RED) process of the pyrethroid insecticide permethrin (USEPA 2006). Concerns were raised that clothes pretreated with permethrin may cause adverse water quality impacts due to releases to POTWs when washed and result in subsequent discharges to receiving waters by POTWs. It is noteworthy that potential releases of antimicrobial pesticides to POTWs have routinely been considered in OPP environmental risk assessments due to their widespread use in consumer care products that result in substantive 'down the drain' (DtD) releases (*e.g.*, antibacterial ingredients in hand soaps). In contrast, this issue is relatively new for conventional pesticides where exposure from outdoor uses has traditionally been assumed to dominate environmental risk concerns. Monitoring data described later in this section indicates that for some pesticides, releases to (and from) POTWs may be significant to the extent that this exposure pathway requires consideration in USEPA environmental risk assessments. More recently as part of OPP's pesticide Registration Review process, the aforementioned concerns were echoed and additional concerns were identified regarding the potential for environmental exposure to pesticides resulting from their sorption onto biosolids and subsequent biosolid application to land (USEPA 2011a).

Part I of the combined ecological risk assessment summarizes the currently available information regarding pyrethroid and pyrethrins pesticide releases to POTWs in the U.S. and approaches being considered for evaluating these exposure pathways in OPP's "Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins." It also discusses sources and pesticide uses associated with releases to POTWs. Following this, a description of approaches and data that are being used to model the fate of these releases in POTWs is provided. Furthermore, a summary of available monitoring data which have been generated specifically to characterize potential pyrethroid exposure to and from POTWs is provided. Additionally, aquatic toxicological endpoints for the pyrethroids and pyrethrins assessed are discussed. In the risk estimation section of the risk characterization, the risk quotient method is used to characterize the risk of pyrethroids reaching POTW effluents. This is followed by the risk description, where data available about monitoring, and other lines-of-evidence are integrated.

It should be noted that this part of the combined Pyrethroid and Pyrethrins Ecological Risk Assessment is focused solely on so called "down-the-drain" (DtD) releases leading to POTW exposure, and only on risk to aquatic organisms, which have been found to be the most sensitive receptors in previous pyrethroid ecological risk assessments. Even though concerns related to DtD releases from POTW facilities have been issued by stakeholders mainly from the state of California, this assessment is national in scope.

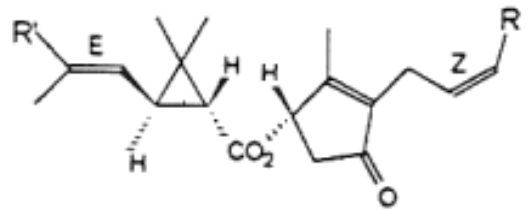
3 Problem Formulation

The Problem Formulation provides a strategic framework for the risk assessment. It sets the objectives for the risk assessment and provides a plan for analyzing the data and characterizing the risk (USEPA 1998). By identifying the important components of the risk assessment process, it focuses the assessment on the most relevant ecological receptors (species), chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA 2004).

3.1 Pesticide Class, Type and Mode of Action

"Pyrethrum is a preparation of dried *Chrysanthemum cinerariaefolium* and/or *Chrysanthemum cineum* flower heads that contains the six insecticidally active chemicals known as pyrethrins. Each of the six naturally-occurring pyrethrins is comprised of a cyclopropane-carboxylic acid group and a cyclopentenolone (alcohol) group joined by an ester linkage… The various synthetic pyrethroid analogues are generally similar in structure to the pyrethrins, although there are some deviations from the basic chrysanthemic acid ester structure…" (Source: Spurlock and Lee, 2008).

It should be noted that the pyrethrins are natural insecticides, while other pyrethroids are synthetic compounds that mimic the pyrethrins backbone structure that is shown in **Figure 1**. The natural pyrethrins consist of two groups of chemicals: cinerin 1, jasmolin 1 and pyrethrin 1 comprise the Pyrethrins I; further, cinerin 2, jasmolin 2 and pyrethrin 2 comprise the Pyrethrins II. Consistent with past assessments, the structure of pyrethrin 1, which is one of the pyrethrins, will be used in this assessment to represent all the pyrethrins.



R = $-CH_4$ (for cinerin), $-CH_3CH_4$ (for jasmolin) or $-CH=CH_2$ (for pyrethrin)
R'= $-CH_3$ (for pyrethrins I) $-CO_2CH_4$ (for the pyrethins II)

Figure 1. The general structure and stereochemistry of the pyrethrins

"The first commercial photostable synthetic pyrethroid based on this approach was permethrin, synthesized in the early 1970s. Permethrin is still the most widely used synthetic pyrethroid in California today. While various photostable synthetic pyrethroids have since been developed based on different structural modifications to the basic chrysanthemate ester moiety, the halogenated vinylcyclopropylcarboxylates are among the

most important in agriculture today, and include the various cypermethrins, cyfluthrins, and cyhalothrins…" (Source: Spurlock and Lee (2008))

Synthetic pyrethroids are classified as Type I and Type II, based on the *alpha*-carbon substitution. Type II pyrethroids are substituted with a cyano moiety (-C≡N) in the *alpha*-carbon (or alcohol carbon). Generally, Type II pyrethroids demonstrate increased activity, compared to Type I pyrethroids. Type I synthetic pyrethroids include for example bifenthrin and permethrin. Type II pyrethroids include cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin and *lambda*-cyhalothrin. Many of the pyrethroids have stereoisomers, based on the presence of asymmetric carbons, or of *cis*/*trans* isomers, that may be enriched to enhance their insecticidal activity (*e.g.*, *alpha*-cypermethrin, *zeta*-cypermethrin, *gamma*-cyhalothrin and *beta*-cyfluthrin).

Pyrethrins and synthetic pyrethroids are neurotoxic insecticides acting through direct contact and ingestion. The insecticidal effect of pyrethroids is characterized by a rapid "knock down," or paralysis, of insects. All pyrethroids act as axonic poisons, affecting both the peripheral and central nervous systems, and share similar modes of action. The primary biological effects of pyrethroids on insects and vertebrates reflect an inhibition of the correct firing of neurotransmitter delivery signals from one cell to another via nerve membrane inhibition of the voltage-gated Ca^{2+} (calcium ion) channels coupled with a stimulatory effect on the voltage-gated Na^{+} (sodium ion) channels.

It is well established that severe neurological symptoms of poisoning with pyrethroids in mammals and insects are the result of modification of the Na^{+} channels activity (cellular pores through which Na^{+} ions are permitted to enter the axon to cause excitation) (Matsumura, 1985). Advanced electrophysiological experiments using voltage clamp and patch clamp, together with ligand-binding and ionic flux experiments, have unveiled unique actions of pyrethroids of keeping the Na^{+} channel in the open state for an extremely long period, sometimes as long as several seconds. This modification of Na^{+} channel properties leads to hyperactivity of the nervous system. This action leads to spontaneous depolarizations, augmented neurotransmitter secretion rate and neuromuscular block, which ultimately results in paralysis of the insect.

Pyrethroids have also been shown to suppress GABA and glutamate receptor-channel complexes and voltage-activated Ca^{2+} channels, but the toxicological significance of these actions is uncertain. As indicated above, relative to physiological responses, researchers have designated two types of pyrethroids, Type I and Type II. Usually, Type II pyrethroids demonstrate increased activity, compared to Type I pyrethroids. Type I pyrethroids action is mainly associated with compounds that cause nerve excitation symptoms typified by the appearance of repetitive firing of axons in the peripheral nervous system and a negatively correlated temperature reversible knockdown property (Clark & Matsumura, 1987).

A brief discussion about relevant environmental fate properties of the pyrethroids is provided in the Risk Conclusions section (**Section 1.2**). Further detail about the fate of these pyrethroids and pyrethrins will be provided in a subsequent part of the comparative preliminary risk assessment. The table in the **Attachment I** provides the nomenclature

(common names, chemical names), CAS numbers, as well as structures of the pyrethroids and pyrethrins involved in this assessment. Please, refer to the **Attachment III** for detailed environmental fate assessments for eight individual synthetic pyrethroids which are supported by PWG plus pyrethrins.

3.2 Conclusions from Previous Down the Drain Assessments

EFED has conducted previous down the drain risk assessments for the natural pyrethrins and for the pyrethroids permethrin and deltamethrin. For permethrin and pyrethrins, the risks to estuarine/marine species was not previously assessed, since the model used for these assessments is based on freshwater receiving bodies of water of the POTW effluents (*e.g.*, rivers or ponds). Later, EFED started assessing estuarine/marine organisms, to get RQs assuming that the receiving bodies of water behave similar to freshwater bodies of water.

In 2008 EFED conducted an endangered species assessment for permethrin, for the California red legged frog and a number of other threatened or endangered species (USEPA 2008). The EECs were based on three levels of removal and three sets of RQs were calculated. There were exceedances of acute and/or chronic LOCs for freshwater fish and invertebrates. There were no LOC exceedances for non-vascular plants. Estuarine/marine species were not included in this assessment.

Additionally, in the Problem Formulation for Registration Review of Pyrethrins (December 1, 2011, DP Barcode D391619), a preliminary down-the-drain assessment was conducted, in order to assess the need for a POTW treatability study. Based on the available data and results, there were no exceedances of LOCs for freshwater fish and invertebrates. Estuarine/marine species were not included in the assessment. Based on these results, no POTW treatability study was required.

More recently in 2013, an endangered species assessment was conducted for a number of threatened and endangered species in California for deltamethrin uses in sewage systems (USEPA 2013). There were no exceedances of LOCs for both freshwater and estuarine/marine fish and for vascular and non-vascular plants. However, there were exceedances of LOCs for freshwater and estuarine/marine invertebrates.

3.3 Overview of Pesticide Uses that Lead to POTW Exposure

In response to the concerns raised by the public regarding the potential release of conventional pesticides to POTWs, OPP has reviewed indoor uses of conventional and antimicrobial pesticides and identified those that present a high potential for “down the drain” (referred to as DtD) releases. For a table or chart describing these uses, comparing EFED and AD uses is provided in the **Appendix B**. Generally, these include pesticidal treatments of fabric, clothing and carpets, pet shampoos, and drains with hydrologic connections to sewer systems. In the past, selected uses in greenhouses have been

evaluated in the context of pesticide releases to both POTWs (assuming connectivity with sewer systems) and surface waters through direct discharge to bodies of water. More recently, analysis of these uses shows that they are less likely to lead to exposure to POTWs in most instances. Therefore, they are not being considered as exposure pathways of potential concern in current and forthcoming environmental risk assessments by OPP.

For pyrethroids supported by the PWG, and pyrethrins, there are a number of sources that were identified by the Pesticide Re-evaluation Division (PRD) to have a potential to end up "down-the-drain" and consequently in wastewater treatment plant influent and subsequently effluent. These are detailed in **Table 4** (**Section 5**), and they include uses such as carpet treatments, certain pet uses, and treated clothing/impregnated fabrics among others. For additional information and details about use and usage of pyrethroids, refer to **Section 5**.

3.4 Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a plausible route of exposure. The conceptual model is intended to provide a written description and visual representation of predicted relationships between pyrethroids or pyrethrins, potential routes of exposure, and the effects related to the Agency assessment endpoints. The conceptual model consists of two major components: the risk hypotheses and a conceptual diagram (USEPA 1998).

3.4.1 Risk Hypothesis

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA 1998). For this assessment, the risk is stressor-initiated, where the stressor is the release of pyrethrins and pyrethroids into the environment. The following risk hypothesis is presumed for this assessment:

> *Pyrethroids and pyrethrins, when used indoors, in accordance with current labels, may result in off-site movement of the compound via wash-off into surface waters via drains and municipal wastewater treatment plants, leading to exposure of nontarget aquatic plants and animals. This potential exposure pathway may result in adverse effects upon the survival, growth, and/or reproduction of non-target aquatic animals, but not to non-target aquatic plants*.

This risk assessment will evaluate the aforementioned risk hypothesis and determine if it is supported by the risk conclusions.

3.4.2 Conceptual Diagram

The conceptual model for potential risks of pyrethroids and pyrethrins to aquatic organisms for various indoor uses of the chemical that could potentially end up in a domestic wastewater "drain" is depicted in **Figure 2**. The stressor is the chemical of concern (pyrethroids and pyrethrins). It is noted that the transport pathway is wastewater flow, the exposure media is the treatment facility that discharges into a surface water body, where it may undergo dilution. The exposure route, receptor and possible attribute changes for aquatic organisms are similar to the ones in the conceptual model for conventional agricultural applications. The receptors are aquatic plants and aquatic animals (vertebrates and invertebrates). However, based on their toxicity profile, it is believed that aquatic plants are at lower risk than aquatic animals.

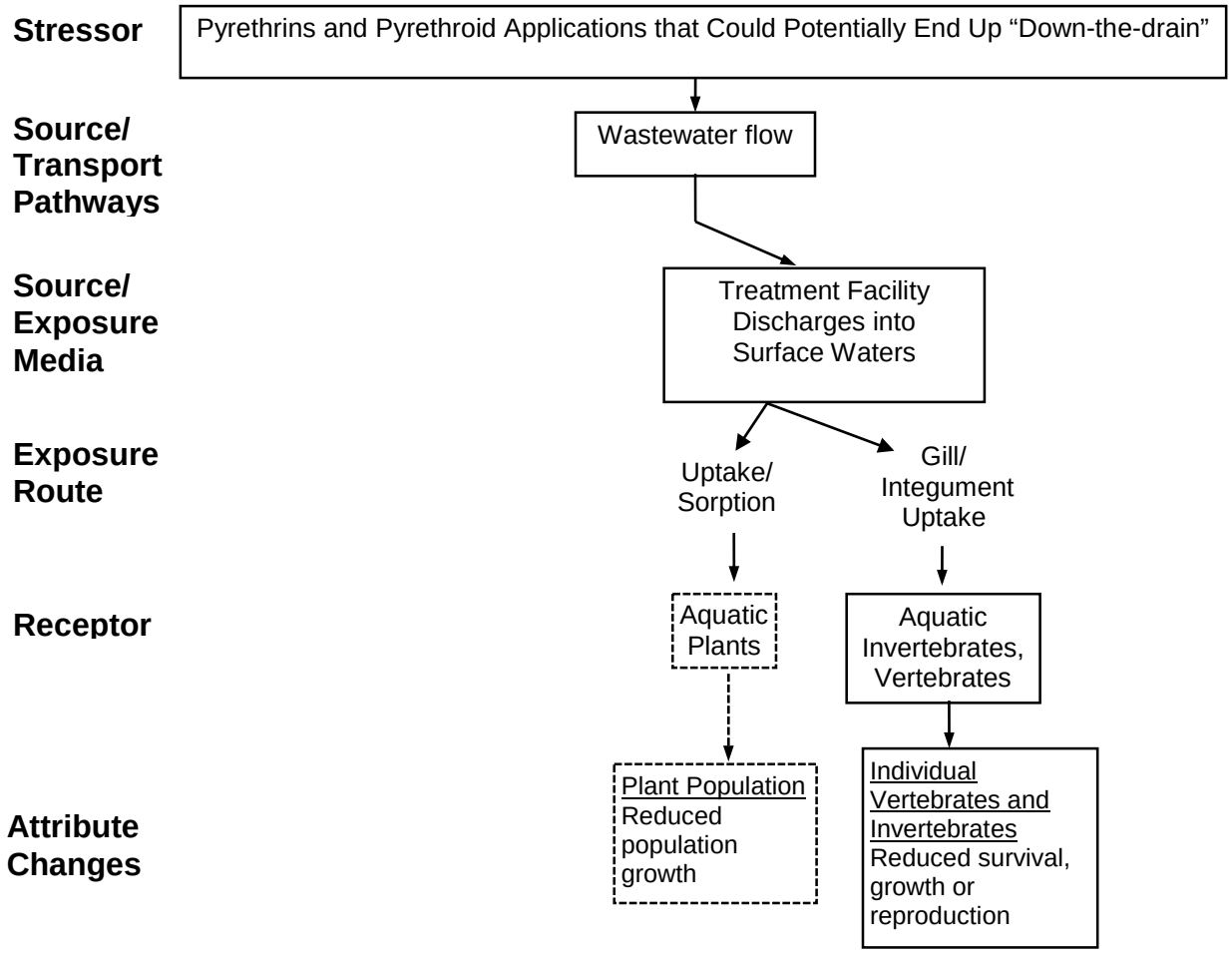


Figure 2. Conceptual diagram for potential risks of pyrethrins and pyrethroids to aquatic organisms for various indoor uses of the chemical that could potentially end up in the "drain".

4 Analysis Plan

The primary method used to assess risk in this assessment is the risk quotient (RQ) and follows closely methods outlined in the EPA Overview Document (USEPA, 2004). The RQ is the risk value for the assessment and is the result of comparing measures of exposure to measures of effect. A commonly used measure of exposure is the estimated environmental exposure concentration (EEC), and commonly used measures of effect include toxicity values such as the median lethal dose to 50% of the organisms tested (LD_{50}), median lethal concentration to 50% of tested organisms (LC_{50}), the no observed adverse effect level (NOAEL), and the no observed adverse effect concentration (NOAEC). The resulting ratio of the point estimate of exposure (EEC) and the point estimate of toxicity, *i.e.*, the RQ, is then compared to a specified level of concern (LOC), which represents a threshold for concern; if the RQ exceeds the LOC, risks concerns are triggered. Risk presumptions, along with the corresponding RQs, equations, and LOCs are summarized in **Section 7** and **Appendix B** of this assessment.

4.1 Measures of Exposure

In order to address the issue of releases to domestic wastewater, OPP has relied on the consumer exposure model, *Exposure and Fate Assessment Screening Tool* (E-FAST 2014) that was developed for assessing industrial chemicals in EPA's Office of Pollution Prevention and Toxics (USEPA 2015a).[3] The 'Down-the-Drain' module of E-FAST 2014 is specifically designed to address sources of a chemical that could potentially be disposed into domestic wastewater from a DtD application. For more information about calculations by the model, see **Section 5.3** (*Modeling Approach*). The E-FAST 2014 model estimates a pesticide concentration in surface water. A pesticide concentration in pore-water and sediment is not calculated and this assessment focuses on risk to organisms in the water-column. Besides modeling, available monitoring data on certain pyrethroids will also be used, for comparison purposes.

4.2 Measures of Effects

Measures of ecological effects are obtained from a suite of registrant-submitted guideline studies conducted with a limited number of surrogate species. The test species are not intended to be representative of the most sensitive species but rather were selected based on their ability to thrive under laboratory conditions. Measures of effect are based on deleterious changes in an organism as a result of chemical exposure. Functionally, measures of effect typically used in risk assessments include changes in survival, reproduction, or growth as determined from standard laboratory toxicity tests. The focus

[3] The current version of E-FAST is 2014, which has the same graphical user interface than version 2.0. The user's manual is the same for both versions and it is dated 2007. It is available at the following site accessed 08/05/2016: https://www.epa.gov/tsca-screening-tools/e-fast-exposure-and-fate-assessment-screening-tool-version-2014.

on these effects for quantitative risk assessment is due to their clear relationship to higher-order ecological systems such as populations, communities, and ecosystems. Monitoring data such as adverse effect incident reports may also be used to provide supporting lines of evidence for the risk characterization. Due to the nature of ecological incident reporting, absence of incidents cannot be construed with absence of incidents. In addition, effects other than survival, reproduction, and growth may be considered, rarely are they used quantitatively to estimate risks since, in many cases, the relationship between these effects and higher-order processes is uncertain.

Laboratory-derived toxicity values include estimates of acute mortality (*e.g.*, LC_{50}) and estimates of effects due to longer term, chronic exposures (*e.g.*, NOAEC, NOAEL). The latter can reflect changes seen in mortality, reproduction, or growth. In general, for a given assessment endpoint, the lowest (*i.e.*, most sensitive) relevant measure of effect is used in estimating the RQ. Examples of assessment endpoints and their respective measures of effect are listed in **Table 2** below.

Table 2. Summary of measures of exposure and effect for assessing the environmental risk of the proposed down-the-drain uses of pyrethroids and pyrethrins

Assessment Endpoint	Measure of Exposure	Measure of Effect
3. Survival and reproduction of individuals and communities of freshwater fish[1] and invertebrates.	Acute and chronic surface water EEC[2]	3a. Most sensitive freshwater vertebrate acute LC_{50} 3b. Most sensitive freshwater vertebrate chronic NOAEC and LOAEC 3c. Most sensitive freshwater invertebrate acute LC_{50} or EC_{50} 3d. Most sensitive invertebrate chronic NOAEC and LOAEC
4. Survival and reproduction of individuals and communities of estuarine/marine fish and invertebrates.	Acute and chronic surface water EEC[2]	4a. Most sensitive estuarine/marine vertebrate acute LC_{50} 4b. Most sensitive estuarine/marine vertebrate chronic NOAEC and LOAEC 4c. Most sensitive estuarine/marine invertebrate acute LC_{50} or EC_{50} 4d. Most sensitive estuarine/marine invertebrate chronic reproduction NOAEC and LOAEC
7. Maintenance and growth of individuals and populations of aquatic vascular and non-vascular plants	Acute surface water EEC[2]	7a. Vascular plant EC_{50} values based on yield and growth rate 7b. Nonvascular plant EC_{50} values based on cell density, growth rate, and biomass

LD_{50} = Lethal dose to 50% of the test population; NOAEC = no-observed adverse effect concentration; LOAEC = lowest-observed adverse effect concentration; LC_{50} = lethal concentration to 50% of the test population; $EC_{50/25}$ = effect concentration to 50/25% of the test population.

[1] According to EFED risk assessment guidance, freshwater fish may be used as surrogates to aquatic phase amphibians

[2] Based on stream flow SF_{1Q10} (acute) and SF_{7Q10} (chronic), 10th percentile, and stream dilution factor of 1.00 (refer to **Section 5.*C*** for further details about these stream flows and stream dilution factor).

5 Exposure Assessment

5.1 Pesticide Sources to POTWs

As outlined in **Section 3.3** (*Overview of Pesticide Uses that Lead to POTW Exposure*), OPP reviewed all indoor uses of conventional pesticides and identified those that present a high potential for "down the drain" releases. These are tabulated in the **Appendix B.** (*Identification of Pesticides of Concern Likely to End Up in POTWs*). These uses are therefore being considered as exposure pathways of potential concern in current and forthcoming environmental risk assessments by OPP.

A number of indoor pesticide uses are considered to have lower potential for substantive releases to POTWs based on labeled uses. These include labeled applications of indoor foggers, baits, crack and crevice treatment, and bed and mattress treatments where a hydrological connection to sewer systems is considered highly unlikely or at most, rare. Considerable attention has placed on the use of 'spot on' treatments for pets (*e.g.*, flea and tick control) as well as insecticide-impregnated collars. With spot on treatments, it is expected (and advised on some pesticide labels) that shampooing soon after application of spot on treatments would reduce the efficacy of such treatments, and those would not be cost effective and are discouraged. Regarding pet collars, the potential substantive releases to POTWs are considered low based on their expected slow release rate of pesticides from the collars.

It is important to note that the pesticide uses identified in **Appendix B** do not represent *all* potential sources of pesticide input to POTWs. Rather, they represent those uses that are currently being assessed as part of DtD modeling in OPP environmental risk assessments. For example, pesticides may potentially be released by industrial discharges to POTWs from pesticide manufacturers. However, such releases are subject to regulation under other environmental statutes and regulatory programs (*e.g.*, state and federal pretreatment programs under the authority of the Clean Water Act), and not under FIFRA. It is recognized that certain outdoor residential uses of pesticides may contribute to pesticide loadings to storm water systems which are connected to POTWs. Modeling of outdoor residential use of pesticides in OPP environmental assessments is presently focused on direct loadings to surface water. Information from the open literature suggests that some POTWs may experience greater flow during wet weather events even when direct connections to storm water inputs are not apparent (Weston and Lydy, 2010). Presumably, such inputs represent groundwater intrusion and/or fugitive inputs from storm water runoff. For these and other sources of pesticides to POTWs unaccounted for in **Appendix B**, OPP is relying on targeted monitoring data to ascertain inputs to and discharges from POTWs.

As a next step, all the indoor uses of the synthetic pyrethoids and pyrethrins were investigated, in order to distinguish which ones would lead to "down-the-drain" exposure (**Table 3**). This would allow for the identification of specific uses likely to lead to exposure through POTWs. This identification and evaluation was performed using OPPIN (an internal database of submitted data), as the first source of information, followed by

inspection and confirmation with product labels.

Table 3. Universe of Indoor Uses for the Pyrethroids Supported by PWG and Pyrethrins (Includes Both Down-the-Drain Uses and Less Likely to End Up in Drains[1])

Active Ingredient	***All Indoor Uses***
Bifenthrin	Crack and crevice, bed frames, box springs, walls, floors, spot treatments, fogger, aerosol, spray (surface and space), ***pet bedding***, ***carpets***, ***drains***, greenhouse, ***bedding***
Cyfluthrin	Crack and crevice, walls, floors, spot treatments, fogger, aerosol, spray (surface and space), ***drainage systems***, ***carpet edges***
Beta-cyfluthrin	Crack and crevice, walls, floors, spot treatments, spray (surface and space)
Lambda-cyhalothrin	***Pet bedding***, ***edges of carpets***, ***upholstery***, storm drains, ***sewers***, greenhouse, ***drains***
Gamma-cyhalothrin	Crack and crevice, bed frames, box springs, mattress, walls, floors, spot treatments, aerosol, spray (surface and space), ***pet bedding***, ***edges of carpets***, ***upholstery***, storm drains, ***sewers***, greenhouse, drains
Cypermethrin	Crack and crevice , walls, floors, fogger, aerosol, spray (surface and space), ***draperies***, ***drains***, ***upholstered furniture***, ***pet bedding***, ***rugs/ carpets***, swimming pool areas
Alpha-cypermethrin	None
Zeta-cypermethrin	Crack and crevice, bed frames, box springs, mattress, walls, floors, spot treatments, fogger, aerosol, spray (surface and space), ***drain pipes/drain/plumbing installations***, ***rugs/carpets***, greenhouse
Deltamethrin	Crack and crevice, bed frames, box springs, mattress, walls, floors, pet collar, aerosol, spray (surface and space), furniture, ***drains***, ***rugs/ carpets***
Esfenvalerate	Crack and crevice, walls, floors, bed frames, box springs, mattress, fogger, spray (surface and space), ***pet bedding***, ***drain system treatments***, ***carpet treatments***, furniture, ***drains***
Fenpropathrin	None
Permethrin	Crack and crevice, bed frames, box springs, walls, floors, spot treatments, pet collar, fogger, aerosol, spray (surface and space), ***dog spray or dip***, ***treated clothing/impregnated fabric***, ***rugs/carpets***, greenhouses, ***upholstery***, ***clothing***, ***bedding pet/human***, furniture, drapes, ***sewage and sewer or drain pipe***, swimming pool areas
Pyrethrins	Crack and crevice, bed frames, box springs, walls, floors, fogger, aerosol, spray (surface and space), ***pet and human bedding***, ***upholstery/sofas/chairs***, ***clothing***, ***surface application to rugs/carpet and drapes***, ***carpet edges (bedbugs)***, ***pet shampoos/dusts/sprays***, ***sewer lines***, swimming pool areas

[1] **Bolded** and *italics* uses are believed to have a higher potential to lead to down-the-drain exposure.

For pyrethroids supported by the Pyrethroid Working Group and pyrethrins, there are a number of sources that were specifically identified by the EFED and PRD to have a potential to end up "down-the-drain" and consequently in wastewater treatment plant influent and subsequently effluent. These are detailed in **Table 4**. Note that for *beta*-cyfluthrin, *alpha*-cypermethrin and fenpropathrin no DtD uses were identified.

Table 4. Down-the-Drain Uses for the Pyrethroids Supported by PWG and Pyrethrins

Active Ingredient	***Down-the-Drain Uses***
Bifenthrin	Pet bedding, carpets, drains, bedding

Active Ingredient	*Down-the-Drain Uses*
Cyfluthrin	Drainage systems, carpet edges
Beta-cyfluthrin	None
Lambda & *gamma* cyhalothrin	Pet bedding, edges of carpets, upholstery, sewers, drains
Cypermethrin	Draperies, drains, upholstered furniture, pet bedding, rugs/carpets
Alpha-cypermethrin	None
Zeta-cypermethrin	Drain pipes/drain/plumbing installations, rugs/carpets
Deltamethrin	Drains, rugs/carpet
Esfenvalerate	Pet bedding, drain system treatments, carpet treatments, drains
Fenpropathrin	None
Permethrin	Dog spray or dip, treated clothing/impregnated fabric, rugs/carpets, upholstery, clothing, bedding pet/human, drapes, sewage and sewer or drain pipe
Pyrethrins	Pet and human bedding, upholstery/sofas/chairs, clothing, surface application to rugs/carpet and drapes, carpet edges (bedbugs), pet shampoos/dusts/sprays, sewer lines

5.2 Production Volume/Usage Information for Pyrethroids and Pyrethrins

In lieu of a production volume, which is usually provided by the registrant(s), the Biological and Economic Analysis Division (BEAD) provided usage information for several synthetic pyrethroids (**Table 5**; USEPA 2015b). In short, BEAD concluded, based on private market research data to determine the estimated amounts of pyrethroids used indoor in the U.S. by Pest Control Operators (PCOs) and consumers, that overall approximately 225,000 pounds (102,000 kilograms) active ingredient of pyrethroids and pyrethrins (combined) are estimated to be used indoors annually in the U.S., in ways that have some likelihood of resulting in DtD exposure. BEAD considered this a very high-end estimate, "since it assumes that all indoor treatments targeting flies, bedbugs, and cockroaches are equally likely to result in DtD exposure every time an application is made." High-end values for individual active ingredients are listed in **Table 5**. Information is provided for six pyrethroids assessed in this document and pyrethrins, plus a number of other pyrethroids. For a characterization of the reported usage and adjustment factors, refer to USEPA 2015b (**Attachment V**).

Table 5. Down-the-Drain Pyrethroid/Pyrethrin Usage: Indoor Residential Use by Market Sector (Source of table: USEPA 2015b, Attachment V)

Active Ingredient (a.i.)	Amount (1,000 lb a.i.)		
	PCO	Consumer Household/ Houseplant/Pets	Total (high-end estimate only)
Bifenthrin	14-32	0.06-0.1	32
Cypermethrin	13-29	2-5	34
Permethrin	4-10	3-7	17
Deltamethrin	1-3	0.2-0.5	3.5
d-*Trans*-Allethrin	nr	0.06-0.1	0.1
Imiprothrin	nr	1-3	3
Lambda-Cyhalothrin	1-3	0.06-0.1	3
Cyfluthrin	1-2	nr	2

Active Ingredient (a.i.)	Amount (1,000 lb a.i.)		
	PCO	Consumer Household/ Houseplant/Pets	Total (high-end estimate only)
Prallethrin	nr	0.05-0.1	0.1
Pyrethrin	nr	89*	89
S-Bioallethrin	nr	1-2	2
Sumithrin	nr	0.01-0.03	0.03
Tetramethrin	nr	0.5-1	1
Tralomethrin	nr	0.02-0.05	0.05
Other *a.i.*s [(#)]	4-8	13-28	36
Total (high-end estimate only)	87	137	225

Source: Proprietary Data, 2011
PCO = pest control operator; nr = not reported
*Consumer use on pets
[(#)] Includes prallethrin, pyrethrin, esfenvalerate, and d-*trans* allethrin, among other unspecified pyrethroids.
Notes:

(i) The range of figures in each row represents use estimated based on sales by PCOs for bedbugs (approximately 6 %) or cockroaches (approximately 12 %). Therefore, the "high end estimates" are based on the sales for cockroach control. For additional discussion, please see the discussion of "adjustment factors" in USEPA 2015b.

(ii) Totals are rounded up to the nearest whole figure.

Individual information about esfenvalerate was not available from BEAD. In the absence of specific usage information for esfenvalerate, the registrant was consulted, and Production Volume was provided. Based on the available information, it is concluded that on average, production volume should not exceed ~6,000 kg A.I./year. Therefore, the generated EECs are considered upperbound estimates of concentrations of esfenvalerate in effluent-receiving bodies of water.

5.3 Modeling Approach

In order to address the issue of releases to domestic wastewater, OPP has relied on the consumer exposure model, *Exposure and Fate Assessment Screening Tool* (E-FAST 2014) that was developed for assessing industrial chemicals in EPA's Office of Pollution Prevention and Toxics (USEPA 2015b). The 'Down-the-Drain' module of E-FAST 2014 is specifically designed to address sources of a chemical that could potentially be disposed into domestic wastewater from a DtD application. The DtD module can be used to represent residential, domestic and certain commercial facilities (*e.g.*, supermarkets, storage facilities, and warehouses uses likely to end up in drains). This model provides first tier estimates of chemical residues in surface water that may result from household uses and the disposal of consumer products into wastewater.

Conceptually, the E-FAST 2014's DtD module assumes that in a given year the entire production volume of a chemical (*i.e.*, the amount of pesticide) is parceled out on a daily basis to the entire U.S. population and converted to a mass release per capita, and subsequently, a daily per capita release to a wastewater treatment facility (*i.e.*, g/person/day). This mass is then diluted into the average daily volume of wastewater released per person to arrive at an estimated concentration of the chemical in wastewater

prior to entering a treatment facility. The underlying equations used by the DtD module are shown below. According to the E-FAST manual, the daily per capita release is defined as follows.

$$H_R = \frac{PV}{Pop} \times \frac{1000\ g}{1\ kg} \times \frac{1\ year}{365\ days}$$

Where,

a) H_R is the daily per capita release of the chemical (g/person/day);
b) *PV* is the production volume of the chemical being evaluated that is produced annually in the USA that is discharged into domestic wastewaters (kg/year); and
c) *Pop* is the 2003 U.S. resident population (2.908×10^8 persons) (U.S. Bureau of the Census, 2004-2005).

The chemical's concentration in untreated wastewater is then reduced by the fraction removed during wastewater treatment processes. The remaining chemical is discharged into surface water (*e.g.*, a river or stream), where it is assumed that it is instantaneously diluted, with no further removal. The surface water concentration is calculated using the following generalized equation.

$$SWC = \frac{H_R \times \frac{1}{Q_H} \times \left(1 - \frac{WWT}{100}\right) \times \frac{10^6\ \mu g}{g}}{SDF}$$

Where,

a) *SWC* is the surface water concentration (µg/L);
b) Q_H is the household wastewater volume released daily (it is estimated to be 388 L per person per day), it includes only domestic and residential POTWs;
c) *WWT* is the wastewater treatment removal (percent removed prior to discharging into a body of water, %); and
d) *SDF* is the stream dilution factor.

The Stream Dilution Factor (*SDF*) is the volume of the receiving stream flow divided by the volume of the wastewater released from the POTW or effluent flow (*SDF = SF/EF*). This value is estimated by the Stream Dilution Factor Program (SDFP) for 36 industrial categories. The Stream Dilution Factor Program (SDFP) estimates surface water concentrations using the 50th and 10th percentile stream dilution factors for all active POTWs, for streams to which the wastewater facilities discharge. SDFP retrieves receiving stream flow data for facilities, calculates dilution factors for each facility, ranks the flow data and stream dilution factors, and reports the results in terms of percentiles. For E-FAST 2014's DtD module, SDFP calculates these values from 9,619 POTWs for which stream flow and effluent flow information is available in the Main Facility File. The Main Facility File contains facility and basic receiving stream information for a large number of direct discharging facilities. The Main Facility File is used by three of the E-FAST 2014 modules, including the DtD and the Probabilistic Dilution Model (PDM) modules.

There are four types of stream flows that the developers of the model have deemed adequate for the protection of aquatic life and human health (acute and chronic). These are 1Q10, 7Q10, 30Q5 and Harmonic Mean. The 30Q5 and Harmonic Mean flows are used for human life exposure and are not further discussed here. Additionally, flows have been characterized to represent mid-sized stream flows and smaller stream flows. For the protection of aquatic life, the developers of the model have deemed the following stream flows (SFs) suitable:

a) SF_{1Q10} is the stream flow that corresponds to the single day of lowest flow over a 10-year period (*i.e.*, lowest 1-day flow during any 10-year period). The 1Q10 stream flows provide acute surface water concentrations to compare with acute concentrations of ecological concern or acute endpoints for aquatic animals and plants; and

b) SF_{7Q10} is the stream flow corresponding to seven consecutive days of lowest flow over a 10-year period (*i.e.*, lowest consecutive 7-day average flow during any 10-year period). The 7Q10 stream flows give chronic surface water concentrations to compare with chronic concentrations of concern or chronic endpoints, for aquatic animals.

The manual describes results provided by the model related to small stream flows and mid-sized stream flows as shown below.

a) 10th Percentile Results — exposure results are calculated based on the high-end surface water concentrations (*i.e.*, upper 10th percentile). These results represent the bounding high-end exposures. These flows are used to represent small streams.

b) 50th Percentile Results — exposure results are calculated based on the median surface water concentrations (*i.e.*, 50th percentile). These results represent central tendency exposure. These flows are used to represent mid-sized stream flows.

It should be noted that the DtD module of E-FAST 2014 is a first tier model. It does not take into account processes such as degradation prior to treatment at the facility, or after the effluent is released to the body of water, or partitioning (*i.e.*, sorption by sediment or particulate matter). As indicated earlier, the model used for these assessments assumes that the freshwater bodies of water receive the POTW effluents (*e.g.*, rivers or ponds); however, EFED calculated risk quotients for estuarine/marine species, assuming that in saltwater bodies of water the EECs are similar to the ones calculated by E-FAST's DtD module.

5.4 Description of Model Inputs

5.4.1 Production Volume/Usage and POTW Removal

There are two main input values in the E-FAST's DtD module: the production volume (PV), and the percent removal from wastewater treatment (WWT). The PV can be obtained from the registrant(s) sources or an estimate can be supplied by the Biological and Economic Analysis Division (BEAD). The reported usage for the synthetic pyrethroids and pyrethrins was discussed in **Section 5.2** above.

Model results are also sensitive to the WWT, which in turn is dependent on the physicochemical properties of the active ingredient of concern and the extent of wastewater treatment (*e.g.*, primary, secondary, tertiary, or ultrafiltration). An estimate of WWT is available from the Sewage Treatment Plant Fugacity Model (STPWIN™) of EPISUITE v.4.11 (USEPA 2012). This model provides estimates of the fate of organic chemicals in conventional wastewater treatment plant that uses activated sludge secondary treatment, using the default half-lives of 10,000 hours (~417 d) in the primary tank, the aeration tank, and the settling tank. This may be considered a conservative half-life value. Note that alternatively EPISUITE provides the second option to enter half-lives derived from monitoring experiments, or the third option to use model-estimated half-lives for the above mentioned processes. According to the STPWIN™ Help manual, EPI Suite's STP program was conservative (*i.e.*, leading to higher concentrations) predicting removal percent (WWT) 88% of the time using its default half-lives of 10,000 hours for 29 of 33 chemicals evaluated, for primary clarifier, aeration vessel and settling tank; however, the evaluation was based on a set chemicals which are not pesticides. A potentially more suitable and reliable alternative, is data derived from a bench scale study that may be required either during the new chemical registration process of the chemical or during Registration Review, to further refine this input parameter. Finally, for a few chemicals, when available, WWT can be obtained from actual monitoring studies of influent and effluent from POTWs. As will be seen later, there is monitoring data for pyrethroids from 31 POTW facilities in California (Markle *et al.*, 2014).

Table 6 provides a summary of removals by various mechanisms for eight pyrethroid insecticides predicted by STPWIN™. As shown in the table, the module predicts that for all these chemicals, the main removal mechanism is sludge sorption. The total biodegradation is low while the release to air is minimal. For all the chemicals, the removal is above 90%.

Table 6. Removal Percent of Eight Pyrethroids in Wastewater Treatment Plants Obtained from EPISUITE v.4.11 and Its STPWIN Module[1]

Process	Bifent.	Fenprop.	Cyhalot.	Permet.	Cyflut.	Cypermet	Esfenval.	Deltamet.	Pyrets.[2]
Sludge sorption	93.2	91.4	93.1	92.7	91.2	93.0	92.1	92.1	90.9
Total Biodegradation	0.78	0.77	0.78	0.78	0.77	0.78	0.77	0.77	0.77
Total to Air	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Removal	94.0	92.2	93.8	93.4	91.9	93.8	92.9	92.8	91.7

[1] All results were rounded to two decimal places or three significant figures.

[2] Based on results for pyrethrin 1, which has been designated as the representative pyrethrin in the available

environmental fate studies.

5.4.2 Bench Scale Study

Based on experience with DtD modeling with pyrethroids, OPP requested additional data from registrants to improve modeling of the fate and removal efficiency of certain pyrethroids in POTWs. In response, PWG submitted a bench scale study simulating four processes that occur in POTWs: primary settling, aerobic biological treatment, anaerobic digestion, and ultra-filtration (Cleary and McGrath, 2012, MRID 48762906)[4]. Pyrethroids studied in these processes included: permethrin, deltamethrin, bifenthrin, cyfluthrin, *lambda*-cyhalothrin, cypermethrin, esfenvalerate, and fenpropathrin. Although in treatment plants, they occur simultaneously, these processes were evaluated separately from each other (*i.e.*, they were treated as modules). This treatability study is useful in understanding the relative contributions of the different processes that occur at a treatment facility. Removal processes included primary settling, which showed very limited removal (this was an unexpected result), and aerobic and anaerobic digestion, which show moderate levels of removal. Only ultrafiltration appeared to remove over 90% of the material in the bench scale study. Results from modelling (using EPISUITE v.4.11 giving total removal) and monitoring data (discussed below) indicate levels of removal of above 90%. However, direct comparison of the bench scale study results to modelling and monitoring data is confounded by the fact that the bench scale study design does not enable determination of an overall removal efficiency based on the sum total of the simulated treatment processes. Therefore, the utility of the bench scale study mostly relates to how separate processes affect pyrethroid removal and not for an estimate of the overall removal efficiency of pyrethroids from POTWs. The study was considered supplemental, providing limited information about the individual processes, and their relative contributions in a treatment plant.

5.5 Summary of Model Outputs

In this assessment, the removal percentages were obtained from the model EPISUITE v.4.11, as shown in **Table 6**. The usage information was supplied by BEAD (see **Table 5**, and USEPA 2015b). The usage data from **Table 5** was converted from pounds active ingredient/year to kilograms active ingredient/year. The input values are summarized in **Table 7**.

Model outputs from the E-FAST 2014 model are provided in **Table 7**. These include the acute and chronic EECs (µg/L). Both the peak and chronic EECs are the same, since they represent stream dilution factors of 1.0 at the 10th percentile (*i.e.*, no dilution or effluent dominated body of water, and small receiving bodies of water or small streams). It was noted that for bifenthrin, the output acute and chronic EECs exceeded the limit of

[4] A bench scale study is a study conducted in a small scale basis, to mimic the processes that occur in a POTW plant. In the pyrethroids bench scale study, four processes were simulated. A number of issues were observed in the study, and its results were not used for the modeling in E-FAST 2014.

solubility by around 50%, which is by itself extremely low (s = 0.014 µg/L). Given that the wastewater treatment removals (WWTs) were of a similar level for all the chemicals, then the EECs appear to be very dependent on the reported usage or PV. The highest predicted EECs were for pyrethrins, followed by cypermethrin, with respective reported usages of 196,000 and 75,000 kg a.i./year. For an example output file from E-FAST 2014 for permethrin, refer to **Appendix C**.

Table 7. Estimated Environmental Concentrations for Eight Pyrethroids and Pyrethrins

Chemical	Reported Usage (kg/year)	Wastewater Removal / (%)	Peak EEC = Chronic EEC[1] (µg/L)
Bifenthrin	14,500	94.0	0.014 – 0.0211 [2]
Cyfluthrin	910	91.9	0.00179
Lambda-Cyhalothrin	1,360	93.8	0.00205
Cypermethrin	15,400	93.8	0.0232
Deltamethrin	1,590	92.8	0.00278
Esfenvalerate	6,000	92.9	0.0103
Fenpropathrin	N/A	92.2	N/A
Permethrin	7,710	93.4	0.0124
Pyrethrins	40,400	91.7	0.0814

N/A = does not apply, no applicable down-the-drain uses for fenpropathrin.
NA = not available.
1 Stream flow SF_{1Q10} (acute) and SF_{7Q10} (chronic) stream dilution factor = 1.
2 Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration predicted by E-FAST 2014 was 0.0211 µg/L.

5.6 POTW Monitoring Data

The available information on the occurrence of pesticides in U.S. POTW influent, effluent and biosolids was reviewed and is summarized here with a focus on the following questions:

> Which pesticides are most commonly detected in POTWs and how does this relate to their intended uses?
>
> What is the removal efficiency of pesticides by wastewater treatment processes and how does this compare to estimates based on modeling?

Although a number of country-wide surveys of pesticides and other micropollutants in POTW wastewater have been conducted in Europe (*e.g.*, Loos *et al.*, 2013; Luo *et al.*, 2014), an analogous U.S. wide survey was not identified in this review. Instead, a number of state-wide and POTW-specific surveys were identified, some of which are mainly about pyrethroids and are summarized below.

5.6.1 Pyrethroids in POTW Influent and Effluent

5.6.2 California POTWs

In a comprehensive state-wide survey, Markle *et al.* (2014) sampled 31 POTWs in California for the presence of eight pyrethroids in influent, effluent, and biosolids. This effort was conducted by the PWG, in response to pyrethroid re-evaluation activities by both the California Department of Pesticide Regulation and the USEPA. The POTWs they surveyed represent approximately 40% of the treated municipal wastewater in California and include primary, secondary and tertiary treatment as terminal wastewater treatment processes. Samples were taken from January through March, 2013 during dry weather period. Consecutive grab samples were taken from influent, effluent and biosolids (when available) and did not account for hydrologic retention time between entry to the POTW and discharge. Extensive quality control measures were instituted including separate analytical measurement by two laboratories.

Results indicate high detection frequencies (*e.g.*, 43% to 100%) for 7 of the 8 pyrethroids sampled in POTW influent (**Table 8**). Frequencies of detection exceeded 80% for bifenthrin, cyfluthrin, *lambda*-cyhalothrin, cypermethrin and permethrin. Fenpropathrin was the least detected pyrethroid in influent at 4.5% (3 of 67 samples), and is the only pyrethroid sampled that is not registered for residential uses in California. This suggests residential uses of these products are contributing to their loadings to California POTWs. By far the highest maximum and median influent concentrations reported are for permethrin (3,800 and 230 ng/L, respectively), which may be related to its topical use to treat lice infestations (a pharmaceutical use that is regulated by the Food and Drug Administration (FDA)).

Table 8. Summary of pyrethroid measurements in influent from 31 California POTWs (Source: Markle *et al.*, 2014)

Chemical	# of Detects	% Detected	LOQ (ng/L)	Max. (ng/L)	Min. (ng/L)	Average[1] (ng/L)	Median[1] (ng/L)
Bifenthrin	64	96%	5	74	ND	15	9.7
Cyfluthrin	59	88%	5	55	ND	11	7.4
Lambda-Cyhalothrin	54	81%	5	72	ND	5.6	2.8
Cypermethrin	54	81%	5	200	ND	35	21
Deltamethrin	29	43%	10	210	ND	8	3.3
Esfenvalerate	31	46%	5	360	ND	8.1	1.7
Fenpropathrin	3	4.5%	5	130	ND	4.6	1.7
Permethrin	67	100%	50	3800	30	330	230

ND = Not detected. Units of ng/L = parts per trillion.
A total of 67 influent samples were collected (62 samples + 5 repeats).
[1] Median and average values were calculated assuming the limit of quantitation for non-detects.

In POTW effluent, the greatest detection frequencies are observed for bifenthrin (82%), followed by cypermethrin (81%), permethrin (65%), cyfluthrin (60%), *lambda*-cyhalothrin (48%) and esfenvalerate (32%; **Table 9**). Comparatively, the rates of detection for deltamethrin and fenpropathrin are much lower (16% and 3%, respectively) in effluent than

influent. Consistent with the influent sampling results, the greatest maximum and median concentrations in POTW effluent are observed for permethrin (170 and 9.4 ng/L, respectively). Cypermethrin showed the next highest effluent concentrations with maximum and median values of 13 and 1.3 ng/L, respectively. Maximum and median concentrations for the other six pyrethroid are 2 and 1 orders of magnitude below that for permethrin.

Table 9. Summary of pyrethroid measurements in effluent from 31 California POTWs (Source: Markle *et al.*, 2014)

Chemical	# of Detects	% Detected	LOQ (ng/L)	Max. (ng/L)	Min. (ng/L)	Average[1] (ng/L)	Median[1] (ng/L)
Bifenthrin	51	82%	0.5	3.9	ND	0.89	0.6
Cyfluthrin	37	60%	0.5	4	ND	0.6	0.3
Lambda-Cyhalothrin	30	48%	0.5	1.6	ND	0.3	0.2
Cypermethrin	50	81%	0.5	13	ND	2.11	1.3
Deltamethrin	10	16%	1.0	1.2	ND	0.31	0.3
Esfenvalerate	20	32%	0.5	0.6	ND	0.25	0.2
Fenpropathrin	2	3.2%	0.5	0.8	ND	0.22	0.2
Permethrin	40	65%	5.0	170	ND	20	9.4

ND = Not detected. Units of ng/L = parts per trillion.
A total of 67 effluent samples were collected.
[1] Median and average values were calculated assuming the limit of quantitation for non-detects.

It is also of interest to evaluate the removal of pyrethroids by POTW treatment, since this information can help inform modeling approaches for estimating pyrethroid loadings from POTWs. Influent and effluent data from Markle *et al*. (2014) were used to calculate percent removal of pyrethroids using the following equation:

$$\%\ \text{Removal} = \left(1 - \frac{\text{Effluent Concentration}}{\text{Influent Concentration}}\right) \times (100\%)$$

When the effluent concentration was reported below limits of quantitation (LOQ), the concentration was equated to the LOQ. When the influent was reported to be below the LOQ, no calculation was made. On average, pyrethroid concentrations measured in POTW effluent are approximately 10% those measured in influent, representing a reduction of approximately 90% (**Figure 3**). The higher mean % removal indicated for esfenvalerate (97%) and fenpropathrin (99%) are based on very few samples and are therefore considered highly uncertain.

In terms of POTW-specific factors affecting pyrethroid concentrations, there was typically a large reduction in pyrethroid concentrations in effluent from primary to secondary treatment, although only one plant sampled had primary treatment as its terminal treatment process. The relationship between secondary and tertiary treatment was less clear, whereby some POTWs containing secondary treatment had higher concentrations in effluent compared to those with tertiary treatment and vice versa.

It is noted that the study by Markle *et al*. (2014) was not specifically designed to

estimate % removal efficiency of pyrethroids because samples were taken concurrently from influent and effluent without regard to the retention time of treated water in the POTW. Therefore, differences between concentrations of pyrethroid in influent and effluent may reflect, not only partitioning and degradation processes associated with wastewater treatment, but also variation in pesticide loadings over time. Nonetheless, average % removal efficiencies based on the monitoring data (90-99%) are quite similar to those calculated using the STPWIN™ model summarized in **Table 6** (91-94%).

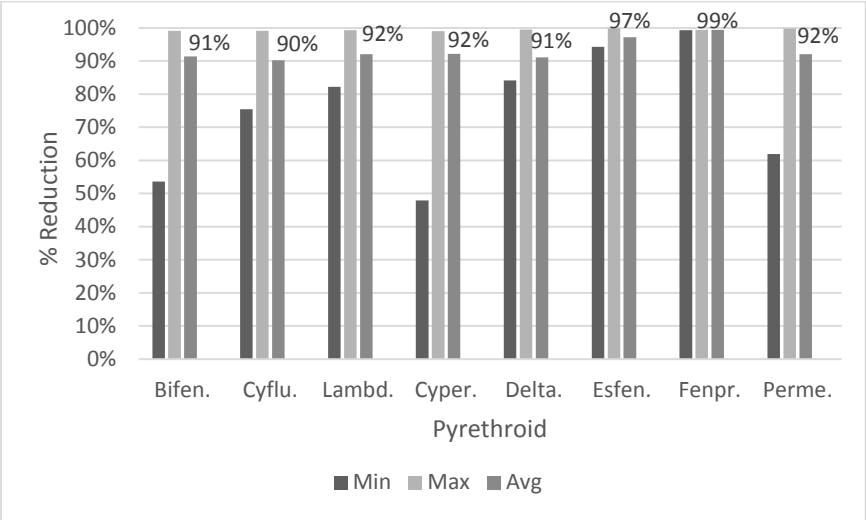


Figure 3. Percent reduction in pyrethroid concentrations in POTW effluent relative to influent (Source: Markle *et al.*, 2014)

5.6.3 Sacramento POTW

In contrast to the previous study which conducted limited sampling of POTW wastewater across many facilities, Weston *et al.* (2013) focused their efforts on a single facility, the Sacramento Regional County Sanitation District Treatment Plant. Concentrations of eight pyrethroids in influent and effluent were sampled over multiple time periods from November 2010 to January 2012. Twelve, 24-h composite samples were taken monthly from influent and seven 24-h, flow-weighted composite samples were taken from effluent (4 during rain events and 3 during dry events). Importantly, the timing of effluent samples was adjusted to account for the retention time of the wastewater in the plant. This facilitates more accurate estimation of % removal efficiency compared to the previous study by Markle *et al.* (2014). Weston *et al.* (2013) also sampled three POTW wastewater interceptors during the course of this study, one of which (City interceptor) received both municipal sewage and storm water runoff while the other two (Folsom and Laguna interceptors) received only municipal sewage.

Results from this study indicate that four pyrethroids were detected in all (100%) of the 12 monthly POTW influent samples (permethrin, bifenthrin cypermethrin, and *lambda*-cyhalothrin). Among these, permethrin was the dominant pyrethroid detected in terms of overall concentration and typically ranged between 200 and 400 ng/L (ppt). Cypermethrin

and bifenthrin were generally found between 20 and 40 ng/L in influent while cyhalothrins were found up to 30 ng/L. Cyfluthrin was detected once in influent during the study, while deltamethrin, fenpropathrin and esfenvalerate were not detected in any of the 12 influent samples. Attempts to correlate temporal peaks in influent concentrations with known use pattern or sales data were not successful. Analysis of pyrethroids in the wastewater interceptor upstream of the treatment plant suggest that storm water runoff was not the dominant source of pyrethroids to the plant. Concentrations of permethrin in the City interceptor (receiving stormwater) were slightly lower than those which did not receive stormwater. Furthermore, all the interceptors sampled contained substantially lower concentrations of permethrin than what was found in the POTW influent, suggesting that other sources of permethrin to the plant are likely. The other pyrethroids were found in similar concentrations in the three interceptors compared to POTW influent. The authors speculate that indoor uses of pyrethroids, container washing and possibly improper disposal of unwanted pesticide may be leading to the loadings to the Sacramento POTW.

In terms of effluent quality, permethrin was again the dominant pyrethroid detected in all but one of the seven effluent samples, ranging from 12-45 ng/L. Bifenthrin and cyhalothrins ranged from 1-5 ng/L in effluent and were detected 43% and 29% of the time, respectively. Concentrations of permethrin, bifenthrin and cyhalothrin were up to 2 times the respective 96-h EC_{50} values reported for the freshwater amphipod, *Hyalella azteca*. However, attempts to correlate observed toxicity to *H. azteca* in effluent samples with toxic units or TIE procedure were not definitive in terms of the cause of toxicity. Removal efficiencies of the pyrethroids from the POTW influent generally ranged from 90-95%, which is similar to the findings by Markle *et al.* (2014) in their California-wide POTW survey.

5.6.4 Weston and Lydy (2010)

In this study, Weston and Lydy sampled three California POTWs (Sacramento, Stockton, and Vacaville) for the presence of 8 pyrethroids and chlorpyrifos during three dry and three wet seasons in 2008 and 2009. The authors indicate that except for a small portion of the Sacramento POTW influent, all plants contained sanitary sewer systems that were separate from stormwater systems. They further note that the Stockton POTW included tertiary treatment via routing secondary treated wastewater through 240 ha of treatment ponds which yielded a retention time of about 30 days. Results above 1 ng/L are considered by the authors to be reliable. A total of 18 POTW samples were taken. Other samples of agricultural drains and urban runoff were also analyzed but are not relevant for this discussion here.

Weston and Lydy (2010) report that of all the samples, quantifiable concentrations of one or more pyrethroids were found in 67% of the samples taken. Across all three facilities, chlorpyrifos (40%), bifenthrin (39%) and permethrin (33%) were most commonly detected (**Table 10**). Generally, the highest concentrations of pyrethroids and chlorpyrifos are seen with the Sacramento POTW. In terms of toxicological relevance, 22% of the effluent samples containing bifenthrin, 17% containing *lambda*-cyhalothrin, and 6% of the samples

containing cypermethrin exceeded the respective EC_{50} or LC_{50} values for *H. azteca*. The authors note that the presence of pyrethroids is surprising especially given the low levels of suspended solids in the effluent (< 8 mg/L). They suggest that sewer disposal of household pesticides, use of pet and lice control shampoos and laundering of permethrin-treated clothing may be potential sources of pyrethroids to the POTWs. Despite 25-50% greater flows in wet weather, Weston and Lydy (2010) report similar concentrations in effluent during dry and wet weather flows, which indicates that pesticide loadings from urban/residential runoff may be contributing to loadings to POTWs.

Table 10. Pyrethroids and chlorpyrifos in effluent from three California POTWs (Source: Weston and Lydy, 2010)

POTW[1]	Bifen.	Cyfl.	Cyp.	Delt.	Esfen.	Fenp.	*L.* Cyh.	Perm.	Chlor.
Maximum Concentration Detected (ng/L)									
Sacr.	2.7	1.7	17.0	0	3.7	0	5.5	17.2	24.1
Stock.	4.8	0	0	1.3	0	0	0	7.9	5.5
Vaca.	6.3	0	0	2.7	0	0	2.8	7.6	0
Overall Detection Frequency (n=18) [2]									
	39%	6%	6%	11%	6%	0%	17%	33%	40%
Frequency exceeding EC_{50} or LC_{50} [3]									
	22%	0	6%	NA	NA	NA	17%	0	0

[1] Sacr. = Sacramento; Stock. = Stockton; Vaca. = Vacaville.
[2] Detection frequency = # samples > 1 ng/L / total samples from all 3 plants (n=18).
[3] Frequency of exceeding EC_{50} or LC_{50} for *H. azteca* (Bif =3.3 ng/L; Cyf = 1.9 ng/L; Cyp = 1.7 ng/L; L. Cyh = 2.3 ng/L; Per = 21.1 ng/L and Chlor = 96 ng/L).

5.6.5 Suffern, NY POTW

In a study submitted to the Agency (MRID 48072901), the software TOXCHEM+ was used to estimate the fate of eight pyrethroids in the Village of Suffern Sewage Treatment Plant (Suffern, NY). The software is used to predict the behavior of a chemical in a treatment plant. Since the software's approach is not relevant to this assessment, it will not be described here. Nonetheless, in the study, sampling of the POTW was conducted and results are reported below. **Table 11** summarizes the measured and predicted concentrations in filtered and total effluent waters, and sludge cake. Since the measured filtered effluent waters were reported as <10 ng/L, all the predicted values were within this range. The measured and predicted total effluent water concentrations were within the same order of magnitude of each other.

Table 11. Measured and Predicted Concentrations in Effluent (Filtered & Total) and Sludge

Chemical\Conc. (ng/L)	Measured Filtered Effluent	Predicted Filtered Effluent	Measured Total Effluent	Predicted Total Effluent	Measured Sludge Cake	Predicted Sludge Cake
Bifenthrin	<10	0.371	<10	0.628	103100	40580
Cyfluthrin	<10	1.50	1.88	2.09	55830	43320
Cypermethrin	<10	2.76	9.5	5.08	249100	286600
Deltamethrin[1]						

Chemical\Conc. (ng/L)	Measured Filtered Effluent	Predicted Filtered Effluent	Measured Total Effluent	Predicted Total Effluent	Measured Sludge Cake	Predicted Sludge Cake
Esfenvalerate	<10	3.0	<10	10.5	6560	5940
Fenpropathrin	<10	0.137	<10	0.193	4310	6280
Lambda-cyhalothrin	<10	0.23	0.54	0.58	10030	7010
Permethrin	<10	4.7	<10	6.9	567000	555000

[1] For deltamethrin the concentrations were too low.

5.6.6 Sacramento, CA POTW

In another similar study (MRID 48857505), the software TOXCHEM+ was also used to estimate the fate of eight pyrethroids in the Sacramento Regional County Sanitation District (SRCSD) (Elk Grove, California) treatment plant. In SRCSD plant, 23 locations were sampled, including 18 wastewater and five biosolids samples in three sampling events in three different days. Analyses for eight pyrethroids was conducted. **Table 12** summarizes the ranges in measured and predicted concentrations in influent, dechlorinated final effluent, primary sludge, and secondary sludge. These results are taken to be representative of overall results (of measured *vs.* predicted concentrations), since several other measured and predicted concentrations were reported in this study. Cypermethrin and permethrin had the highest measured influent concentrations, and the highest measured and predicted effluent and sludge concentrations.

Table 12. Ranges in Measured and Predicted Concentrations in Final Effluent, Primary Sludge and Secondary Sludge

Chemical	Measured Plant Influent	Measured Dechlorinated Final Effluent	Predicted Dechlorinated Final Effluent	Measured Primary Sludge	Predicted Primary Sludge	Measured Mixed Sludge	Predicted Mixed Sludge
	ng/L	ng/L	ng/L	ng/mL	ng/mL	ng/mL	ng/mL
Bifenthrin	18.8-19.7	1.49-1.81	1.09-2.26	<2.5-2.77	3.59-5.78	<2.5-2.61	1.39-2.43
Cyfluthrin	6.95-9.55	0.556-0.608	0.32-0.69	<2.5	1.63-2.52	<2.5	0.51-0.81
Cypermethrin	46.1-48.6	3.81-4.68	1.72-2.72	4.51-6.41	7.95-13.0	4.60-5.92	2.53-4.05
Deltamethrin[1]							
Esfenvalerate[1]							
Fenpropathrin[1]							
Lambda-cyhalothrin	10.6-16.5	1.05-1.47	0.77-1.77	<2.5	2.10-4.37	<2.5	0.77-1.66
Permethrin	352-368	24.7-26.2	10.2-20.1	36.5-50.0	65.4-103	31.8-34.9	21.3-32.0

[1] An insufficient number of detections of deltamethrin, esfenvalerate and fenpropathrin did not allow for calibration of the model.

5.6.7 Comparison of the Suffern, NY and Sacramento, CA POTW Facilities

Discrepancies were observed in the predicted distribution of pyrethroids in various compartments between the NY study and the study involving a plant in CA. For example, for bifenthrin the model predicts 24% is emitted through volatilization in NY, compared to

1.8% in CA. For the same chemical, the model predicts that 1.6% is in the effluent in NY, compared to 10% in the CA study. It is acknowledged, however, that there are differences in treatment plant design. In addition, more usage may be registered in one region of the U.S. than in others. Compared to the CA study, the NY study was more limited in scope with fewer samples monitored and analyzed.

5.7 Comparison of Monitoring and Modeling Results

It is instructive to compare the results of POTW monitoring to that predicted by down-the-drain modeling (DtD) using E-FAST described earlier, as a way of evaluating model predictions. A comparison of EECs predicted by E-FAST's Down-the-Drain module is presented in **Table 13** along with the monitored concentrations in effluent summarized in **Table 9**. With bifenthrin, the predicted concentrations in POTW effluent is 14 ng/L (*i.e.*, the limit of solubility) to 21.1 ng/L (*i.e.*, the actual model-predicted concentration), which is more than an order of magnitude above the median (0.6 ng/L) concentration measured in California POTWs by Markle *et al.* (2014). However, it is about an order of magnitude above the maximum concentration detected in California POTW effluent (3.9 ng/L). Similarly, for *lambda*-cyhalothrin, cypermethrin, and deltamethrin, the predicted concentration was above the maximum concentration detected in California POTWs. For cyfluthrin, both the predicted and the maximum concentration were of the same order of magnitude, although the predicted concentration was slightly below the maximum concentration detected in California POTWs. For permethrin, the predicted concentration was around an order of magnitude below the maximum concentration detected in California POTWs, which may be due to the additional permethrin uses for lice control, which are considered drug uses, and are not considered in this assessment. These products are regulated by FDA, but if the active ingredient in these products is also a pesticidal active ingredient, the risk assessor should consider the pesticidal uses in the ecological risk assessment. Another possible reason may be that permethrin usage in California may be higher than elsewhere in the United States. Nonetheless, for both cyfluthrin and permethrin, the predicted concentration is above the median measured concentration.

Table 13. Estimated Environmental Exposure Concentrations of Pyrethroids and Pyrethrins, from POTW Discharges, Compared to Monitored Concentrations (Markle *et al.*, 2014)

Chemical	Reported Usage (kg)	WWT (% Removal)	Median Measured Conc. (ng/L)[1]	Maximum Measured Conc. (ng/L)	Predicted Conc. (ng/L)	<1 Order of Magnitude Difference?
Bifenthrin	14,500	94.0	0.6	3.9	14 – 21.1[2]	Yes
Cyfluthrin	910	91.9	0.3	4	1.79	Yes
Lambda-Cyhalothrin	1,360	93.8	0.2	1.6	2.05	Yes
Cypermethrin	15,400	93.8	1.3	13	23.2	Yes
Deltamethrin	1,590	92.8	0.3	1.2	2.78	Yes
Esfenvalerate	6,000	92.9	0.2	0.6	10.3	Yes
Fenpropathrin	N/A	92.2	0.2	0.8	N/A	N/A
Permethrin	7,710	93.4	9.4	170	12.4	No[3]
Pyrethrins	40,400	91.7	NA	NA	81.4	NA

WWT = Percent removal from wastewater treatment; N/A = not applicable (fenpropathrin does not have

applicable indoor down-the-drain uses).
[1] Median values were calculated assuming the limit of quantitation for non-detects.
[2] The actual output concentration in E-FAST 2014 was 21.1 ng/L. This value exceeded the limit of solubility for bifenthrin (14 ng/L).
[3] Uses for lice control, which are considered pharmaceutical uses, and possible higher usage of this chemical in California than elsewhere in the nation, may be the reasons why the maximum monitored concentration is above the predicted EEC for permethrin.

5.8 Pesticides in POTW Biosolids

Section 405(d) of the Clean Water Act (CWA) requires the USEPA to identify and regulate toxic pollutants that may be present in biosolids (sewage sludge) at levels of concern for public health and the environment. Historically, the focus of identification and regulatory efforts has been on industrial chemicals, pharmaceuticals, metals, and selected antimicrobial chemicals (USEPA 2009). However, recent studies have raised attention on the occurrence of conventional pesticides in biosolids, which often are treated and applied to land. Potential consequences of land-applied biosolids that contain appreciable amounts of pesticides include alteration of soil and terrestrial biota, runoff to surface waters and contamination of ground water.

In addition to quantifying pyrethroid concentrations in POTW influent and effluent, the previously summarized study conducted by Markle *et al.* (2014) also measured pyrethroids in biosolids from 24 of the POTWs included in the survey (**Table 14**). In terms of overall detection frequency, results mirror those described previously for influent and effluent, with the highest detection frequencies reported for bifenthrin (96%), permethrin (92%), cypermethrin (90%), and cyfluthrin (87%). The maximum concentration of permethrin (11,000 ng/g d.w.) [or 11,000 µg/kg d.w.] is 10X that of the pyrethroids with the next highest maximum concentrations (bifenthrin, cypermethrin). Median concentrations are greatest for permethrin (1,200 ng/g d.w.), bifenthrin (120 ng/g d.w.) and cypermethrin (79 ng/g d.w.). Permethrin was also reported in sewage sludge from the U.K. (Rogers *et al.*, 1989) and Switzerland (Plagellat *et al.*, 2004).

Table 14. Summary of pyrethroid measurements in biosolids from 24 California POTWs (Source: Markle *et al.*, 2014)

Chemical	# of Detects	% Detected	LOQ (ng/g)	Max. (ng/g)	Min. (ng/g)	Average[1] (ng/g)	Median[1] (ng/g)
Bifenthrin	50	96%	2.5	1100	ND	150	120
Cyfluthrin	45	87%	2.5	190	ND	34	29
Lambda-Cyhalothrin	27	52%	2.5	200	ND	29	28
Cypermethrin	47	90%	2.5	1000	ND	110	79
Deltamethrin	16	31%	5.0	78	ND	28	24
Esfenvalerate	16	31%	2.5	42	ND	15	14
Fenpropathrin	3	5.8%	2.5	71	ND	12	6.8
Permethrin	48	92%	25	11000	30	1500	1200

ND = Not detected. A total of 52 biosolid samples were collected.
[1] Median and average values were calculated assuming the limit of quantitation for non-detects.

As a consequence of these and other reports of conventional pesticides in POTW biosolids, OPP has undertaken efforts along with counterparts in the Office of Water to develop approaches to screen uses of conventional pesticides for their potential to end up and persist in biosolids. The initial efforts focused on identifying pesticide uses with the greatest potential for releases down the drain (**Table B1** in the **Appendix B**). Subsequently, efforts have focused on developing models for evaluating the potential risks associated with pesticides in land-applied biosolids. One approach being evaluated is adapting the current Office of Water Biosolids Core Risk Assessment Model (BCRAM) for a first tier assessment. Other approaches being investigated include adapting existing OPP models (*e.g.*, PRZM) and exposure scenarios for evaluation of land applied biosolids.

6 Aquatic Receptors and Ecological Effects Characterization

In first tier ecological risk assessments, effects characterization describes the types of effects a pesticide can produce in an aquatic (or terrestrial) organism. This characterization is based chiefly on registrant-submitted studies that describe acute and chronic effects toxicity information for various aquatic and terrestrial animals and plants. Data from the open literature are also considered; in this case, when updated ECOTOX queries were available, papers were screened to see if data from any of those studies were more sensitive than available data from submitted studies and, if so, reviewed according to approved procedures (USEPA, 2011b). Toxicity testing reported in this section does not represent all species of aquatic organisms. Only a few surrogate species for freshwater fish are used to represent all freshwater fish (2000+) species in the United States, although the most sensitive useable endpoints available are used in risk calculation. Estuarine/marine testing is usually limited to a crustacean, a mollusk, and a fish. Also, amphibians are not usually tested. The risk assessment assumes that freshwater fish serve as a surrogate for aquatic-phase amphibians.

Acute and chronic laboratory studies with pyrethroids and pyrethrins on aquatic organisms provide information regarding survival, growth, and reproduction. Data on the technical grade active ingredient (TGAI) and the effects on freshwater and estuarine/marine fish and invertebrates, aquatic vascular and nonvascular plants (algae), and freshwater and estuarine/marine sediment dwelling organisms are used to evaluate the potential risk from aquatic exposure resulting from indoor uses.

A comparison of freshwater and estuarine/marine fish most sensitive endpoints is provided in **Table 15**. A comparison of freshwater and estuarine/marine invertebrates' most sensitive endpoints is provided in **Table 17**. Vascular and non-vascular plant toxicity data is summarized in **Table 18**. In comparing the endpoints, it should be taken into account that a number of species are tested for each chemical, and only the most sensitive endpoints are included in these tables; in other words, species may vary across chemicals. Further information about the below included endpoints, selected species, study identification, and effects observed, is presented in the **Attachment II**.

For freshwater fish, the most sensitive acute toxicity endpoint is for cyhalothrin (0.029 µg/L) and the least sensitive endpoint for pyrethrins (5.1 µg/L). On a chronic basis, the most sensitive NOAEC is for bifenthrin [0.004 µg/L, however this is an estimated value that is based on the most sensitive pyrethroid (*i.e.*, tefluthrin, which is not included in this assessment)], and the least sensitive endpoint is for pyrethrins (1.9 µg/L).

It appears that, *in general*, the estuarine/marine fish are less sensitive than freshwater fish to pyrethroids. On an acute basis, for estuarine/marine fish the lowest endpoint is for cypermethrin (0.58 µg/L) and the highest is for esfenvalerate (>19.3 µg/L). For bifenthrin, the acute endpoint is 1270 times higher than the limit of solubility for the chemical (17.8 µg/L compared to a solubility of 0.014 µg/L). (As will be shown later, the acute RQ values would always be below the LOC for estuarine/marine fish, based on its limit of solubility.) On a chronic basis, the most sensitive NOAEC belongs to deltamethrin (0.024 µg/L), followed very closely by cyfluthrin (0.025 µg/L). The least sensitive NOAEC is for fenpropathrin (0.81 µg/L).

Table 15. Comparison of Freshwater and Estuarine/Marine Fish Most Sensitive Endpoints for Pyrethroids and Pyrethrins

	Freshwater Fish / (µg/L)		Estuarine/Marine Fish / (µg/L)	
Chemical	**96-hr LC_{50}**	**NOAEC/LOAEC**	**96-hr LC_{50}**	**NOAEC/LOAEC**
Bifenthrin	0.15	0.004 (estimate[1])	17.8	0.1/0.14
Cyfluthrin	0.068	0.0042/0.008	4.05	0.025/0.084
Lambda-cyhalothrin	0.029	0.031/0.062	0.807	0.25/0.38
Cypermethrin	0.39	0.051/0.077	0.95	0.125 (ACR[2])
Deltamethrin	0.15	0.017/0.035	0.58	0.024/0.049
Esfenvalerate	0.142	0.017/0.036	>19.3	0.63/1.3
Fenpropathrin	2.2	0.06/0.091	3.1	0.81/2.0
Permethrin	0.79	0.052 (ACR[2])	2.2	0.143 (ACR[2])
Pyrethrins	5.1	1.9/3.0	16	0.7/1.7

For additional details and MRID citations, refer to **Attachment II**.
[1] Estimated based on the most sensitive pyrethroid (tefluthrin).
[2] Estimated value, based on acute-to-chronic ratio (ACR).

For freshwater and estuarine/marine fish, the acute endpoints exceed the limit of solubility of some of the pyrethroids. This is the case for bifenthrin (both freshwater and estuarine/marine fish acute endpoints), cyfluthrin (estuarine/marine fish), deltamethrin (estuarine/marine fish), and esfenvalerate (estuarine/ marine fish). Endpoints measured at above the limit of solubility appear to indicate lower toxicity; however, these measurements are uncertain. The pyrethroids are highly hydrophobic, and should not be bioavailable above the limit of solubility. **Table 16** shows the limit of solubility of the eight pyrethroids in this comparative assessment, plus pyrethrins.

Table 16. Solubility Values for Synthetic Pyrethroids and Pyrethrins

Chemical	Water Solubility (µg/L)
Bifenthrin	0.0140
Cyfluthrin	2.32
Lambda-cyhalothrin	5.00
Cypermethrin	3.97
Deltamethrin	0.200

Chemical	Water Solubility (µg/L)
Esfenvalerate	6.00
Fenpropathrin	10.3
Permethrin	5.50
Pyrethrins	200 – 9,000[1]

[1] Range given for pyrethrin 1 – pyrethrin 2.

Freshwater and estuarine/marine invertebrates are more sensitive to pyrethroids and pyrethrins than freshwater and estuarine/marine fish. For example, for freshwater invertebrates, the least sensitive acute endpoint belongs to the pyrethrins (0.76 µg/L), while the most sensitive endpoint is for *lambda*-cyhalothrin (0.00008 µg/L). Note that the range of endpoints is very wide (*i.e.*, four orders of magnitude). On a chronic basis, the least sensitive endpoint is for pyrethrins (0.04 µg/L), and the most sensitive NOAEC belongs to deltamethrin (0.000026 µg/L).

For estuarine/marine invertebrates, the most sensitive acute endpoint is for cyfluthrin (0.0022 µg/L), and the least sensitive acute endpoint is for the pyrethrins (1.4 µg/L). Meanwhile, on a chronic basis, the most sensitive NOAEC also belongs to cyfluthrin (0.00007 µg/L), and the least sensitive belongs to the pyrethrins (0.25 µg/L).

In general, the chemical showing the least toxicity to fish and invertebrates are the pyrethrins, with the exception of estuarine/marine fish, for which the acute endpoints for bifenthrin and esfenvalerate are less sensitive than for pyrethrins, and the chronic NOAEC for fenpropathrin is less sensitive than for pyrethrins.

Table 17. Comparison of Freshwater and Estuarine/Marine Invertebrates Most Sensitive Endpoints for Pyrethroids and Pyrethrins

	Freshwater Inverts / (µg/L)		Estuarine/Marine Inverts / (µg/L)	
Chemical	**96-hr EC_{50}**	**NOAEC/LOAEC**	**96-hr EC_{50}**	**NOAEC/LOAEC**
Bifenthrin	0.000493	0.000050/0.00009	0.00397	<0.0006/0.0006[2]
Cyfluthrin	0.025	0.00012/0.00025	0.0022	0.00007/0.00017
Lambda-cyhalothrin	0.00008	0.00022/0.00031	0.00491	0.0002/0.0008
Cypermethrin	0.00056	<0.00005/0.00005[2]	0.0054	0.000781/0.00197
Deltamethrin	0.0002	0.000026/0.000050	0.0037	0.00047/0.00073
Esfenvalerate	0.000848	0.0000309 (ACR[1])	0.00466	0.00017/0.00025
Fenpropathrin	0.00305	<0.0015/0.0015[2]	0.021	0.012/0.024
Permethrin	0.0066	0.0042/0.0074	0.018	0.0024/0.0046
Pyrethrins	0.76	0.04/0.10	1.4	0.25/0.64

For additional details and MRID citations, refer to **Attachment II**.
[1] Estimated value, based on acute-to-chronic ratio (ACR).
[2] Non-definitive endpoint.

Although no plant toxicity data were readily available for cyfluthrin, it appears that aquatic plants are much less sensitive to pyrethroids than freshwater and estuarine/marine fish and invertebrates based on the plant data that is available. In many cases, the endpoints were non-definitive, due to low toxicity.

Table 18. Comparison of Vascular and Non-vascular Plants Most Sensitive Endpoints for Pyrethroids and Pyrethrins

Chemical	Vascular Plants / (µg/L)		Non-vascular Plants / (µg/L)	
	EC_{50}	NOAEC	EC_{50}	NOAEC
Bifenthrin	>330[1]	330	>290[1]	290
Cyfluthrin	NA	NA	>2[1]	NA
Lambda-cyhalothrin	>0.508[1]	0.508	>310[1]	≥310[1]
Cypermethrin	>1.62	1.62	25000	60
Deltamethrin	>779[1]	779	>3.1[1]	3.1
Esfenvalerate	>8.6[1]	8.6	>5.6[1]	5.6
Fenpropathrin	>1000[1]	1000	63	24
Permethrin	>3.2[1]	3.2	>4.4[1]	0.65
Pyrethrins	1230	480	105	29

NA = No available toxicity data.
For additional details and MRID citations, refer to **Attachment II**.

The endpoints selected for RQ calculations are presented in the footnotes to each of the RQ tables in **Section 7.1** (*Risk Estimation*).

7 Risk Characterization

Risk characterization provides the final step in the risk assessment process. In this step, exposure and effects characterization are integrated to provide an estimate of risk relative to established levels of concern (LOCs; **Section 7.1**). The results are then interpreted for the risk manager through a risk description and synthesized into an overall conclusion (**Section 7.2**). In addition, the risk description also contains a discussion of relevant sources of uncertainty in the risk assessment and sensitivity of the risk assessment findings to important methodological assumptions.

7.1 Risk Estimation

Results of the exposure modelling and toxicity effects data are used to evaluate the likelihood of adverse ecological effects on non-target species. For the assessment of pyrethroids and pyrethrins, the risk quotient (RQ) method is used to compare exposure and measured toxicity values (refer to **Appendix A**). Estimated environmental concentrations (EECs) are divided by the most sensitive acute and chronic toxicity values. The RQs are then compared to the Agency's levels of concern (LOCs). These LOCs, summarized in **Appendix A**, are the Agency's interpretive policy and are used to analyse potential risk to non-target organisms and the need to consider regulatory action. These criteria are used to indicate when a pesticide's use as directed on the label has the potential to cause adverse effects on non-target organisms. LOCs currently address the following risk presumption categories:

Aquatic Animals:

- **Acute risk** - potential for acute risk to non-target organisms which may warrant regulatory action in addition to restricted use classification,

• **Acute risk, listed species** – listed species may be potentially affected by use,
• **Chronic risk** – potential for chronic risk may warrant regulatory action, listed species may potentially be affected through chronic exposure.

7.1.1 Freshwater Fish Risk Quotients

For freshwater fish, there were only a few exceedances of levels of concern (LOCs) (for bifenthrin, *lambda*-cyhalothrin, cypermethrin, and esfenvalerate). For these chemicals, the acute RQs were only slightly above the listed (endangered and/or threatened) species LOC (LOC = 0.05) (RQ range 0.06-0.14). The acute non-listed LOC (0.5) was not exceeded by any of the evaluated pyrethroids and pyrethrins. On a chronic basis, only bifenthrin exceeded the LOC (LOC = 1.0), with an RQ range of 3.5 – 5.3. For all the remaining pyrethroids, the chronic RQs were below the LOC (RQs ≤ 0.61).

Table 19. Freshwater Fish Risk Quotients for Eight Pyrethroids and Pyrethrins

Chemical	Peak EEC = Chronic EEC[1] (µg/L)	96-hr LC_{50} (µg/L)	Acute RQ	NOAEC (µg/L)	Chronic RQ
Bifenthrin	0.014 – 0.0211[2]	0.15	***0.09 – 0.14***	0.004	**3.5 – 5.3**
Cyfluthrin	0.00179	0.068	0.03	0.0042	0.43
Lambda-Cyhalothrin	0.00205	0.029	***0.07***	0.031	0.07
Cypermethrin	0.0232	0.39	***0.06***	0.051	0.45
Deltamethrin	0.00278	0.58	<0.01	0.017	0.16
Esfenvalerate	0.0103	0.142	***0.07***	0.017	0.61
Fenpropathrin	N/A	2.2	N/A	0.06	N/A
Permethrin	0.0124	0.79	0.02	0.052	0.24
Pyrethrins	0.0814	5.1	0.02	1.9	0.04

N/A = does not apply, there are no applicable down-the-drain uses for fenpropathrin.
LOC for acute risk 0.5, acute restricted use 0.1, acute endangered species 0.05, and chronic risk 1.
[1] Stream flow SF_{1Q10} (acute) and SF_{7Q10} (chronic) stream dilution factor = 1.
[2] Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration from E-FAST 2014 was 0.0211 µg/L.

7.1.2 Estuarine/Marine Fish Risk Quotients

For estuarine/marine fish there were no exceedances of any of the acute or chronic listed and/or non-listed LOCs (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5; chronic LOC = 1.0). On an acute basis, the RQs were ≤0.02 for all the chemicals. The chronic RQs were ≤0.21 for all the chemicals.

Table 20. Estuarine/Marine Fish Risk Quotients for Eight Pyrethroids and Pyrethrins

Chemical	Peak EEC = Chronic EEC[1] (µg/L)	96-hr LC_{50} (µg/L)	Acute RQ	NOAEC (µg/L)	Chronic RQ
Bifenthrin	0.014 – 0.0211[2]	17.8	<0.01	0.1	0.14 – 0.21
Cyfluthrin	0.00179	4.05	<0.01	0.025	0.07
Lambda-	0.00205	0.807	<0.01	0.25	0.01

Chemical	Peak EEC = Chronic EEC[1] (µg/L)	96-hr LC_{50} (µg/L)	Acute RQ	NOAEC (µg/L)	Chronic RQ
Cyhalothrin					
Cypermethrin	0.0232	0.95	0.02	0.125	0.19
Deltamethrin	0.00278	0.58	<0.01	0.024	0.12
Esfenvalerate	0.0103	>19.3[3]	<0.01	0.63	0.02
Fenpropathrin	N/A	3.1	N/A	0.81	N/A
Permethrin	0.0124	2.2	0.01	0.143	0.09
Pyrethrins	0.0814	16	0.01	0.7	0.12

N/A = does not apply, there are no applicable down-the-drain uses for fenpropathrin.
LOC for acute risk 0.5, acute restricted use 0.1, acute endangered species 0.05, and chronic risk 1.
[1] Stream flow SF_{1Q10} (acute) and SF_{7Q10} (chronic) stream dilution factor = 1.
[2] Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration from E-FAST 2014 was 0.0211 µg/L.
[3] Non-definitive endpoint.

7.1.3 Freshwater Invertebrates Risk Quotients

For freshwater invertebrates, on an acute basis, all the RQs exceeded one or more of the LOCs. Cyfluthrin and pyrethrins exceeded only the listed species LOC (acute listed species LOC = 0.05; RQs of 0.07 and 0.11, respectively). The remaining pyrethroids exceeded all the acute LOCs, including the acute non-listed LOC (LOC = 0.5). The highest RQ was for bifenthrin (RQ = 42.8).

On a chronic basis, only the natural pyrethrins and permethrin slightly exceeded the LOC (LOC = 1.0; RQs = 2.0-2.9). All the synthetic pyrethroids and natural pyrethrins exceeded the chronic LOC (1.0) with RQs ranging from 2.0 for pyrethrins (only slightly above the LOC), to >464 for cypermethrin.

Table 21. Freshwater Invertebrates Risk Quotients for Eight Pyrethroids and Pyrethrins

Chemical	Peak EEC[1] (µg/L)	96-hr EC_{50} (µg/L)	Acute RQ	NOAEC (µg/L)	Chronic RQ
Bifenthrin	0.014 – 0.0211[2]	0.000493	**28.4 – 42.8**	0.000050	**280 – 422**
Cyfluthrin	0.00179	0.025	***0.07***	0.00012	**15**
Lambda-Cyhalothrin	0.00205	0.00008	**26**	0.00022	**9.3**
Cypermethrin	0.0232	0.00056	**41**	<0.00005[3]	**>464**
Deltamethrin	0.00278	0.0002	**14**	0.000026	**107**
Esfenvalerate	0.0103	0.000848	**12.1**	0.0000309	**333**
Fenpropathrin	N/A	0.00305	N/A	<0.0015[3]	N/A
Permethrin	0.0124	0.0066	**1.88**	0.0042	**2.9**
Pyrethrins	0.0814	0.76	***0.11***	0.04	**2.0**

N/A = does not apply, there are no applicable down-the-drain uses for fenpropathrin.
LOC for acute risk 0.5, acute restricted use 0.1, acute endangered species 0.05, and chronic risk 1.
[1] Stream flow SF_{1Q10} (acute) and SF_{7Q10} (chronic) stream dilution factor = 1.
[2] Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration from E-FAST 2014 was 0.0211 µg/L.
[3] Non-definitive endpoint.

7.1.4 Estuarine/Marine Invertebrates Risk Quotients

For estuarine/marine invertebrates, on an acute basis, all the chemicals exceeded at least one LOC. For pyrethrins and *lambda*-cyhalothrin the listed species LOC was exceeded (RQs of 0.06 and 0.42, respectively). For all the remaining chemicals the acute non-listed species LOC (0.5) was exceeded and the RQs ranged from 0.69 (permethrin) to 5.31 (bifenthrin).

On a chronic basis, the only chemical that did not exceed the LOC (chronic LOC = 1.0) was pyrethrins with an RQ of 0.33. The remaining chemicals exceeded the LOC with a range of 3.8 (deltamethrin) to 61 (esfenvalerate).

Table 22. Estuarine/Marine Invertebrates Risk Quotients for Eight Pyrethroids and Pyrethrins

Chemical	Peak EEC = Chronic EEC[1] (µg/L)	96-hr EC_{50} (µg/L)	Acute RQ	NOAEC (µg/L)	Chronic RQ
Bifenthrin	0.014 – 0.0211[2]	0.00397	**3.53 – 5.31**	<0.0006[3]	**>23 – >35**
Cyfluthrin	0.00179	0.0022	**0.81**	0.00007	**26**
Lambda-Cyhalothrin	0.00205	0.00491	***0.42***	0.0002	**10**
Cypermethrin	0.0232	0.0054	**4.3**	0.000781	**30**
Deltamethrin	0.00278	0.0037	**0.75**	0.00073	**3.8**
Esfenvalerate	0.0103	0.00466	**2.21**	0.00017	**61**
Fenpropathrin	N/A	0.021	N/A	0.012	N/A
Permethrin	0.0124	0.018	**0.69**	0.0024	**5.2**
Pyrethrins	0.0814	1.4	***0.06***	0.25	0.33

N/A = does not apply, there are no applicable down-the-drain uses for fenpropathrin.
LOC for acute risk 0.5, acute restricted use 0.1, acute endangered species 0.05, and chronic risk 1.
[1] Stream flow SF_{1Q10} (acute) and SF_{7Q10} (chronic) stream dilution factor = 1.
[2] Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration from E-FAST 2014 was 0.0211 µg/L.
[3] Non-definitive endpoint.

7.1.5 Vascular and Non-vascular Aquatic Plants

For vascular plants, there were no exceedances of the listed and non-listed species LOC (LOC = 1.0). All RQs available were ≤0.01. There were no vascular plant endpoints for cyfluthrin. Based on the overall risk picture for all the remaining pyrethroids and pyrethrins, it appears that aquatic vascular plants are not sensitive to pyrethroids.

Table 23. Vascular Plants Risk Quotients for Eight Pyrethroids and Pyrethrins

Chemical	Peak EEC[1] (µg/L)	NOAEC (µg/L)	Listed RQ	EC_{50} (µg/L)	Non-listed RQ
Bifenthrin	0.014 – 0.0211[2]	330	<0.01	>330[3]	<0.01
Cyfluthrin	0.00179	NA	NA	NA	NA
Lambda-Cyhalothrin	0.00205	0.508	<0.01	>0.508[3]	<0.01
Cypermethrin	0.0232	1.62	0.01	>1.62[3]	<0.01
Deltamethrin	0.00278	779	<0.01	>779[3]	<0.01

Chemical	Peak EEC[1] (µg/L)	NOAEC (µg/L)	Listed RQ	EC_{50} (µg/L)	Non-listed RQ
Esfenvalerate	0.0103	8.6	<0.01	>8.6[3]	<0.01
Fenpropathrin	N/A	1000	N/A	>1000[3]	N/A
Permethrin	0.0124	3.2	<0.01	>3.2[3]	<0.01
Pyrethrins	0.0814	480	<0.01	1230	<0.01

N/A = does not apply, there are no applicable down-the-drain uses for fenpropathrin.
NA = not available.
LOC for acute risk 1, and acute endangered species 1.
[1] Stream flow SF_{1Q10} and stream dilution factor = 1.
[2] Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration from E-FAST 2014 was 0.0211 µg/L.
[3] Non-definitive estimate; no effects seen at the highest test concentration.

For non-vascular plants, there were no exceedances of the listed and non-listed species LOC (LOC = 1.0). All RQs available were ≤0.02. There was no reported NOAEC for cyfluthrin. Based on the overall risk picture for all the remaining chemicals, it appears that aquatic non-vascular plants are not sensitive to pyrethroids.

Table 24. Non-vascular Plants Risk Quotients for Eight Pyrethroids and Pyrethrins

Chemical	Peak EEC[1] (µg/L)	NOAEC (µg/L)	Listed RQ	EC_{50} (µg/L)	Non-listed RQ
Bifenthrin	0.014 – 0.0211[2]	290	<0.01	>290[3]	<0.01
Cyfluthrin	0.00179	NA	NA	>2[3]	<0.01
Lambda-Cyhalothrin	0.00205	≥310[3]	≤0.01	>310[3]	<0.01
Cypermethrin	0.0232	60	<0.01	25000	<0.01
Deltamethrin	0.00278	3.1	<0.01	>3.1[3]	<0.01
Esfenvalerate	0.0103	5.6	<0.01	>5.6[1]	<0.01
Fenpropathrin	N/A	24	N/A	63	N/A
Permethrin	0.0124	0.65	0.02	>4.4[3]	<0.01
Pyrethrins	0.0814	29	<0.01	105	<0.01

N/A = does not apply, there are no applicable down-the-drain uses for fenpropathrin. NA = not available.
LOC for acute risk 1, and acute endangered species 1.
[1] Stream flow SF_{1Q10} and stream dilution factor = 1.
[2] Exceeded the limit of solubility for bifenthrin (0.014 µg/L). The actual concentration from E-FAST 2014 was 0.0211 µg/L.
[3] Non-definitive estimate; no effects seen at the highest test concentration.

7.2 Risk Description

7.2.1 Factors Affecting the Risk Quotients

Synthetic pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} <0.1 mg/L). **Table 15** shows the most sensitive LC_{50}s and NOAECs for freshwater and estuarine/marine fish and **Table 17** presents the most sensitive EC_{50}s and NOAECs for freshwater and estuarine/marine invertebrates. Freshwater fish are generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic

basis. In general, freshwater invertebrates are more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis. On a chronic basis, a trend is not clear for freshwater invertebrates, when compared to estuarine/marine invertebrates. Comparison of **Table 15** against **Table 17** shows clearly that freshwater and estuarine/ marine invertebrates are orders of magnitude more sensitive to pyrethroids and pyrethrins than freshwater and estuarine/marine fish.

Besides each chemical's toxicity, the RQs are also a function of the EECs, which are in turn dependent of the reported usage (or the production volume for esfenvalerate), and the wastewater removal at the treatment plant (WWT). The wastewater removals for these chemicals lied in the very narrow range from 91.7% (pyrethrins) to 94.0% (bifenthrin), based on EPISUITE v.4.11 estimates. These removals were similar to those estimated based on monitoring of POTWs in California (Markle *et al.*, 2014). In terms of the reported usage, provided by BEAD, the chemical with the highest usage is pyrethrins, with 89,000 lb a.i./year, followed by cypermethrin and bifenthrin with less than half the usage than pyrethrins (34,000 and 32,000 lb a.i./year, respectively). Another chemical with relatively high usage is permethrin (17,000 lb a.i./year). Meanwhile, for the remaining chemicals, the usage is around an order of magnitude lower than permethrin (2,000 – 6,000 lb a.i./ year for the remaining chemicals).

7.2.2 Summary of Risk Quotients

Table 25 provides an overall summary of all the risk quotients for freshwater and estuarine/marine animals for eight pyrethroids and pyrethrins (see also **Tables 19-22** for additional details, including endpoints, EECs, etc.)

Acute and chronic risks quotients (RQs) for freshwater and estuarine/marine fish were generally orders of magnitude lower than for freshwater and estuarine/marine invertebrates. For freshwater fish, there were a few exceedances of the acute listed species LOC (but the RQs did not exceed the non-listed species LOC), and one chronic LOC exceedance, while for estuarine/marine fish there were no exceedances of acute and chronic LOCs.

The highest freshwater fish acute RQ (bifenthrin, RQ = 0.14) does not exceed the acute non-listed LOC (0.5). However, if one considers the reported limit of solubility of bifenthrin and caps the acute EEC at the limit of solubility, the RQ is 0.09.

On a chronic basis, the only chemical that exceeds the LOC (1) for freshwater fish is bifenthrin, with RQs of 3.5 – 5.3. For bifenthrin the NOAEC is an estimate, based on the lowest NOAEC of all synthetic pyrethroids (*i.e.*, NOAEC for tefluthrin[5]). This NOAEC was chosen given the lack of a measured value and the uncertainty that would be introduced if an acute-to-chronic ratio was used, using an LC_{50} of 17.8 µg/L for estuarine/marine fish,

[5] Tefluthrin is one of the chemicals supported by PWG; however, it is not included in this comparative assessment, plus it has no indoor or residential uses.

which is several orders of magnitude higher than the limit of solubility of bifenthrin (0.014 µg/L).

Table 25. Summary of Risk Quotients for Down-the-Drain Uses of Pyrethroids and Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates.

Chemical	Risk Quotients							
	FW Fish		E/M Fish		FW Inverts		E/M Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	*0.09 – 0.14*	**3.5 – 5.3**	<0.01	0.14 – 0.21	**28.4 – 42.8**	**280 – 422**	**3.53 – 5.31**	**>23 – >35**
Cyfluthrin	0.03	0.43	<0.01	0.07	*0.07*	**15**	**0.81**	**26**
Lambda-Cyhalothrin	*0.07*	0.07	<0.01	0.01	**26**	**9.3**	*0.42*	**10**
Cypermethrin	*0.06*	0.45	0.02	0.19	**41**	**>464**	**4.3**	**30**
Deltamethrin	<0.01	0.16	<0.01	0.12	**14**	**107**	**0.75**	**3.8**
Esfenvalerate	*0.07*	0.61	<0.01	0.02	**12.1**	**333**	**2.21**	**61**
Fenpropathrin[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Permethrin	0.02	0.24	0.01	0.09	**1.88**	**2.9**	**0.69**	**5.2**
Pyrethrins	0.02	0.04	0.01	0.12	*0.11*	**2.0**	*0.06*	0.33

A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.
[1] N/A = There are no applicable down-the-drain uses for fenpropathrin.

For aquatic invertebrates the overall risk picture is different than for fish, since for both freshwater and estuarine/marine invertebrates there are multiple exceedances of LOCs for all the chemicals evaluated. For freshwater invertebrates, the lowest acute RQs were for cyfluthrin and pyrethrins, with RQs of 0.07 and 0.11, exceeding only the acute listed species LOC (0.05). Even though cyfluthrin is more acutely toxic to freshwater invertebrates than pyrethrins (EC_{50}s of 0.025 for cyfluthrin and 0.76 µg/L for pyrethrins), the acute EEC for pyrethrins is higher as a result of its higher usage, resulting in a higher EEC and consequently RQ. On an acute basis, for all the remaining pyrethroids the RQs exceed the acute non-listed species LOC (0.5) (RQ range **1.88 – 42.8**). On a chronic basis, all chemical's RQs exceeded the chronic LOC (1), with values ranging from 2.0 to >464. Meanwhile, for estuarine/marine invertebrates, on an acute basis all nine chemicals exceeded at least one LOC. The lowest RQ (0.06) for pyrethrins exceeded only marginally the listed species LOC (0.05). The highest acute RQ was for bifenthrin (RQ = 5.31). On a chronic basis, only the pyrethrins did not exceed the chronic LOC. For all the other pyrethroids, the RQs ranged from 3.8 (deltamethrin) to 61 (esfenvalerate).

7.2.3 Number of Days an Acute Concentration of Concern is Exceeded

The Probabilistic Dilution Model (PDM) is itself another module of E-FAST that may be run in tandem with DtD. It is intended to address aquatic ecological exposures and risks. PDM is used by the DtD module to calculate daily concentrations and to predict the number of days per year a chemical's concentration of concern (COC) in an ambient water body

will be exceeded by the discharge from a facility. Up to three COCs may be entered in EFAST 2014.

For additional characterization, one representative chemical was selected to run PDM. The chemical selected was permethrin and only acute exposure to aquatic invertebrates was addressed. The permethrin RQs were deemed to be representative of other pyrethroids since they are approximately in the middle, compared to the RQs for other pyrethroids and pyrethrins.

The acute COC may be calculated by multiplying the acute endpoint (*i.e.*, 96-hr EC_{50} for invertebrates) by the level of concern (*e.g.*, 0.05 for listed species). For permethrin, the acute COC for freshwater invertebrates and listed species is 0.00033 µg/L (*i.e.*, acute endpoint x 0.05 = 0.0066 µg/L x 0.05). Meanwhile, the acute COC for estuarine/marine invertebrates and listed species is 0.00090 µg/L (*i.e.*, 0.018 µg/L x 0.05). Since three COCs can be entered, an additional COC was entered, related to an acute non-listed LOC (0.5) for freshwater invertebrates. Therefore, the additional COC entered was 0.0033 µg/L for freshwater invertebrates and non-listed species (*i.e.*, 0.0066 µg/L x 0.5). **Table 26** summarizes the PDM results for permethrin (for the example output file, see the **Appendix C**).

Table 26. Number of Days per Year and Percent of Year a Concentration of Concern Is Exceeded for Permethrin

Taxa	LOC	Concentration of Concern (COC) (µg/L)	Number of Days Concentration of Concern is Exceeded (# days)	Percent of Year Concentration of Concern is Exceeded (%)[1]
Freshwater invertebrates	0.05 (acute listed species)	0.00033	327	89
Freshwater invertebrates	0.5 (acute non-listed species)	0.0033	154	42
Estuarine/marine invertebrates	0.05 (acute listed species)	0.00090	268	74

[1] Percent value was rounded to the nearest digit.

As indicated in the table, for freshwater invertebrates the *acute listed species* concentration of concern is exceeded 327 days/year (*i.e.*, 89% of the year) and the *acute non-listed species* concentration of concern is exceeded 154 days/year (*i.e.*, 42% of the year). For estuarine/marine invertebrates, the *acute listed species* concentration of concern is exceeded 268 days/year (74% of the year). All these numbers of days are related to the high end scenario (10th percentile), and results provide additional line-of-evidence that the chemical has the potential to affect both freshwater and estuarine/marine invertebrates.

7.2.4 Comparison of RQs for Small *vs.* Medium-Sized Recipient Streams

As it has been described earlier, for the protection of aquatic life, the developers of the

model have deemed two types of stream flows (SFs) suitable for ecological effects. They include the SF_{1Q10} (single day of lowest flow over a 10-year period), providing acute surface water concentrations to compare with acute endpoints. For chronic exposure, the stream flow SF_{7Q10} (seven consecutive days of lowest flow over a 10-year period) is used to compare with chronic endpoints for aquatic animals. Additionally, exposure results are calculated based on high-end surface water concentrations (*i.e.*, upper 10th percentile). These results represent the bounding high-end exposures and small streams, and they are used for risk assessment purposes. Besides the 10th percentile results, the model provides the 50th percentile results. These are exposure results calculated based on the median surface water concentrations (*i.e.*, 50th percentile). They represent central tendency exposure and mid-sized stream flows.

For characterization purposes, for permethrin (taken as a representative pyrethroid), at the 50th percentile, the acute exposure concentration is 6.15×10^{-4} µg/L and the chronic concentration is 5.10×10^{-4} µg/L. The stream dilution factors are 20.08 and 24.22, respectively. By way of comparison, the concentration for the 10th percentile is 1.24×10^{-2} µg/L (for both, acute and chronic exposure), with a stream dilution factor of 1.00 (for acute and chronic exposure). This means that the 10th percentile concentration is up to 20-24 times higher than the acute and chronic 50th percentile concentrations (for the example output file, see the **Appendix C**). EFED calculated RQs for mid-sized stream flows (50th percentile) and the compared results for permethrin are shown in **Table 27**.

For permethrin it was found that there are no exceedances of the LOCs for freshwater or estuarine/marine fish. For *small stream flows* (high-end scenario), there are exceedances of all the acute listed and acute non-listed and chronic LOCs for freshwater and estuarine/marine invertebrates. Meanwhile, it was found that for *mid-sized stream flows* (lower-end scenario), there is only a single slight exceedance of the listed species LOC for acute exposure for freshwater invertebrates (RQ = 0.09; LOC = 0.05). There are no exceedances of the acute non-listed, or chronic LOCs for freshwater and estuarine/marine invertebrates, or freshwater or estuarine/marine fish.

For freshwater and estuarine/marine invertebrates, the chronic LOC is exceeded for small stream flows, but not for mid-sized stream flows.

Table 27. Risk Quotients for Down-the-Drain Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates: Small & Medium-Sized Stream Flows

Chemical Permethrin (represented body of water)	Risk Quotients							
	FW Fish		E/M Fish		FW Inverts		E/M Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Low stream flows EEC = 0.0124 µg/L[1]	0.02	0.24	0.01	0.09	**1.9**	**3.0**	**0.69**	**5.2**

Chemical Permethrin (represented body of water)	Risk Quotients							
	FW Fish		E/M Fish		FW Inverts		E/M Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Mid-sized stream flows Acute EEC = 6.15×10^{-4} µg/L; chronic EEC = 5.10×10^{-4} µg/L[2]	<0.01	0.01	<0.01	<0.01	*0.09*	0.12	0.03	0.21

A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

[1] Based high-end surface water concentrations (*i.e.*, upper 10th percentile), representing small streams. The stream dilution factor is 1.00 (both acute and chronic).

[2] Based on median surface water concentrations (*i.e.*, 50th percentile), representing mid-sized streams. The stream dilution factor is 20.08 (acute) and 24.22 (chronic).

7.2.5 Comparison of Modelled and Monitored Concentrations in POTWs

Another line of evidence is the monitoring of pyrethroids. Monitoring data from POTWs in California corroborate the presence of synthetic pyrethroids in POTW effluents. For example, monitoring of 31 POTWs by Markle *et al.* (2014) in 67 effluent samples, and tested for eight pyrethroids, demonstrated that the pyrethroid detected with the lowest frequency (3.2% or 2 samples) was fenpropathrin. This result is not unexpected, since fenpropathrin does not have residential uses. Other pyrethroids were detected from 16% frequency (deltamethrin) to 81-82% frequency (cypermethrin and bifenthrin). Comparison of monitored and modelled results indicated that measured and predicted concentrations are comparable. Refer to **Table 13**, in **Section 5.7** for further details. One notable exception is permethrin, which is a chemical that is also used for lice control in human medications (shampoos and lotions); however, these products are regulated by FDA; if the active ingredient in these products is also a pesticidal active ingredient, the risk assessor should consider only the pesticidal use in the ecological risk assessment.

Table 28. Summary of Risk Quotients for Down-the-Drain Uses of Pyrethroids and Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates, Based Upon Maximum Monitored Concentrations (based on Markle *et al.*, 2014)

Chemical	Max. Conc. µg/L	Risk Quotient Based on Monitored Concentration							
		FW Fish		E/M Fish		FW Inverts		E/M Inverts	
		Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	0.0039	0.03	0.98	<0.01	0.04	**7.9**	**78**	**0.98**	**>6.5**
Cyfluthrin	0.004	*0.06*	0.95	<0.01	0.16	*0.16*	**33**	**1.8**	**57**
Lambda-Cyhalothrin	0.0016	*0.06*	0.05	<0.01	0.01	**20**	**7.3**	*0.33*	**8.0**
Cypermethrin	0.013	0.03	0.25	0.01	0.10	**23**	**>260**	**2.4**	**17**

Chemical	Max. Conc. µg/L	Risk Quotient Based on Monitored Concentration							
		FW Fish		E/M Fish		FW Inverts		E/M Inverts	
		Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Deltamethrin	0.0012	0.01	0.07	<0.01	0.05	**6.0**	**46**	*0.32*	**2.6**
Esfenvalerate	0.0006	<0.01	0.04	<0.01	<0.01	**0.71**	**19**	*0.13*	**3.5**
Fenpropathrin[1]	0.0008	<0.01	0.01	<0.01	<0.01	*0.26*	>0.53	0.04	0.07
Permethrin	0.170	*0.22*	**3.3**	*0.08*	**1.2**	**26**	**40**	**9.4**	**71**
Pyrethrins[2]	NA	NA	NA	NA	NA	NA	NA	NA	NA

A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" means it exceeds the listed species and non-listed species LOCs.

[1] N/A = There are no applicable down-the-drain uses for fenpropathrin; however, it was observed in the monitoring report.

[2] NA = There is no available monitoring data for pyrethrins. Chemical was not included in the Markle, *et al.*, 2014 monitoring report.

Comparison of RQs derived based on the maximum monitored concentration against the acute and chronic endpoints yields the following findings and are detailed in **Table 28**:

- All RQ values based on maximum monitoring concentration for bifenthrin, *lambda*-cyhalothrin, cypermethrin, deltamethrin and esfenvalerate are lower than the previously calculated RQs, based on modelling.
- All RQs for cyfluthrin are slightly above previously calculated from the modelling results, but they are of the same order of magnitude.
- RQs for permethrin are higher than previously calculated from modelling results. This may be due to the additional uses for permethrin for lice control in humans (*considered drug uses*), which may have caused permethrin concentrations in the environment (*i.e.*, in POTW effluents reaching bodies of water), to be higher than predicted based solely on pesticidal uses of the chemical. The drug uses of permethrin are under the purview of the Food and Drug Administration (FDA) and are evaluated separately by the sister Agency. Another factor that may have affected the RQs for permethrin based on the usage information is that BEAD could not locate usage information on the products used for the treatment of clothes or the pretreated clothes, which are used to prevent mosquito bites. Based on usage information, the RQs for freshwater and estuarine/marine fish for permethrin were below the LOCs; however, based on the highest monitored values, the RQs exceed LOCs for both freshwater and estuarine/marine fish.
- A set of RQs could be derived for fenpropathrin, based on a limited number of detections. For fenpropathrin, there is only one exceedance and only of the acute listed species LOC for freshwater invertebrates. Previously in this assessment, no RQs were calculated since fenpropathrin does not have residential uses and therefore there was no usage data or production volume.
- No RQs could be derived for pyrethrins, based on monitoring, since there is no available monitoring data for this chemical.

7.2.6 Uncertainties and Other Issues

7.2.6.1 Usage Information and Production Volume

The Biological and Economic Analysis Division (BEAD) provided usage information for several synthetic pyrethroids (USEPA 2015b). In short, BEAD concluded, based on private market research data to determine the estimated amounts of pyrethroids used indoor in the U.S. by Pest Control Operators (PCOs) and consumers, that overall approximately 225,000 pounds A.I. of pyrethroids and pyrethrins (combined) are estimated to be used indoors annually in the U.S., in ways that have some likelihood of resulting in DtD exposure. BEAD considered this a very high-end estimate, "since it assumes that all indoor treatments targeting flies, bedbugs, and cockroaches are equally likely to result in DtD exposure every time an application is made" (USEPA 2015b). Information is provided for seven pyrethroids assessed in this document plus the pyrethrins; in addition, a number of other pyrethroids were included (but not assessed in this document). For a characterization of the provided usage and adjustment factors, refer to USEPA (2015b). It should be noted that the EECs are highly dependent on the usage. The reason is that these pyrethroids and pyrethrins show a narrow range of wastewater treatment removals. Therefore, the estimated usage uncertainties affect the risk quotients to a high degree. Stakeholders have indicated that the lack of source characterization frustrates design of targeted mitigation measures to reduce POTW discharges. This issue is acknowledged. This PRA relies on the best available usage data (or production volume), for each of the chemicals evaluated. Also, stakeholders have indicated that there is no method to estimate influent loads and that EFED just assumes 100% of the production of a pesticide is discharged down indoor drains. This is a conservative assumption, although it should be stressed that BEAD applied certain correction factors to the usage information, to refine their estimates of pyrethroid and pyrethrins usage.

7.2.6.2 Wastewater Treatment Removal

Wastewater treatment plant removal efficiencies (WWT) were calculated using the Sewage Treatment Plant (STPWIN™) module of EPI Suite v.4.1. According to the STPWIN™ Help manual, EPI Suite's STPWIN™ program was conservative (*i.e.*, leading to higher concentrations) predicting removal percent (WWT) 88% of the time (using its default half-lives of 10,000 hours for 29 of 33 chemicals evaluated, for primary clarifier, aeration vessel and settling tank); however, the evaluation was based on a set of chemicals which are not pesticides. Stakeholders have indicated that EFED uses of the average or a single available literature wastewater treatment plant removal efficiency value, with no accounting for the range of removal efficiencies in real POTWs. Comparison of modeled WWTs against estimated monitoring removal values from POTWs in CA are favorable. However, even though a relatively large data set of monitored concentrations from California POTWs was available, it is uncertain whether the estimated WWTs are representative of other sites across the U.S. A potentially more suitable and reliable alternative, is data derived from a bench scale study that may be required either during the new chemical registration process of a chemical or during Registration Review, to further refine this input parameter (see next paragraph). Finally, for a few chemicals, when

available, WWT can be obtained from actual monitoring studies of influent and effluent from POTWs.

For the pyrethroids, the Division requested a bench scale study, with the expectation to obtain reliable removal efficiency data for each pyrethroid. It was found that the study did not provide suitable removal efficiency information. EFED then compared monitoring data from 31 California POTWs (of variable treatment design), against EPI Suite's STPWIN estimates. Data were comparable. Thus, the STP – EPI Suite estimates were used in this draft Part I of the Tier 1 Preliminary Aquatic Ecological Risk Assessment (PRA) for Eight Pyrethroids and Pyrethrins. EFED acknowledges that there were limitations in the California monitoring data (*e.g.*, use of grab samples, see next paragraph); however, it was the best available information available, which was submitted to EFED, and also published in the open literature. For pyrethroids, which bind to organic matter tightly, EFED believes that setting the removal efficiency to 0 (zero) is unrealistically conservative. Additionally, the results of the draft PRA were consistent with the expected behavior of the pyrethroids, and the monitoring and modeling results were similar.

It should be acknowledged that in the study by Markle *et al.* (2014), in which the monitoring of 31 POTWs in California was reported, tested samples were grab samples, as opposed to 24-hour composite samples. The composite samples represent a longer period of time and avoid the variability inherent to a single grab sample. Despite this uncertainty, it was noted a good agreement between the modeled (E-FAST's DtD), and measured values.

7.2.6.3 E-FAST 2014 Uncertainties

Concentrations derived from the E-FAST 2014 model are uncertain. The model assumes no degradation and no sorption of the chemical with organic matter or with the sediments in the body of water. Pyrethroids are known to bind to sediments, particulate matter and suspended organic matter. The E-FAST model is intended to be a Tier 1 model, and concentrations are considered conservative. Nonetheless, comparison of modeled concentrations *vs.* maximum monitored concentrations from California POTWs indicated similar concentrations (within about one order of magnitude).

In natural water, it appears that pyrethroids are less bioavailable than in pure water, at the same concentrations. For example, Parry & Young (2013) reported the distribution of pyrethroid insecticides in dechlorinated final effluent from Sacramento Regional Wastewater Treatment Plant. In sorption studies for four pyrethroids to suspended particulate matter, it was found that the estimated K_{iDOC} values were about $2x10^5$ L/kg for permethrin, cypermethrin and *lambda*-cyhalothrin, and $8x10^5$ L/kg for bifenthrin. A large percentage of the pyrethroid load was further associated with dissolved organic carbon (DOC). They observed in samples taken at different times of the years 2010-2011, that <6% of the total pyrethroid load was dissolved (bioavailable) across sampling and chemicals. However, these results should be taken with caution. When the whole water concentrations and the estimated dissolved concentrations were compared against the observed toxicity of the water to *Hyalella azteca*, it was found that neither of them

correlated well with the toxicity (assuming additive pyrethroid toxicity, based on toxic units). The study authors speculated that toxicity may have been attributable to other factors.

Certain stakeholders have noted that many POTWs have zero dilution. Peak and chronic EEC results in E-FAST 2014 used by EFED are the higher level estimates, 90th percentile and a stream dilution factor of 1.00 (one) for acute and chronic exposure, representing small receiving or effluent dominated bodies of water. This is a conservative approach.

The comment about use of dilution factors has been raised in certain Problem Formulations for Registration Review, and more recently, in meetings with stakeholders. Evaluation of E-FAST's DtD module results indicated that for the high end scenario, the stream dilution factor (SDF) is 1.00, which appears to be the minimum allowed value. The SDF is the volume of the receiving stream flow divided by the volume of the wastewater treatment facility effluent flow. The high end scenario concentration represents small receiving streams (10th percentile and SDF = 1.00). A SDF of 1.00 also represents "effluent dominated" surface bodies of water. These results may be compared against the alternative SDFs on the order of 20-24 for the 50th percentile concentration that represents midsized receiving streams. The SDF of 1.00 is used in the risk assessment, while SDFs of 20-24 may be used for characterization of results. For characterization, for one chemical, EFED calculated RQs for the 50th percentile and stream dilution factor of ~20 to ~24, representing a mid-sized receiving body of water.

7.2.6.4 Use of E-FAST for Estuarine/Marine Bodies of Water

In prior consultation with OPPT, it was pointed out that the DtD module better represents freshwater receiving bodies of water; however, in the majority of the risk assessments to date, and in the draft Pyrethroids and Pyrethrins PRA, it has been assumed that the effluent from a POTW can come in contact with estuarine/marine bodies of water. OPP considers exposure in saltwater environments, including discharges into estuarine/marine environments by comparing estimated exposure concentrations (EECs), to toxicity endpoints from estuarine/marine organisms, especially when they are more sensitive than freshwater taxa. The EECs from the DtD module of E-FAST 2014 are therefore compared against saltwater endpoints. This is somewhat similar to what the Division does with the results from agricultural modeling and the standard ecological pond. Note, however, that estuarine/marine bodies of water are larger than freshwater bodies of water, so it appears that this is a conservative approach.

7.2.6.5 Uncertainty Regarding Possible Pest Outbreaks

The observed EECs may be higher or lower than predicted by E-FAST 2014 depending on the usage in households in a certain areas leading to POTWs. For example, there could be high pest pressure in a particular site during a period of time that leads to higher observed environmental concentrations (compared to predicted EECs), in that particular POTW. E-FAST 2014's DtD module does not account for possible pest outbreaks in a

certain region that would cause a sizable use of a single pyrethroid. In such a case, it is possible that a single plant would receive a higher pesticide amount and as a consequence, the effluent would show higher pesticide levels than predicted by E-FAST 2014.

7.2.6.6 Use of the National Per-Capita Wastewater Release

Furthermore, E-FAST 2014 uses a per capita wastewater release based on the national average. The amount of water used regionally may be largely variable, presumably leading to differences in EECs. Another comment that has arisen regarding the DtD module is that it assumes even per-capita use across the entire nation. According to stakeholders, water conservation has greatly reduced per capita flows in the west, southwest, and southeast US. These lower flows mean less dilution. The per capita flow is not an optional input value in the model. This is a limitation of the model and it is discussed in the modeling assumptions. Currently, for a national Tier 1 assessment, the model is the best available approach for the down-the-drain uses assessed.

7.2.6.7 Issues of Biosolids, Recycled Water and Air Emissions

Stakeholders have indicated that EFED has not modeled biosolids, recycled water, or air emissions from POTWs. Regarding air emissions, EPI Suite predicts short half-lives for pyrethroids, in air, due to OH-radical emissions. For example, for bifenthrin, which appears to be the pyrethroid with the highest volatilization potential due to its extremely low solubility, EPI Suite predicts an OH-radical reaction half-life of only 0.36 days. Furthermore, pyrethroids show low vapor pressures and Henry's Law Constants, and very high K_{OC}s and K_{OW}s. Based upon these physicochemical and fate properties, the potential air emissions should be limited (further details about the fate of the individual pyrethroids can be found in the **Attachment III**). Pyrethroids and pyrethrins should not persist in air for long periods of time.

EFED and PRD have worked with the Office of Water to obtain a better handle on the potential exposure from application of biosolids to land. However, for the purposes of the down-the-drain assessment, EFED considers removal of pyrethroids to be a "sink" that reduces the direct exposure to water from down-the-drain uses. In addition, the Divisions believe that the exposure from land-applied biosolids is likely to be significantly less than the exposure that could occur from direct application of pyrethroids in agriculture according to product labels.

7.2.6.8 Ecological Effects Data Gaps and Uncertainties

Although the aquatic toxicity dataset was fairly robust for this group of chemicals, some data gaps were present. For bifenthrin, chronic fish toxicity data were not available and so an estimated endpoint was used in risk calculations. For bifenthrin, cypermethrin, permethrin and pyrethrins, some or all of the vascular and non-vascular aquatic plant toxicity data were missing. This is an uncertainty and risk could not be estimated nor precluded.

Several of the toxicity studies also had non-definitive endpoints. For esfenvalerate, the estuarine/marine fish acute endpoint was a non-definitive, greater than (>), value due to low toxicity. For cyfluthrin, *lambda*-cyhalothrin, deltamethrin, esfenvalerate and fenpropathrin, some or all of the vascular and non-vascular aquatic plant endpoints were also non-definitive, greater-than (>), values. However, in all cases, information was sufficient to provide boundaries of the risk estimate resulting in clear evidence that the RQs were below LOCs. Therefore, data were sufficient for risk estimations.

An additional uncertainty is the unknown potential for synergists, such as piperonyl butoxide and MGK-264, to persist in POTW discharges. Information on their persistence through POTW treatment processes has not yet been quantified. Since they are present in some pet shampoos and other end-use products containing pyrethroids, they may also enter POTWs. Because their synergistic mechanism of binding mixed-function oxidases that would break down pyrethroids, is associated with acute toxicity, rather than chronic toxicity and considered to be a short-term effect; for this Part I of the comparative risk assessment, synergism was not assessed. However, synergists that persist in POTW effluents, along with pyrethroids may enter the aquatic environment and be available for simultaneous exposure to aquatic organisms. Therefore, the likelihood of enhanced toxicity due to DtD synergists is an uncertainty.

For freshwater and estuarine/marine fish, the acute endpoints exceed the limit of solubility of some of the pyrethroids. This is the case for bifenthrin (both freshwater and estuarine/marine fish acute endpoints), cyfluthrin (only estuarine/marine fish), deltamethrin (both freshwater and estuarine/marine fish), and esfenvalerate (only estuarine/ marine fish). Endpoints derived at above the limit of solubility may be uncertain.

In summary, the toxicity data gaps and resulting uncertainties affecting the risk conclusions were:

- Chronic risk to fish from bifenthrin use due to missing toxicity data, although the approach taken appears to be conservative;
- Risk to aquatic plants from bifenthrin, cypermethrin, permethrin and pyrethrins use due to missing toxicity data;
- Potential for toxicity enhancement from synergists due to lack of information synergist persistence in POTW discharges; and,
- Endpoints derived at above the limit of solubility, which is typically very small for all the pyrethroids.

Acclimation/Adaptation

The risk characterization for aquatic organisms is based on standard toxicity studies using laboratory-reared cultures. Recently, two studies have been published which document much greater tolerance of field-collected freshwater amphipods (*Hyalella azteca*) from urban and agriculturally-impacted streams in California with a known history of pyrethroid contamination (Weston *et al.,* 2013; Clark *et al.,* 2015). Compared to laboratory populations, Weston *et al.* report that field-collected *H. azteca* from urban impacted sites were up to 550 times less sensitive on an acute exposure basis to two

common pyrethroids (cyfluthrin, bifenthrin). Using multiple lines of evidence, Weston *et al.* report that the resistant populations of field-collected *H. azteca* originate from genetically-distinct clads[6] and that the increased tolerance to pyrethroids likely pertains to genetic mutations associated with voltage-gated sodium channel membrane proteins, which are the target receptors of pyrethroid insecticides. Similarly, Clark *et al.* report field collected aquatic *H. azteca* to be less sensitive on an acute exposure basis to bifenthrin and cypermethrin by up to two orders of magnitude. Interestingly, Clark *et al.* report a substantial reduction in pyrethroid resistance of field collected *H. azteca* when reared in the laboratory over three generations, although the F3 generation populations were still about an order of magnitude less sensitive compared to populations that originated in the laboratory. These authors also report a strong seasonal variation in sensitivity of field-collected amphipods to these pyrethroids, which may be related to temporal variation in pyrethroid exposure history and subsequent activation of compensatory mechanisms associated with pesticide resistance (*e.g.*, enzyme activation).

Considering the well-documented occurrence of insect resistance to pyrethroids and other insecticides, these examples of pyrethroid resistance with aquatic arthropods are not surprising. However, they do have implications for this ecological risk assessment, particularly since *H. azteca* is consistently among the most sensitive aquatic invertebrate species to pyrethroids. One implication is that acute risks to pyrethroid-impacted populations of aquatic invertebrates may be much lower (by up to two orders of magnitude) than predicted from this ecological risk assessment. However, it is important to caveat this interpretation because there is evidence that suggest *H. azteca* may experience periods of more or less tolerance depending on the prior history of pesticide exposure.

Another implication is that pyrethroids are already altering the genetic and/or epigenetic composition of aquatic crustaceans (amphipods), which could have deleterious consequences for overall organism and population fitness. For example, populations that become genetically tolerant to pyrethroids due to repeated exposures over generations may be genetically less diverse compared to less impacted populations. This loss of genetic diversity may have deleterious consequences when organisms are challenged by other anthropogenic or natural stressors, thereby compromising population health and fitness (*e.g.*, Reed and Frankham, 2003). Currently, the evolutionary consequence of genetic tolerance to chemical stressors is not well understood. Furthermore, there is uncertainty when extrapolating results from *H. azteca* to other species, which may have a lower or greater capacity for acclimating or adapting to pyrethroid perturbations.

7.2.6.9 Methodologies for Effects Assessment

Another comment stakeholders have made is that methodologies for effects assessment once environmental concentrations are estimated by POTW modeling are also an issue. Toxicity estimates used in EFED risk calculations often come from submitted studies using recommended species (*e.g.*, *Daphnia magna*), but when more sensitive toxicity endpoints are available, these are also used if the study is determined to be sound. NPDES permit

[6] *H. azteca* is currently considered a "species complex" consisting of multiple genetically distinct populations across geographic regions.

limits are more likely based on effluent toxicity to species selected for routine testing rather than the more detailed toxicity profile compiled for pesticide registration (*e.g.*, *Ceriodaphnia dubia*, rather than *Daphnia magna;* https://www.epa.gov/npdes/npdes-permit-limits#wet). In both cases, species tested are viewed as surrogates for other species present in the environment and the selection of test species based on multiple considerations. If more sensitive toxicity data are available, EFED encourages its submission to the Division.

8 Conclusions

As shown in **Section 3.4.1**, the risk hypothesis in this assessment:

Pyrethroids and pyrethrins, when used indoors, in accordance with current labels, may result in off-site movement of the compound via wash-off into surface waters via drains and municipal wastewater treatment plants, leading to exposure of non-target aquatic plants and animals. This potential exposure pathway may result in adverse effects upon the survival, growth, and/or reproduction of non-target aquatic animals, but not to non-target aquatic plants.

The assessment concludes that the use of bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, cyhalothrins, permethrin and pyrethrins, when used in accordance with registered labels, can result in acute and/or chronic risk LOC exceedances for freshwater and estuarine/marine invertebrates, from the indoor down-the-drain exposure to POTWs which in turn result in releases to certain bodies of water. Additionally, it results in acute risk listed species LOC exceedances for freshwater fish for bifenthrin, *lambda*-cyhalothrin, cypermethrin and esfenvalerate, plus chronic risk LOC exceedances for freshwater fish for bifenthrin. There are no potential acute or chronic risk LOC excedances for estuarine/marine fish, or acute listed or non-listed species LOC exceedances for vascular and non-vascular plants from the down-the-drain uses for bifenthrin, cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, *lambda*-cyhalothrin, permethrin, and the pyrethrins. Since it has no residential indoor down-the-drain uses, for fenpropathrin there is no potential risk to freshwater or estuarine/marine aquatic animals or aquatic plants.

Two additional lines of evidence appear to support the conclusion that pyrethroids have a potential to cause acute and/or chronic risk for freshwater and estuarine/marine invertebrates: First, the monitoring of 31 POTWs in California shows that the pyrethroid concentrations in effluents are within an order of magnitude than it was predicted by E-FAST's DtD module. Second, an analysis of the percent of days in a year that a concentration of concern (COC) is exceeded for the example chemical permethrin (excluding the pharmaceutical uses) for acute exposure is 89% (acute listed species COC for freshwater invertebrates), 42% (acute non-listed species COC for freshwater invertebrates) and 74% (acute listed species COC for estuarine/ marine invertebrates). These high percentages suggest that there is risk of concern.

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Appendix A. Risk Quotient Method

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of this integration is called the quotient method. Risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are used by OPP to analyze potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) acute risks - regulatory action may be warranted in addition to restricted use classification, (2) acute restricted use - the potential for acute risk is high, but may be mitigated through restricted use classification, (3) acute endangered species - endangered species may be adversely affected, and (4) chronic risk - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, or chronic risk from granular/bait formulations to birds or mammals.

The ecotoxicity test values (measurement endpoints) used in the acute and chronic risk quotients are derived from required studies. Examples of ecotoxicity values derived from short-term laboratory studies that assess acute effects are: (1) LC_{50} (fish and birds), (2) LD_{50} (birds and mammals), (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOAEL or LOAEC (birds, fish, and aquatic invertebrates) and (2) NOAEL or NOAEC (birds, fish and aquatic invertebrates). For birds, mammals, fish and aquatic invertebrates the NOAEL or NOAEC generally is used as the ecotoxicity test value in assessing chronic effects, although other values may be used when justified. Risk presumptions and the corresponding RQs and LOCs, are tabulated below.

Table A-1. Summary of the levels of concern used for the risk quotient method.

Risk Presumption	RQ	LOC
Birds and mammals		
Acute Risk	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.5
Acute Restricted Use	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50} (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.1
Chronic Risk	Diet or dose-based EEC/NOAEC	1
Aquatic Animals		
Acute Risk	EEC/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/NOAEC	1
Terrestrial and Semi-Aquatic Plants, and Aquatic Plants		
Acute Risk	EEC/EC_{25}	1
Acute Endangered Species	EEC/EC_{05} or NOAEC	1
Terrestrial Invertebrates		
Acute risk to bees	EEC (adult contact)/LD_{50} (adult contact) EEC (adult or larval oral)/LD_{50} (adult or larval oral)	0.4
Chronic risk to bees	EEC (adult contact)/NOAEC (adult contact) EEC (adult or larval oral)/NOAEC (adult or larval oral)	1

Appendix B. Identification of Pesticides of Concern Likely to End Up in POTWs

A number of indoor pesticide uses are considered to have lower potential for substantive releases to POTWs based on labeled uses. These include labeled applications of indoor foggers, baits, crack and crevice treatment, and bed and mattress treatments where a hydrological connection to sewer systems is considered highly unlikely or at most, rare. Considerable discussion arose around the use of 'spot on' treatments for pets (*e.g.*, flea and tick control) as well as insecticide-impregnated collars. With spot on treatments, it is expected (and advised on some pesticide labels) that shampooing soon after application of spot on treatments would reduce the efficacy of such treatments, and those would not be cost effective and discouraged. Regarding pet collars, the potential substantive releases to POTWs are considered low based on their expected slow release rate of pesticides from the collars.

It is important to note that the pesticide uses identified in **Table B-1** do not represent *all* potential sources of pesticide input to POTWs. Rather, they represent those uses that are currently being assessed as part of DtD modeling in OPP environmental risk assessments. For example, pesticides may potentially be released by industrial discharges to POTWs from pesticide manufacturers. However, such releases are subject to regulation under other environmental statutes and regulatory programs (*e.g.*, state and federal pretreatment programs under the authority of the Clean Water Act), and not under FIFRA. It is recognized that certain outdoor residential uses of pesticides may contribute to pesticide loadings to storm water systems which are connected to POTWs. Modeling of outdoor residential use of pesticides in OPP environmental assessments is presently focused on direct loadings to surface water. Information from the open literature suggests that some POTWs may experience greater flow during wet weather events even when direct connections to storm water inputs are not apparent (Weston and Lydy, 2010). Presumably, such inputs represent groundwater intrusion and/or fugitive inputs from storm water runoff. For these and other sources of pesticides to POTWs unaccounted for in **Table B-1**, OPP is relying on targeted monitoring data to ascertain inputs to and discharges from POTWs.

Table B-1. Identification of Pesticides of Concern Likely to End Up in POTW Effluents and/or Biosolids (EFED and AD Comparison Chart)

Description of Use	EFED[1]	AD
Products registered for indoor domestic residential uses, certain indoor commercial facility uses (*e.g.*, supermarkets, storage facilities, restaurants, and warehouses), and institutional uses (*e.g.*, hospitals)		
Pet lotions or shampoos (*e.g.*, treatment for fleas and ticks)	Y	n/a[2]
Pesticide-containing pet collars and spot-on treatments	N[A]	n/a[2]
Products for the treatment of shoes/clothing/textiles (*e.g.*, miticides, sanitizers, deodorizers)	Y	Y[3]
Pre-treated clothes/textiles, bed sheets, linens, etc.	Y	Y[3]
Bed and mattress treatments (except products to treat bed sheets)	N[B]	N[4]
Drain treatments that convey water to sanitary sewer systems (root herbicides)	Y	n/a[5]

Description of Use	EFED[1]	AD
Storm drain/storm system treatments (*e.g.*, root herbicides and filtration media for storm water filtration systems)	Y[6]	Y[6]
Sewage system treatments (*e.g.*, filtration media for municipal wastewater filtration)	Y[6]	Y[6]
Carpet treatments (except materials preservatives) removed from carpets during shampooing then subsequently disposed with wash water down-the-drain	Y	Y
Lice shampoos, skin lotion treatments (*e.g.*, for mites)	N[12]	n/a[2]
Toilet bowl cleaners	n/a[7]	Y
Shower, sink, and bathtub cleaning products	n/a[7]	Y
Sanitizers and deodorizers applied to sinks, showers, dishes, countertops, etc. that are subsequently rinsed down-the-drain	n/a[7]	Y[3]
Dishwashing liquids and detergents	n/a[7]	Y
Laundry detergents used in residences, commercial laundries, and institutional establishments (*e.g.*, hospitals)	n/a[7]	Y
Laundry detergents used in industrial laundries	n/a[7]	Y[8]
Products, such as insecticides, intended to treat wood, walls, floors, spot treatments, or crack and crevice	N[C]	N
Foggers	N[C]	N
Sprays (surface and space)	N[C]	Y[3]
Aerosols	N[C]	N
Antifouling products	n/a[7]	Y
Egg washing treatments and/or fruit and vegetable rinses	Y	Y
Products registered for outdoor domestic residential uses		
Pool, spa, and fountain treatments (some localities require draining to sanitary sewer)	Y	Y
Residential and domestic products intended for *outdoor* applications (except pool, spa, and fountain treatments)	N[D]	N[9]
Wood preservatives and stains (excludes industrial application during processing)	N	N[10]
Oil and gas well production process water / recovery	N	Y[11]

Footnotes:

[A] Pet collars and spot on treatments have a low potential for substantive release down the drain going to POTW.

[B] Bed mattress treatments do not lead to a complete exposure pathway down the drain.

[C] These uses will not lead to a substantial amount of chemical going down the drains and/or they do not represent complete exposure pathways.

[D] This use does not lead to direct down the drain exposure going to POTWs.

[1] If monitoring of POTW effluent shows that a pesticide is present, this may be an indication that an assessment may be required.

[2] Not an antimicrobial pesticide use pattern

[3] This type of end-use for an antimicrobial pesticide would typically be listed on a label along with several other end uses. As a screen to estimate potential exposures and risks to humans and aquatic organisms from releases of an antimicrobial pesticide from domestic wastewater treatment plants, the contribution from all of these end-uses would be considered rather than this end use alone. The total production volume for the antimicrobial pesticide would be used as an input to the DtD module of E-FAST and the resulting estimate of exposure would include, but not be limited to, this specific use.

[4] Although materials preservatives are used in mattresses, these chemicals might be released to industrial WWTPs during application, but would not be expected to be released to domestic WWTPs.

[5] No known antimicrobial use

[6] These types of uses can potentially lead to acute adverse effects to microorganisms at WWTPs immediately downstream of application sites. For these types of uses that are sporadic and localized, the down-the-drain

module of E-FAST will tend to underestimate concentrations of chemicals entering WWTPs immediately downstream of application sites and corresponding concentrations of chemicals in receiving waters downstream of these WWTPs.

[7] Not a conventional pesticide use pattern

[8] Releases from this use are expected to be predominantly to industrial WWTPs; the down-the-drain module of E-FAST is not appropriate for estimating exposures from releases to industrial WWTPs.

[9] AD does, however, examine releases during processing and industrial use for residential/domestic products intended for outdoor applications (*e.g.*, pressure-treated wood products)

[10] Releases from this use are to industrial WWTPs only. The down-the-drain module of E-FAST is not appropriate for estimating exposure from releases to industrial WWTPs. The appropriate module of E-FAST to use is the General Population Exposures from Industrial Releases module.

[11] Releases from this use can be to domestic or industrial WWTPs.

[12] These products are regulated by FDA, but if the active ingredient in these products is also a pesticidal active ingredient, the risk assessor should consider the pesticidal uses in the ecological risk assessment.

Appendix C. Example Output File for Permethrin

INITIAL REVIEW EXPOSURE REPORT

CHEMICAL ID: tmpcas

ENVIRONMENTAL RELEASES OF CHEMICALS IN HOUSEHOLD PRODUCTS

SCENARIO #: 1 EXPOSED POPULATION: Adult

WWT REMOVAL (%)	PRODUCTION VOLUME (kg/yr)	HOUSEHOLD RELEASE DAYS	PRETREATMENT RELEASE (g/person/day)	POST-TREATMENT RELEASE (g/person/day)	BODY WEIGHT (kg)	BCF (L/kg)
93.40	7710.00	365.00	7.26E-05	4.79E-06	80.00	0.00

High-end scenario

CONCENTRATION OF CONCERN (ug/L)	NUMBER OF DAYS CONCENTRATION OF CONCERN EXCEEDED	PERCENT OF YEAR CONCENTRATION OF CONCERN EXCEEDED
3.30E-04	326.61	89.48
3.30E-03	153.95	42.18
9.00E-04	268.48	73.56

10th PERCENTILE DRINKING WATER AND FISH INGESTION EXPOSURE ESTIMATES						
Exposure Units	Drinking Water Results	Fish Ingestion Results	ASSUMPTIONS			
			ED (years)	AT (years)	DW IR (L/day)	FISH IR (g/day)
Cancer						
$LADD_{pot}$	1.48E-08 mg/kg/day	N/A mg/kg/day	57.00	78.00	1.04	7.50
$LADC_{pot}$	1.14E-06 mg/L	N/A mg/kg	57.00	78.00	NA	NA
Acute						
ADR_{pot}	2.60E-07 mg/kg/day	N/A mg/kg/day	NA	1 day	3.03	279.00

50th PERCENTILE DRINKING WATER AND FISH INGESTION EXPOSURE ESTIMATES						
Exposure Units	Drinking Water Results	Fish Ingestion Results	ASSUMPTIONS			
			ED (years)	AT (years)	DW IR (L/day)	FISH IR (g/day)
Cancer						
$LADD_{pot}$	8.75E-10 mg/kg/day	N/A mg/kg/day	57.00	78.00	1.04	7.50
$LADC_{pot}$	6.70E-08 mg/L	N/A mg/kg	57.00	78.00	NA	NA
Acute						
ADR_{pot}	1.18E-08 mg/kg/day	N/A mg/kg/day	NA	1 day	3.03	279.00

50th PERCENTILE AQUATIC EXPOSURE ESTIMATES - SURFACE WATER				
DESCRIPTOR	Harmonic Mean	30Q5	7Q10	1Q10
STREAM DILUTION FACTOR	134.85	39.66	24.22	20.08
CONCENTRATION (µg/L)	9.16E-05	3.12E-04	5.10E-04	6.15E-04

10th PERCENTILE AQUATIC EXPOSURE ESTIMATES - SURFACE WATER				
DESCRIPTOR	Harmonic Mean	30Q5	7Q10	1Q10
STREAM DILUTION FACTOR	7.95	1.80	1.00	1.00
CONCENTRATION (µg/L)	1.55E-03	6.86E-03	1.24E-02	1.24E-02

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins

Part II. Assessing Outdoor Urban Uses of Pyrethroids

Chemical Names	PC Code
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

Date: September 30, 2016 **DP Barcode:** D429641

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Part II. Assessing Outdoor Residential, Commercial, Turf, and Nursery Uses of Pyrethroids and Pyrethrins

1 Executive Summary

1.1 Purpose

The preliminary risk assessment (PRA) examines the potential ecological risks associated with labeled uses of a pesticide, based on the best available scientific and commercial information on the use, environmental fate and transport, and effects of the chemical on non-target organisms. The U.S. Environmental Protection Agency (U.S. EPA, USEPA, EPA, or the Agency) has developed a pyrethroid registration review risk assessment strategy that will assess the pyrethroids as a class with regard to ecological risks, rather than conducting assessments by individual chemical. The high toxicity of pyrethroids to aquatic animals and the exposure of aquatic animals to pyrethroids are well established. As such, risks to aquatic animals are expected to be a dominant concern with currently registered uses of pyrethroids. Therefore, this assessment focuses on the risks to aquatic animals, although aquatic plants are also assessed. The assessment also focuses on the pyrethroids for which the Pyrethroid Working Group (PWG), a consortium of registrants representing a number of pyrethroids, has conducted multiple studies and for which there is ample monitoring data. These include the synthetic pyrethroids bifenthrin, cypermethrin (cypermethrin, *zeta*-cypermethrin, *alpha*-cypermethrin)[1], cyfluthrins (cyfluthrin, *beta*-cyfluthrin), deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins (*lambda*-cyhalothrin, *gamma*-cyhalothrin), and permethrin, with the addition of the pyrethrins[2]. This document is **Part II** of the comparative assessment and deals with assessing pyrethroid and pyrethrin outdoor urban uses (residential and commercial), and certain other non-agricultural uses of pyrethroids (*i.e.*, turf and nursery/ornamentals).[3]

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[1] The cypermethrins, cyhalothrins and cyfluthrins are compounds composed of certain stereoisomers. For example, cypermethrin, which has three chiral centers is a racemic mixture of eight stereoisomers, *zeta*-cypermethrin is composed solely of four of those isomers, and *alpha*-cypermethrin is composed of two of the isomers. Cyfluthrin is made up of four pairs of enantiomers (eight isomers), while *beta*-cyfluthrin is a mixture of pairs of enantiomers II and IV of cyfluthrin, in a ratio of 1:2. Finally, *lambda*-cyhalothrin is composed of two isomers of cyhalothrin (cyhalothrin is an unregistered insecticide, which is a mixture of four stereoisomers), while *gamma*-cyhalothrin is composed of only one. In this assessment, only cypermethrin, cyfluthrin and *lambda*-cyhalothrin were modeled, and they were assumed to cover the other compounds which usually have lower application rates.

[2] The pyrethrins are not synthetic compounds, like the pyrethroids. Instead, they are comprised of six natural compounds, obtained from plant flowers of *Chrysanthemum cinerariaefolium* and *Chrysanthemum cineum.* The synthetic pyrethroids resemble structurally the pyrethrins, but certain moieties are added to the structure presumably to improve their stability in the environment.

[3] Portions of this PRA are based on/ or are citations from Shamim, *et al.* 2014.

1.2 Risk Conclusions

This comparative PRA examines the potential ecological risks associated with labeled uses of the insecticides bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins, permethrin, and the pyrethrins, based on the best available scientific and commercial information on the use, environmental fate and transport, and ecological effects of these chemicals on non-target aquatic animals. This section of the PRA deals solely with the potential exposure from certain urban (homeowner/residential, commercial uses) and other non-agricultural uses of pyrethroids (ornamentals/nursery, turf uses) to freshwater and estuarine/marine bodies of water.

1.2.1 Environmental Fate and Transport

The pyrethrins and synthetic pyrethroids are highly hydrophobic compounds, showing relatively low to very low solubility in water (from 0.014 ppb for bifenthrin to 10.3 for fenpropathrin, and 200-9000 ppb for pyrethrin 1 and pyrethrin 2). The octanol/water partition coefficients (K_{OW}s) for the pyrethroids are high (for solubility and K_{OW} values, see Laskowski, 2002). Based on these properties, there would be a potential to bioconcentrate in fish tissue. However, the fish bioconcentration factors (BCFs) for many of these compounds are lower than would be predicted based on K_{OW} alone, which would suggest they undergo metabolism in fish tissue and, with exceptions, relatively rapid depuration. The pyrethroids and pyrethrins show a high tendency to sorb with organic carbon in soil, water and sediments and dissolved organic carbon, or particulate matter in the water environment, as suggested by their high K_{OW}s and/or their high organic carbon partition coefficients (K_{OC}s).

Pyrethroids are relatively persistent in the environment and slow to biodegrade and hydrolyze. The eight pyrethroids in this assessment are generally more stable to sunlight than other synthetic pyrethroids, such as allethrin and resmethrin, and less persistent than the pyrethrins. They usually have other stable moieties attached to their backbone structure that cause them to persist longer. The major routes of dissipation of pyrethroids are generally metabolism in soil and water, and soil binding. Most pyrethroids are persistent to hydrolysis, aqueous and soil photolysis. Pyrethroids are usually more persistent in anaerobic than aerobic environments. The naturally derived pyrethrins are less persistent in most environments than the eight synthetic pyrethroids involved in this assessment. For further discussion see **Section 5.2** (*Environmental Fate of Synthetic Pyrethroids and Pyrethrins*).

EFED currently obtains estimated environmental exposure concentrations (EECs) for residential, commercial, nursery, and turf use patterns by modeling the nursery, turf, residential, rights-of-way, and impervious scenarios in the Pesticide in Water Calculator (PWC). For certain non-agricultural uses, exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models Pesticide Root Zone Model (PRZM) and Varying Volume Water Body Model (VVWM). A graphical user interface PWC v.1.5, developed by the EPA, was used to facilitate inputting chemical and

use specific parameters into the appropriate input files and chemical files. For further information about the model and modeling approach, refer to **Section 5.3**.

For all these chemicals, except for fenpropathrin, a single application was modeled, plus only a few selected scenario/location combinations per chemical. This means that two turf, three residential, one commercial, and two nursery scenarios were modeled. As will be explained subsequently (see **Sections 1.2.3 and 7.2.2**), the approach to use a reduced number of scenarios to represent the uses is appropriate.

Comparisons of water modeled and monitored concentrations involve a high degree of uncertainty (*e.g.*, uncertainties in the model, and in missing the peak concentration when sampling). Further, majority of samples are whole (unfiltered) water, which are not directly comparable to EECs, since the EECs represent freely dissolved test substance. There is a general expectation that EFED's modelled concentrations should be greater than monitored concentrations. Assuming low and median dissolved organic carbon (DOC) and particulate organic carbon (POC), many of the modeling results are within one order of magnitude difference, which indicates that EFED's modeling is not beyond the realm of environmental realism.

Comparison of the modeled and the maximum monitored OC-normalized sediment concentrations shows that for all the pyrethroids, except for fenpropathrin the OC-normalized maximum sediment monitored concentrations were above the modeled concentrations. This could be due to the fact that in modeling all these pyrethroids a single application was assumed. Fenpropathrin, which was the exception, was considered as an example chemical with modeling of a single, three and up to 24 applications/year and the maximum modeled concentration was greater than the maximum monitored concentration. However, the urban uses of fenpropathrin are limited to commercial ornamentals. On the other hand, comparison of the 90th percentile monitored OC-normalized concentration against the modelled sediment EEC indicated that they were within one order of magnitude difference of each other, with the exception of fenpropathrin.

1.2.2 Ecological Effects

Synthetic pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} are <0.1 mg/L). Freshwater fish appear to be generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates appear to be more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis (cyfluthrin is an exception). Meanwhile, on a chronic basis, there is no clear trend in the comparison of freshwater and estuarine/marine invertebrates. Aquatic invertebrates (freshwater and estuarine/marine) are usually orders of magnitude more sensitive to pyrethroids and pyrethrins than fish (freshwater and estuarine/marine). Benthic or sediment-dwelling invertebrates tend to be especially sensitive to pyrethrins and synthetic pyrethroids with freshwater species being generally more sensitive; however,

bioavailability seems to vary widely with the type and amount of organic carbon present in natural sediments.

1.2.3 Risk Determinations

Risk determinations for the urban and certain non-agricultural uses of pyrethroid and pyrethrins are summarized in **Table 1** to **Table 10**. In general, this assessment concludes that the use of bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, cyhalothrins, fenpropathrin and permethrin, plus the pyrethrins, in accordance with registered labels, results in exceedances of acute and/or chronic risk Levels of Concern (LOCs) for freshwater and estuarine/marine invertebrates, from the turf, residential, commercial, and ornamentals/nursery uses. Additionally, it results in a number of acute and/or chronic risk quotient LOC exceedances for freshwater and/or estuarine/marine fish for the chemicals analyzed, with the exception of the pyrethrins. It was noted that the number of exceedances for the pyrethrins were far fewer than for the pyrethroids, and included only acute listed species LOC exceedances for invertebrates. For the pyrethrins there were no non-listed species LOC exceedances for freshwater and estuarine/marine fish and water column and benthic invertebrates.

For all these chemicals, except for fenpropathrin, a single application was modeled, plus only a few selected representative scenario/location combinations per chemical. This means that two turf, three residential, one commercial, and two nursery scenarios were modeled per chemical, although this meant around 16 modelling runs per chemical.

Fenpropathrin was selected as a model chemical to perform multiple modeling runs. These included multiple scenarios for the same use pattern, and single and multiple applications per year for a given use, plus runs representing the total toxic residues (*i.e.*, parent compound plus unextracted residues). Inspection of the summary tables and the RQ tables for fenpropathrin (see **Tables 9 and 10**, and **Tables 122 and 123**) reveals the following:

- When several scenarios were run (*e.g.*, seven nursery scenarios), the overall risk picture did not vary substantially from scenario to scenario assuming that the application rate and number of applications were the same. It appears that the approach to use a reduced number of scenarios to represent the uses is appropriate.
- As expected, RQs increased with the application rates and with the number of applications per year.
- RQs for invertebrates (freshwater and estuarine/marine) are higher than for fish (freshwater and estuarine/marine). This observation is common across pyrethroids. Invertebrates are more susceptible than fish to pyrethroid exposure.
- Benthic acute and chronic RQs are lower than water column RQs.
- The overall risk picture for parent only and parent plus unextracted residues were similar, although as expected, for the parent plus unextracted residues the EECs, and consequently the RQs, were somewhat higher. It appears that additional runs for the unextracted residues for all the pyrethroids will not change the overall

conclusions of the risk assessment. Since pyrethroids show high K_d and K_{OC} values, a degree of irreversible binding is expected. It is believed that for the pyrethroids the unextracted residues are not an issue.

The reader is directed to the risk characterization section for further details about risk estimation (risk quotients) and risk description (**Sections 7.1** and **7.1**, respectively).

Table 1. Summary of Risk Determinations for Non-agricultural Uses of Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf					*X*		*X*					
TN Turf					*X*		*X*					
Residential Uses												
CA Residential Lots												
TX Residential Lots												
PA Residential Lots												
Commercial Uses												
FL Commercial Lots					*X*		*X*					
Nursery Uses												
OR Nursery					*X*		*X*					
NJ Nursery					*X*	**X**	*X*					

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 2. Summary of Risk Determinations for Non-agricultural Uses of Bifenthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN Turf	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Residential Uses												
CA Residential Lots					**X**	**X**	**X**	--[2]	**X**	**X**	*X*	--[3]
TX Residential Lots	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA Residential Lots	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Commercial Uses												
FL Commercial Lots	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
Nursery Uses												
OR Nursery	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ Nursery	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

[2]RQ reported as greater than value (>0.76) as a result of a non-definitive endpoint has the potential to exceed the chronic LOC.

[3]RQ reported as greater than value (>0.54) as a result of a non-definitive endpoint has the potential to exceed the chronic LOC.

Table 3. Summary of Risk Determinations for Non-agricultural Uses of Deltamethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*				**X**	**X**	**X**		**X**	**X**	*X*	
TN Turf	*X*				**X**	**X**	**X**		**X**	**X**	*X*	
Residential Uses												
CA Residential Lots					**X**		*X*		*X*			
TX Residential Lots	*X*				**X**	**X**	**X**		**X**	**X**		
PA Residential Lots					**X**	**X**	**X**		*X*	**X**		
Commercial Uses												
FL Commercial Lots	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Uses												
OR Nursery					**X**	**X**	**X**		**X**	**X**		
NJ Nursery	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 4. Summary of Risk Determinations for Non-agricultural Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN Turf	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Residential Uses												
CA Residential Lots	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX Residential Lots	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
PA Residential Lots	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Commercial Uses												
FL Commercial Lots	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Uses												
OR Nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ Nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 5. Summary of Risk Determinations for Non-agricultural Uses of Esfenvalerate for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	
TN Turf	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	
Residential Uses												
CA Residential Lots	*X*				**X**	**X**	**X**	**X**	*X*			
TX Residential Lots	*X*				**X**	**X**	**X**	**X**	**X**		*X*	
PA Residential Lots	*X*				**X**	**X**	**X**	**X**	*X*		*X*	
Commercial Uses												
FL Commercial Lots	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Uses												
OR Nursery	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ Nursery	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 6. Summary of Risk Determinations for Non-agricultural Uses of Cypermethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
TN Turf	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Residential Uses												
CA Residential Lots	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
TX Residential Lots	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
PA Residential Lots	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
Commercial Uses												
FL Commercial Lots	**X**		**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Uses												
OR Nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
NJ Nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 7. Summary of Risk Determinations for Non-agricultural Uses of Cyfluthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*				**X**	**X**	**X**	**X**		**X**	*X*	**X**
TN Turf	*X*				**X**	**X**	**X**	**X**		**X**	*X*	**X**
Residential Uses												
CA Residential Lots							*X*					
TX Residential Lots	*X*				*X*	**X**	**X**	**X**		**X**	*X*	**X**
PA Residential Lots	*X*				*X*	**X**	**X**	**X**				
Commercial Uses												
FL Commercial Lots	**X**		*X*		**X**	**X**	**X**	**X**	*X*	**X**	**X**	**X**
Nursery Uses												
OR Nursery	**X**				**X**	**X**	**X**	**X**		**X**	*X*	**X**
NJ Nursery	**X**				**X**	**X**	**X**	**X**	*X*	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 8. Summary of Risk Determinations for Non-agricultural Uses of *Lambda*-Cyhalothrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Turf Uses												
MI Turf	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN Turf	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
Residential Uses												
CA Residential Lots					**X**	**X**	*X*	**X**	**X**	**X**	*X*	**X**
TX Residential Lots	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
PA Residential Lots	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Commercial Uses												
FL Commercial Lots	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Uses												
OR Nursery	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ Nursery	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 9. Summary of Risk Determinations for Non-agricultural Uses of Fenpropathrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios / Uses/ No. Apps per Year	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Commercial Ornamentals, 1, 3 and 24 applications/year												
FL Commercial Lots / 1 application/year					**X**	**X**	**X**		**X**	**X**	*X*	
FL Commercial Lots / 3 applications/year	*X*		*X*		**X**	**X**	**X**		**X**	**X**	*X*	
FL Commercial Lots / 24 applications/year	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Ornamentals, 1 application/year												
CAnursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MI nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Scenarios / Uses/ No. Apps per Year	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
NJ nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
OR nursery	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Ornamentals, 3 application/year												
CA nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL nursery	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MI nursery	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
OR nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Ornamentals, 24 application/year												
CA nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MI nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
OR nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 10. Summary of Risk Determinations for Non-agricultural Uses of Fenpropathrin plus the Unextracted Residues for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios / Use/ No. Apps per Year	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Commercial Ornamentals, 1, 3 and 24 applications/year												
FL Commercial Lots / 1 application/year					**X**	**X**	**X**		**X**	**X**	*X*	
FL Commercial Lots / 3 applications/year	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL Commercial Lots / 24 applications/year	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Ornamentals, 1 application/year												
CAnursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Scenarios / Use/ No. Apps per Year	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		E/M Inverts		FW Benthic Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
MI nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
OR nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX nursery	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Ornamentals, 3 application/year												
CAnursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MI nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
OR nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX nursery	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Nursery Ornamentals, 24 application/year												
CAnursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MI nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NJ nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
OR nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TN nursery	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
TX nursery	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

1.2.4 Data Gaps and Uncertainties

In this section, the uncertainties are only summarized according to the following six major categories:

i. Uncertainties in the use information utilized in the assessment. With the exception of fenpropathrin, in this assessment a single application at the maximum rate was assumed in all instances. For fenpropathrin, multiple applications were also modeled.
ii. Uncertainties related to the residential/urban and commercial/urban conceptual models.
iii. Environmental fate database/data gaps and their uncertainties.
iv. Ecological effects data gaps and uncertainties.
v. Uncertainties related to the Pesticide in Water Calculator (PWC v.1.5) model and other exposure assessment issues.
vi. Uncertainties related to dilution and chemical transformations in estuarine environments.

For additional details about these uncertainties in this assessment, refer to **Section 7.2.8** of the Risk Description

2 Introduction

Outdoor urban uses of pesticides can result in significant exposure to water bodies through drift, runoff and erosion. These uses include structural pest control, rights of ways, and landscaping. Many pesticides are labeled for outdoor uses to control insect pests such as ants, cockroaches, fleas, occasional invaders, spiders, and wasps, in addition to others used for lawn care. Control is accomplished by professional pest control operators (PCOs) and homeowners through different pesticide formulations, application methods, and timing.

In a regulatory setting, labels are considered first in determining pesticide exposure in various compartments of the environment, as the label is the legal document governing the permitted pesticide use patterns. In addition, pesticide usage data are also important as it indicates quantity, seasonality, historical and geographic usage of currently registered pesticides. Monitoring data are also important and could be a reliable source of exposure data available for use in a risk assessment due to limitations associated with the current modeling approaches. Important aspects of exposure modeling for outdoors uses include establishing a conceptual model for varied types of outdoor uses along with percent/type of areas treated, percent of pesticide available for washoff (if suitable data is available), and other possible sources of pesticide contamination (*i.e.*, drift, contaminated airborne particles and others, as applicable). Recent studies have concentrated in obtaining such important modeling parameters in addition to many other data such as frequency/seasonality of applications, and most frequently used application rate, frequency, equipment and formulations. This data could be used as inputs for the exposure models to characterize and refine the exposure estimates.

In **Part II** of OPP's comparative ecological risk assessment: "*Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins*", a summary of the currently available information regarding pyrethroid and pyrethrins pesticide releases to urban environments in the U.S. and approaches considered for evaluating these exposure pathways is presented. Sources and pesticide uses associated with releases to urban waters are discussed. Following this, approaches and data that are being used to model the fate of these releases are described. Additionally, a summary of available monitoring data which have been generated specifically to characterize potential pyrethroid exposure to urban waters is presented. Aquatic toxicological endpoints for the pyrethroids and pyrethrins assessed are provided and discussed (in first tier assessments, the most sensitive species is used). In the risk estimation section of the risk characterization, the risk quotient method is used to characterize the risk of pyrethroids reaching adjacent surface bodies of water. This is followed by the risk description, where data available about monitoring, and other lines-of-evidence are integrated with modeling results and resulting risk quotients are placed in proper context.

This part of the comparative Pyrethroid and Pyrethrins Ecological Risk Assessment is focused solely on outdoor urban (and certain other non-agricultural) uses of pyrethroids leading to exposure to surface water bodies, and only on risk to aquatic organisms, which have been found to be the most sensitive receptors in previous pyrethroid ecological risk assessments.

3 Problem Formulation

The Problem Formulation provides a strategic framework for the risk assessment. It sets the objectives for the risk assessment and provides a plan for analyzing the data and characterizing the risk (USEPA 1998). By identifying the important components of the risk assessment process, it focuses the assessment on the most relevant ecological receptors (species), chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA 2004).

3.1 Pesticide Class, Type and Mode of Action

Pyrethrins and synthetic pyrethroids are neurotoxic insecticides acting through direct contact and ingestion. The insecticidal effect of pyrethroids is characterized by a rapid "knock down," or paralysis, of insects. All pyrethroids act as axonic poisons, affecting both the peripheral and central nervous systems, and share similar modes of action. The primary biological effects of pyrethroids on insects and vertebrates reflect an inhibition of the correct firing of neurotransmitter delivery signals from one cell to another via nerve membrane inhibition of the voltage-gated Ca^{2+} (calcium ion) channels coupled with a stimulatory effect on the voltage-gated Na^{+} (sodium ion) channels. Type I pyrethroids do not have a cyano group substitution in the *alpha*-position of the alcohol moiety of the ester structure; in contrast, Type II pyrethroids do have the *alpha*-cyano group. For additional discussion on pesticide class, type and mode of action, refer to **Section 3.1** of **Part I** of the PRA.

3.2 Conclusions from Previous Assessments

Ten of the pyrethrins, pyrethroids, and synergists were registered before November 1, 1984, and therefore were subject to reregistration. They are also evaluated in the registration review process. In 2008, EPA completed Reregistration Eligibility Decisions (REDs) for these 10 individual pesticides: pyrethrins, allethrins, cypermethrin, *tau*-fluvalinate, permethrin, resmethrin (now cancelled), *d*-phenothrin (commonly known as Sumithrin®), and tetramethrin. The remaining pyrethroids, registered later, were not subject to reregistration. Additionally, California Red Legged Frog (CRLF) and other threatened or endangered species in the San Francisco Bay (SFB) region endangered

species assessments (ESAs), were issued for a number of pyrethroids. More information about pyrethrins and individual pyrethroid assessments (including ESAs) can be found in the EPA Pesticide Chemical Search site (URL: https://iaspub.epa.gov/apex/pesticides/f?p=chemicalsearch:1).

Previous assessments have generally concluded that pyrethroids can be relatively persistent in the environment and slow to biodegrade and hydrolyze. The major routes of dissipation of pyrethroids are generally aerobic soil and aquatic metabolism, and soil binding, and for some of the pyrethroids, aqueous photolysis in clear shallow water. For pyrethroids, hydrolysis is pH dependent, and they are more prone to hydrolyze at higher pH values (*i.e.*, pH = 9). Pyrethroids usually are more persistent in anaerobic than aerobic environments. It should be noted that the pyrethrins are less persistent in most environments than the eight synthetic pyrethroids involved in this assessment. Additionally, some of the pyrethroids not covered in this comparative assessment are less persistent to certain routes of dissipation than the pyrethroids covered.

Pyrethroids are highly toxic to aquatic animals. As a result, generally risk quotients (RQs) approached or exceeded the levels of concern (LOCs) for fish and invertebrates (freshwater and estuarine/marine); however, RQs were usually higher for invertebrates. Most of the previous assessments involving outdoor urban uses for pyrethroids are Endangered Species Assessments (ESAs) conducted for certain California species.

Because the pyrethroids can accumulate in sediments, risk to sediment-dwelling organisms is an area of particular concern. Previous risk assessments have been largely unable to adequately estimate risk to this group of organisms due to data gaps. Additionally, bioavailability has been difficult to ascertain due to strong influences from varied types and amounts of organic carbon in natural sediments.

Additionally, water quality, and sediment monitoring efforts in California and other states have identified pyrethroids in sediments of water bodies adjacent to agricultural and residential/urban areas. These monitoring data, coupled with additional pyrethroid-specific data submitted to EPA, highlight existing concerns regarding agricultural and residential uses of pyrethroid pesticide products and movement into non-target areas through runoff or spray drift that may occur during applications.

Risk conclusions from previous assessments regarding taxa, other than aquatic, are considered separately from this part of the PRA, which as indicated earlier, is focused on risk to aquatic organisms. To reduce exposure to water bodies from non-agricultural and agricultural uses of pyrethroids, EPA deployed a number of labeling initiatives, as shown in the next **Section 3.3**, and in **Section 5.1.2**.

3.3 Overview of Pesticide Use and Usage

Type I and Type II synthetic pyrethroids are currently registered for numerous diverse uses that span a large variety of use sites and geographical regions throughout the U.S.

Pyrethroids are broad spectrum insecticides that target adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying invertebrates. Formulation types registered for pyrethroids include, among others, wettable powders, dispersible granules, emulsifiable concentrates, liquids, ready to use products, granulars, and dusts. Application methods in nonagricultural settings include: ground spray, hand spray, airblast, mist/fogging, soil band spray, surface spray, soil incorporation, and granular. Potential pyrethroid uses include nursery uses; home garden uses; ornamental uses; turf uses; indoor/outdoor industrial, commercial, and residential uses; and fire ant control. Pyrethroids *may* be applied year-round, especially in the southern states.

To reduce exposure to water bodies from non-agricultural uses of pyrethroids, the Agency implemented a labeling initiative to revise the "Environmental Hazard Statements" and general "Directions for Use" for these chemical products used in non-agricultural outdoor settings. The label statements spell out good stewardship and best-management practices and clarify how these types of products are intended to be used. The Agency approved minor optional modifications to several labeling statements in January 2013 in response to stakeholder feedback and to specifically address the unique needs of pest control operators (PCOs to treat for overwintering pests. These label statements serve to reduce the potential for runoff and drift to water bodies that can result from applications of pyrethroid and pyrethrins end-use products in residential, commercial, institutional, and industrial areas, applied by both professional pesticide control operators and residential consumers. For additional information and details about use and usage of pyrethroids, refer to **Section 5.1.1 and 5.1.2**, respectively.

3.4 Overview of Environmental Fate

A brief discussion about relevant environmental fate properties of the pyrethroids was provided in the Risk Conclusions (**Section 1.2.1**). For more detailed fate information see **Section 5.2**. (*Environmental Fate of Synthetic Pyrethroids and Pyrethrins*).

3.5 Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a plausible route of exposure. The conceptual model is intended to provide a written description and visual representation of predicted relationships between pyrethroids or pyrethrins, potential routes of exposure, and the effects related to the Agency assessment endpoints. The conceptual model consists of two major components: the risk hypotheses and a conceptual diagram (USEPA 1998).

3.5.1 Risk Hypothesis

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA 1998). For this assessment, the risk is stressor-initiated, where the stressor is the release of pyrethrins and pyrethroids into the environment. The following risk hypothesis is presumed for this assessment:

> *Pyrethroids and Pyrethrins, when used outdoors in accordance with registered labels in urban environments, will likely lead to off-site movement of the compound via urban runoff, spray drift, and eroded soil, leading to exposure of nontarget aquatic animals and plants. Based on information on the environmental fate, mode of action, direct toxicity and potential indirect effects, EFED assumes that registered uses of pyrethroids and pyrethrins have the potential to cause reduced survival, growth, and reproduction to non-target aquatic animals, but not to non-target aquatic plants.*

This risk assessment will evaluate the aforementioned risk hypothesis and determine if it is supported by the risk conclusions.

3.5.2 Conceptual Diagram

The conceptual model for potential risks of pyrethroids and pyrethrins to aquatic organisms for various outdoor urban uses of the chemical that could potentially end up in adjacent bodies of water is depicted in **Figure 1**.

Based on an examination of the physicochemical properties of pyrethroids and pyrethrins, the fate and disposition in the environment, and mode of application, a conceptual model (**Figure 1**) was developed that represents the possible relationships between the stressors, ecological receptors, and the assessment endpoints. Through a preliminary iterative process of examining available data, the conceptual model (*i.e.*, the representation of the risk hypothesis) may be refined to reflect the likely exposure pathways and the organisms that are most relevant and applicable to this assessment. They include the potential pesticide or stressor (in this case, pyrethroids and pyrethrins), the sources and/or transport pathways, exposure media and exposure points, biological receptor types and attribute changes.

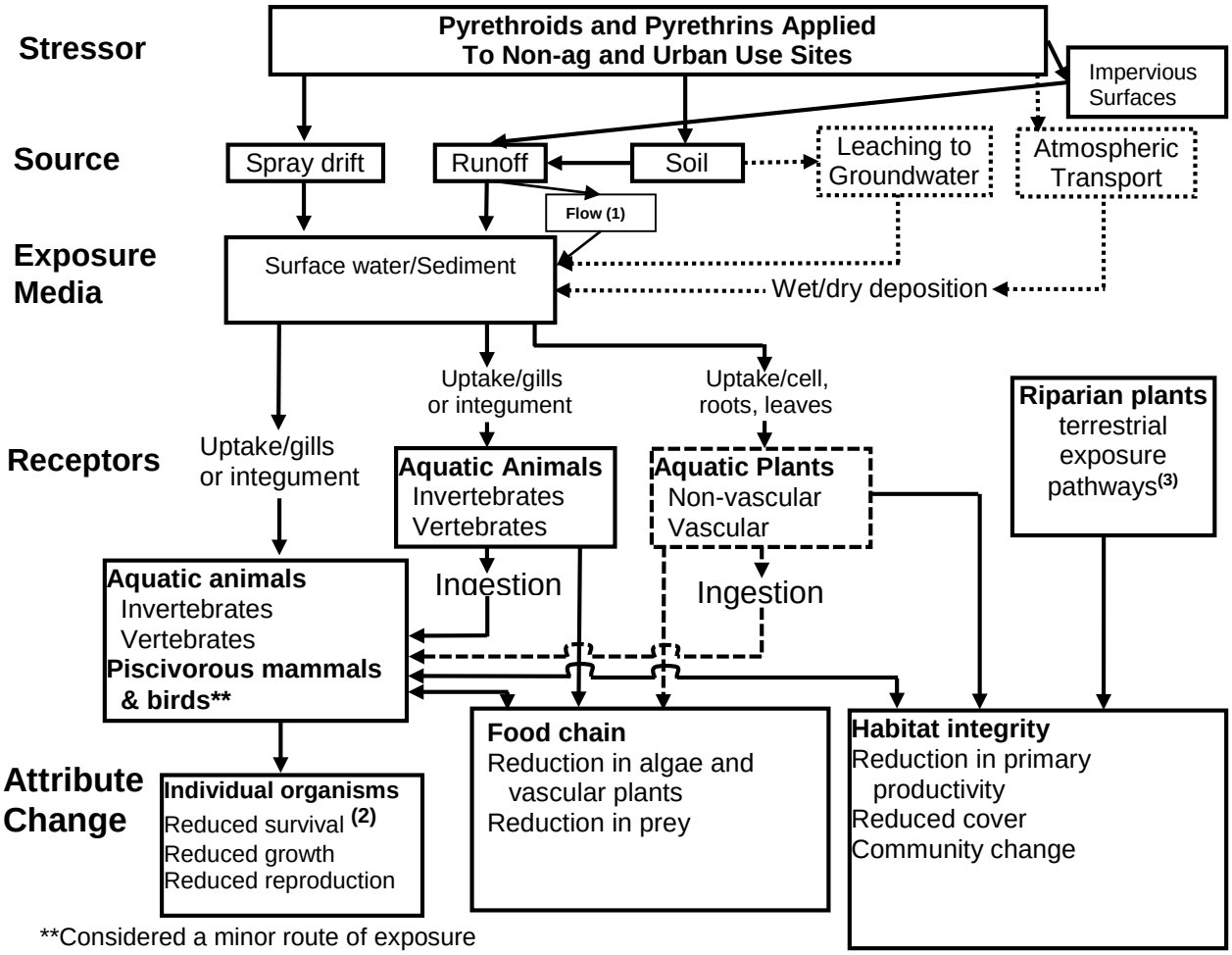
In order for a chemical to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological exposure pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a feasible route of exposure. In addition, the potential mechanisms of degradation/ transformation (*i.e.*, which degradation/transformation products may form in the environment, in which media, and how much) must be understood. The assessment of ecological exposure pathways, therefore, includes an examination of the source and potential migration pathways for constituents, and the determination of potential exposure

routes.

Under the possible uses of pyrethroids and pyrethrins, the sources and mechanisms of release of the compounds are from ground applications. Note that this conceptual model considers only certain non-agricultural applications: residential and commercial settings, turf and ornamentals. Surface runoff from the areas of application is assumed to depend on factors such as topography, irrigation, and rainfall events. Spray drift results in contaminated adjacent areas, including bodies of water. Spray drift is considered meaningful only for the turf and ornamentals applications. For commercial and residential applications generally hand held or back pack equipment is used and spray drift cannot be quantified and is assumed to be negligible. Leaching to groundwater is not considered an important source because the pyrethroids and pyrethrins show low mobility in a variety of soils due to high binding (sorption). Generally, these chemicals appear to have a low potential for volatilization, with a low vapor pressure and Henry's Law Constants. Further, the hydroxyl radical reaction half-life is relatively short for most chemicals, as estimated by quantitative structure-activity relationship (QSAR) methods (*i.e.*, EPI Suite). The short (atmospheric) half-life, the low vapor pressure and relatively low Henry's Law Constants, and their binding capacity, suggest that the potential for atmospheric transport for pyrethroids and pyrethrins is low and that this source of the chemical is of low importance, compared to spray drift and/or runoff after application.

For aquatic receptors, points of exposure are through direct contact with the water column, suspended particulate, sediment, and pore water (gill/integument) contaminated with spray drift (from spray application) and/or runoff and flow (*e.g.*, piped storm drains) from treated areas. For the pyrethroids, due to their hydrophobicity and low solubility, contact with chemical in suspended particulate and sediment are likely higher than direct contact with dissolved chemical in the water column. Indirect effects to aquatic organisms (both fish and aquatic invertebrates) can also occur through impact to various food chains for some of the chemicals. The representative aquatic receptors are certain freshwater and estuarine/marine fish, invertebrates, and aquatic plants. It should be noted, that these species do not cover all the possible species in the animal and plant kingdoms; certain taxa are considered as surrogates for other taxa. For example, freshwater fish are considered surrogates for aquatic phase amphibians.

Pyrethroids and pyrethrins show low solubilities, high K_{OW}'s and high sorption coefficients. These properties suggest that the chemicals partition with the sediments and particulate suspended in bodies of water. Pyrethroids and pyrethrins are likely to concentrate in the sediments, especially after repeated exposures (applications), where they could persist. Such sediments could serve as repositories of the chemical for extended periods of time and could potentially be toxic to sediment dwelling organisms, affecting the food chain. Also, they could serve as sources of pyrethroids in the water column due to desorption from sediments. Aquatic plants show much lower sensitivity to pyrethroids and pyrethrins than aquatic animals; it appears that the pyrethroids and pyrethrins risk to non-target plants is low.



Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

[1] Includes flow across vegetation and vegetated drainage systems (*e.g.*, swales) and flow across impervious surfaces and through impervious (piped) storm drains.

[2] Immobilization is considered equivalent to mortality in toxicity tests for aquatic invertebrates.

[3] Riparian plants are not considered in the part of the PRA.

Figure 1. Conceptual diagram for potential risks of pyrethroids and pyrethrins to aquatic organisms for various outdoor urban uses of the chemicals that could potentially end up in surface water or sediment.

4 Analysis Plan

The primary method used to assess risk in this assessment is the risk quotient (RQ) and follows closely methods outlined in the EPA Overview Document (USEPA, 2004). The RQ is the risk value for the assessment and is the result of comparing measures of exposure to measures of effect. Risk presumptions, along with the corresponding RQs, equations, and LOCs are summarized in **Section 7** and **Appendix A** of this assessment.

4.1 Measures of Exposure

In order to estimate risks of pyrethrins and pyrethroids exposures in aquatic environments, all exposure modeling and resulting risk conclusions will be made based on maximum application rates for the current use patterns, and initially a single application (instead of multiple applications). Available monitoring data will also be considered when describing potential environmental exposure to non-target organisms. Measures of exposure are based on aquatic models, such as the Pesticides in Water Calculator (PWC v.1.5), that predicts estimated environmental exposure concentrations of pyrethrins and pyrethroids using maximum labeled application rates and methods, as well as any mitigation measures specifically indicated on the label. More information on aquatic pesticide exposure models can be found at http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment (accessed June 30, 2016), and in **Section 5.3**.

4.2 Measures of Effect

Measures of ecological effects are obtained from a suite of registrant-submitted guideline studies conducted with a limited number of surrogate species. The test species are not intended to be representative of the most sensitive species but rather were selected based on their ability to thrive under laboratory conditions. Measures of effect are based on deleterious changes in an organism as a result of chemical exposure. Functionally, measures of effect typically used in risk assessments include changes in survival, reproduction, or growth as determined from standard laboratory toxicity tests. The focus on these effects for quantitative risk assessment is due to their clear relationship to higher-order ecological systems such as populations, communities, and ecosystems, and especially their ability to be readily reduced to population sustainability. Monitoring data such as adverse effect incident reports may also be used to provide supporting lines of evidence for the risk characterization. Reviews of the Incident Data System (IDS) for ecological incidents involving the nine pyrethrins/pyrethroids were completed. Due to the nature of ecological incident reporting, absence of incidents cannot be construed as absence of reported incidents. In addition, though effects other than survival, reproduction, and growth may be considered, rarely are they used quantitatively to estimate risks since, in many cases, the relationship between these effects and higher-order processes is uncertain. Rather, these structural and functional changes in organisms may have regulatory significance when combined with other factors and are sometimes considered as valuable lines of evidence in ecological risk assessment and characterization.

Laboratory-derived toxicity values include estimates of acute mortality (*e.g.*, LC_{50}) and estimates of effects due to longer term, chronic exposures (*e.g.*, NOAEC, LOAEC). The latter can reflect changes seen in mortality, reproduction, or growth. In general, for a given assessment endpoint, the lowest (*i.e.*, most sensitive) relevant measure of effect is used in estimating the RQ. Examples of assessment endpoints and their respective measures of effect are listed in **Table 11** below.

Table 11. Summary of measures of exposure and effect for assessing the environmental risk of the non-agricultural (residential, commercial, turf, ornamentals) uses of pyrethroids and pyrethrins

Assessment Endpoint	Measure of Exposure	Measure of Effect
3. Survival and reproduction of individuals and communities of freshwater fish[1] and invertebrates.	Peak surface water EEC, 21-day average EEC, 60-day average EEC	3a. Most sensitive freshwater vertebrate acute LC_{50} 3b. Most sensitive freshwater vertebrate chronic NOAEC and LOAEC 3c. Most sensitive freshwater invertebrate acute LC_{50} or EC_{50} 3d. Most sensitive freshwater invertebrate chronic NOAEC and LOAEC
4. Survival and reproduction of individuals and communities of estuarine/marine fish and invertebrates.	Peak surface water EEC, 21-day average EEC, 60-day average EEC	4a. Most sensitive estuarine/marine vertebrate acute LC_{50} 4b. Most sensitive estuarine/marine vertebrate chronic NOAEC and LOAEC 4c. Most sensitive estuarine/marine invertebrate acute LC_{50} or EC_{50} 4d. Most sensitive estuarine/marine invertebrate chronic reproduction NOAEC and LOAEC
7. Maintenance and growth of individuals and populations of aquatic vascular and non-vascular plants	Peak surface water EEC	7a. Vascular plant EC_{50} values based on yield and growth rate 7b. Nonvascular plant EC_{50} values based on cell density, growth rate, and biomass 7c Vascular plant NOAEC values based on yield and growth rate 7d Non-vascular plant NOAEC values based on cell density, growth rate, and biomass

LD_{50} = Lethal dose to 50% of the test population; NOAEC = no-observed adverse effect concentration; LOAEC = lowest-observed adverse effect concentration; LC_{50} = lethal concentration to 50% of the test population; $EC_{50/25}$ = effect concentration to 50/25% of the test population.

[1] According to EFED risk assessment guidance, freshwater fish may be used as surrogates to aquatic phase amphibians.

5 Exposure Assessment

5.1 Use and Usage Information

5.1.1 California and U.S. Usage Surveys

In this section, a number of use/usage surveys are summarized in approximate chronological order. In 2001-2005 and 2009, surveys were conducted in California, while in 2013, a national survey excluding California was conducted. These surveys can potentially help in refining the preliminary estimated exposure concentrations.

5.1.1.1 Early CDPR Surveys (2001-2005)

The California Department of Pesticide Regulation (CDPR) funded a number of use and usage surveys between 2001 and 2005 to get a better understanding of the pesticide use pattern in urban environments. The 2001 survey, involved the San Diego Creek and East Costa Mesa/Newport Beach watershed areas of Orange County, CA. A majority of the surveyed people that apply pesticide products (58.3%) reported applications one to three times, or four to six times per year. Another survey was conducted in 2002, of residents of the Chollas Creek area of San Diego County and the Delhi Channel area in Orange County. Ants and other insects were the primary target pests. The most frequent use pattern of pesticide application was once every few months (43.1%). Of the responses, 47.2% indicated that they had purchased or used a weed control product, 77.1% indicated that they purchased or used an insecticide, and 32.5% indicated they had purchased or used a product to control plant diseases. The 2003 survey covered the areas of the Arcade Creek watershed in Sacramento, Five Mile Slough watershed in Stockton and San Francisco Bay. From 20-41% indicated they did not apply pesticides in their homes and 37-65% of respondents identified insects as their primary pests of concern. Other pests included snails/slugs (24.4-29.2%) and vertebrates (15-27%). The majority (58-64%) indicated they applied pesticides on hard surfaces such as perimeters of buildings, driveways, sidewalks, or walls; further 44-47% responded that they applied pesticides 1-3 times per year.

The previous surveys examined residential users of pesticides; in contrast, an additional 2005 survey evaluated pesticide use by pesticide managers and applicators in three urban watersheds: Arcade Creek (Sacramento County), Chollas Creek (San Diego County), and Upper Newport Bay/San Diego Creek (Orange County), CA. The CDPR PUR Report database indicated that in 2003 structural PCO use comprised 40% of the total reported non-agricultural use, rights-of-ways (32%), landscape maintenance (15%), public health (12%), and regulatory pest control (1%) in Sacramento, Orange and San Diego Counties. Structural pest control comprised 93-98% of the total insecticide usage. An analysis of usage indicated that organophosphates had been declining and pyrethroids increasing. Right-of-ways accounted for 47-60% of the total herbicide use. The top herbicides used were glyphosate and diuron. Landscape maintenance reported 38-53% of the total herbicide use. The most commonly applied herbicide was glyphosate. San Diego County was the major urban pesticide user (48%), followed by Orange County and Sacramento County.

5.1.1.2 Pyrethroid Working Group Use Surveys (2009-2013)

In response to concerns over increasing pyrethroid use and detections in California, a survey was conducted by Pyrethroid Working Group (PWG) for CDPR in 2009 (MRID 48762913), which assessed pesticide usage by professional pest management companies. Outdoor usage represented 83% of the total pounds of pesticides applied in urban environment, with indoor usage constituting the balance. Taking into account the applications by pest management professionals (PMPs), the application frequency was most common monthly or every other month for residential customers (80% of PMP responses) and monthly for commercial customers (83% of PMP responses) (**Table 12**). For outdoor use, the dominant type of formulations used were liquid sprays (liquids 95% and wettable powder 2%); granules represented 3%, with very small amounts of baits. The

most common equipment used in applying liquid sprays included power sprayers, followed by handheld or back pack sprayers. Granular products were most often used in broadcast application. Treatment types included home or fence perimeter treatments (1-2 feet up and 1-5 feet out, with 1x1 foot being the most common) and/or spot treatment while treatment of the entire yard was less common. Hard surfaces such as patios, outdoor congregation areas and driveways were almost always treated. Less commonly treated areas include walls and uncovered storage. Pest management professionals were asked to name the "Top 5" pesticide products they used, based on volume. The product most commonly named was Termidor (fipronil, named by 73% of respondents). The named products were related to their corresponding active ingredients, which included bifenthrin, fipronil, and deltamethrin (named among the "Top 5" by 60-75% of the pest management professionals surveyed); followed by indoxacarb, *beta*-cyfluthrin, permethrin, cyfluthrin, cypermethrin, *lambda*-cyhalothrin and chlorfenapyr (named among the "Top 5" used by 22-33% of the pest management professionals surveyed); and thiamethoxam, abamectin, and pyriproxyfen (named among the "Top 5" by 2-10% of the pest operators surveyed). Timing of application for most compounds was found to be throughout the year although few compounds were applied more often either in spring and winter or in the summer.

Table 12. Service interval for residential and commercial pesticide accounts

Service Interval	Residential (%)	Commercial (%)
Weekly	4	6
Monthly	39	83
Every other month	41	7
Quarterly	12	0
Other	0	4

Another survey of pest control operators (PCOs) and lawn care operators (LCOs) was sponsored by PWG in 2013 (Winchell and Cyr, MRID 49292101). The survey covered six national regions, excluding California and included both PCOs and LCOs. Pyrethroids were associated with 58% of the outdoor insecticide applications overall for all regions. Overall, for all regions the percentage uses were bifenthrin (40%), cyfluthrin/*beta*-cyfluthrin (17%), *lambda*-cyhalothrin (12%), deltamethrin (11%), permethrin (9%), cypermethrin (8%), and other pyrethroids (2%). The percent of LCOs and PCOs that applied each pyrethroid active ingredient, by use site, is depicted in **Figure 2**. Several types of surfaces were investigated of which only a selection is presented in the figure.

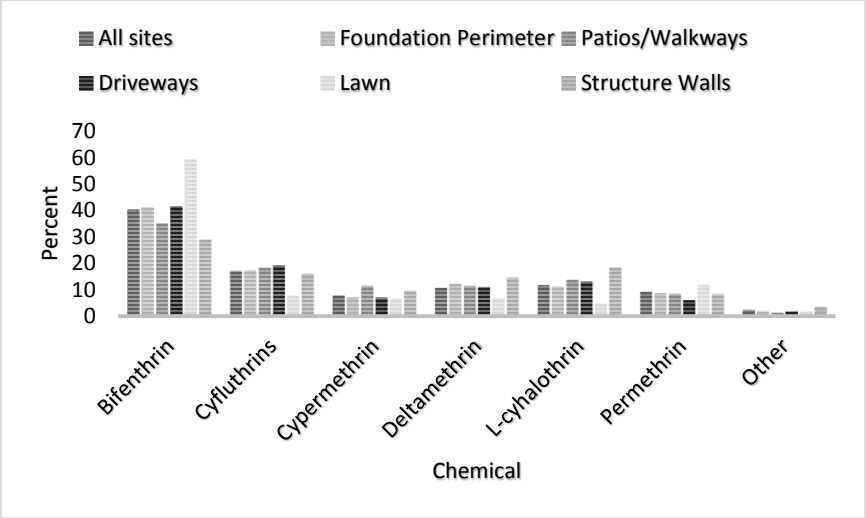


Figure 2. Percent of Respondents' Pyrethroid Active Ingredient Use in Outdoor Applications by Selected Use Sites, Excluding California

The percent applying pyrethroids to different types of surfaces in an urban environment, including California, is depicted in **Figure 3**. By far, the foundation perimeter treatments are the most commonly applied by PCOs. Note that all regions, except California, receive approximately the same percent of building foundation perimeter treatments. Meanwhile, lawn treatments are lower. One reason for the difference in California could be that the methodology to estimate California use was different since the questions asked to PCOs and LCOs were different in the surveys. The foundation perimeters treatment represented an estimated value since this specific question was not asked in California.

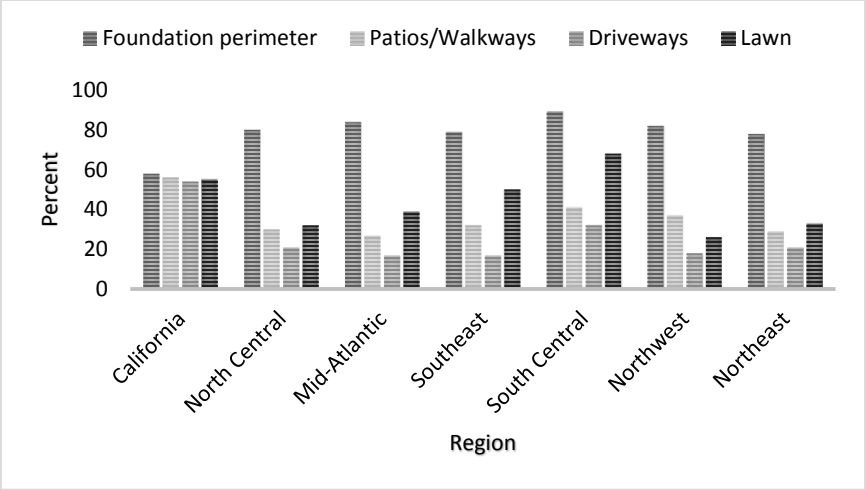


Figure 3. Percent of PCOs and LCOs Applying Pyrethroids to Selected Sites by Region

The overall number of applications per year, average area treated, and the active ingredient most commonly used on each of the use sites for all regions, except California, are summarized in **Table 13**. Each use site receives on average close to 4 applications per year although the foundation perimeters are treated more often than other use sites, and the

fraction of the use site ranges from 36% (driveways away from the garage door or wall) to 77% for lawns. The active ingredient most commonly applied is bifenthrin, irrespective of the use site.

Table 13. Averages of Treatments Per Year, Fraction of Use Site Surface Area Treated and Pyrethroid Active Ingredient Most Commonly Used By Use Site in Six National Regions, Excluding California

Use Site Type of Surface	Average Number of Treatments Per Year	Fraction of Use Site Surface Area Treated	Most Commonly Used Active Ingredient
Building foundation perimeters	4.25	2.4 ft up; 2.9 ft out	Bifenthrin
Patios and walkways away from building	3.73	44%	Bifenthrin
Driveways away from the garage door and wall	3.66	36%	Bifenthrin
Lawn	3.62	77%	Bifenthrin
Landscape and ornamental areas	3.82	63%	Bifenthrin
Structure walls	3.71	42%	Bifenthrin
Eaves	3.38	44%	Bifenthrin

Figure 4 summarized for each active ingredient, the frequency by which PCOs and LCOs responded that they used each active ingredient for each region. This figure confirms that bifenthrin is the active ingredient most commonly used. Note the approximately two-fold increase in use of cypermethrin in the south central region, compared to the other regions.

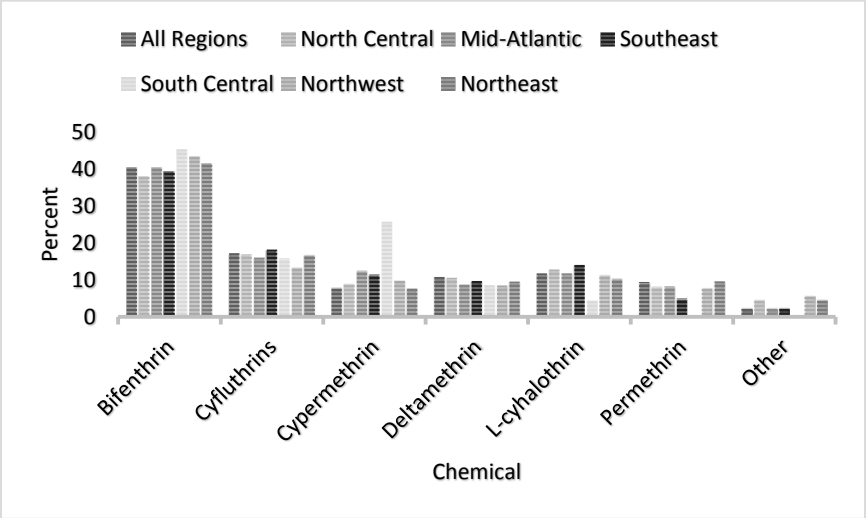


Figure 4. Percent of Respondents' Pyrethroid Active Ingredient Use in Outdoor Applications by Region, Excluding California

These surveys were supplemented by work by Fugate and Hall (2012), which includes frequency of consumer use of specific insecticides, in and around homes, outdoor non-plant, and lawn and garden in 2011. (This report was not provided to the USEPA. Rather,

certain data was extracted and provided in MRIDs 49292101 and 49292102.) Nationally, the likelihood of consumer use of LCO services to apply fertilizer and chemicals is 14% and consumer use of PCO services is 26%. The likelihood of a consumer to purchase lawn and garden insecticides is 31% and outdoor non-plant insecticides is 15%. The likelihood of a consumer applying lawn and garden insecticide is 47% and outdoor non-plant insecticides is 28%. Bifenthrin is the insecticide most likely to be purchased, followed by *lambda*-cyhalothrin.

Winchell (in MRID 49292102) provided an interpretation of the following studies: MRIDs 48762913, 49292101, Wilen (2001 and 2002), and the work by Fugate and Hall (2012). Winchell used certain data manipulations to derive suitable variables, with the potential to be useful in modeling for aquatic exposure in an urban environment. These manipulations were different for California than for other regions of the U.S. due to differences in survey design. These variables for aquatic modeling include: 1) the fraction of the use site treated with each active ingredient; 2) the seasonal application frequency made to each use site; and, 3) the percentage of the use site's surface area that is treated. The work by Fugate and Hall (2012) helped to establish the extent of pyrethroid use in different geographical regions of the U.S. (compared to other insecticides), and the fraction of the households receiving pyrethroid applications outdoors (including PCOs, LCOs, and resident's applications), and to compare against the 2010 and 2013 results. Regarding the frequency of applications, it was estimated that in California, it ranged from 4-8 per year, while in other regions of the U.S., it ranged from 4-5 per year. The percentage of the use site's surface area treated with pyrethroids was not asked in the California surveys and data for other regions of the U.S. would be used to cover California.

5.1.1.3 Value of Surveys

These reports include data on the frequency of homeowners using lawn care or pest control services, the frequency of consumers using outdoor non-plant and lawn & garden insecticides, and data on the frequency of a consumer using specific insecticide active ingredients. The datasets provided the starting point to determine the overall likelihood of an individual homeowner using an applicator service, and then from the survey responses, determine the likelihood by region and use site of the top six pyrethroids being used by both professional applicators and/or homeowners themselves.

Of all the above surveys, it is apparent that the most recent ones, conducted in 2009 and 2013 (MRIDs 48762913, 49292101, and 49292102), with supplemental data from Wilen (2001, 2002), and Fugate and Hall (2012), may be used to estimate the needed usage and the amount of pesticide applied on each use site per region. The studies have the potential to help establish the conceptual model for outdoor pesticide exposure for a variety of outdoor use sites, along with percent/type of areas treated, and, with the help of the washoff studies, the percent of pesticide available for wash-off, and other possible sources of pesticide contamination (*i.e.*, drift, contaminated airborne particles and others). But more than that, they could be used in characterizing and refining exposure and in finding mitigation measures to reduce exposure, such as frequency/seasonality of applications, and most commonly used application rate, frequency of applications, equipment, and

formulations (typical application pattern), percent area treated by each use site, *etc*. Winchell (MRID 49292102) synthetizes previous useful studies in tables that are suitable to do the above tasks for the pyrethroid insecticides.

5.1.2 Non-Agricultural Uses and Considerations

There are a number of non-agricultural use sites for pyrethroids; these include residential, and non-residential developed use sites such as commercial, institutional, industrial premises and equipment, nonagricultural outdoor building structures, as well as general area use, turf and ornamentals. Examination of the application method permitted on current labels for these uses indicate that backpack and hand-held sprayer equipment are among the methods of application in residential settings. It is assumed that spray drift will not occur for hand-held and back pack sprayers. Additionally, ground boom applications may occur in nurseries and with applications to larger golf courses and athletic fields. Finally, some pyrethroid labels for nursery applications also mention airblast equipment (*e.g.*, fenpropathrin). Spray drift may occur with ground boom and airblast equipment. Wide area uses other than turf and ornamentals may occur with ground boom and aerial equipment, which are modeled as a broadcast application like agricultural uses and are not further discussed in this section [agricultural uses of pyrethroids are addressed in **Part III** of the Preliminary Risk Assessment (PRA)].

In addition, examination of the targeted pests (*e.g.*, ants, house flies, fleas, termites, beetles, cockroaches, among others) and type of applications (*e.g.*, drench, crack and crevice, and perimeter) included in the non-agricultural pyrethroids labels suggest that many of the non-agricultural applications are not expected to occur on a large scale (*i.e.*, entire field or watershed). Therefore, these uses are not expected to result in the magnitude of exposure that may result from traditional broadcast applications of pyrethroids to multiple acres of agricultural crops, and treatments are not expected to occur in one day, and as such do not fit the standard modeling paradigm employed by EPA to assess pesticide exposure (*i.e.*, where pesticides are uniformly applied over large areas at specific intervals during a growing season).

To reduce ecological exposure from residential/commercial uses of pyrethroids and pyrethrins products, the Agency revised the "Environmental Hazard Statements" and general "Directions for Use" for these chemical products used in non-agricultural outdoor settings. In January of 2013, minor optional modifications to several labeling statements were approved. These label statements serve to reduce the potential for runoff and drift to water bodies that can result from applications of pyrethroid end-use products in residential, commercial, institutional, and industrial areas, applied by both professional pesticide control operators and residential consumers. The revisions are specified in the revised table of "*Environmental Hazard and General Labeling for Pyrethroid Non-Agricultural Outdoor Products*", provided in a letter dated January 10, 2013 (available at the following URL: http://www.epa.gov/ingredients-used-pesticide-products/environmental-hazard-and-general-labeling-pyrethroid-and, accessed June 15, 2016):

"Do not apply directly to impervious horizontal surfaces such as sidewalks, driveways, and patios except as a spot or crack and crevice treatment. During application, do not allow pesticide to enter or run off into storm drains, drainage ditches, gutters or surface waters."

"All outdoor applications, if permitted elsewhere on this label, must be limited to spot or crack-and-crevice treatments only, except for the following permitted uses, if allowed elsewhere on this label:

1. Applications to soil or vegetation, as listed on this label, around structures;
2. Applications to lawns, turf, and other vegetation, as listed on this label;
3. Applications to the side of a building, up to a maximum height of 3 feet above grade;
4. Applications to underside of eaves, soffits, doors, or windows permanently protected from rainfall by a covering, overhang, awning, or other structure;
5. Applications around potential pest entry points into buildings, when limited to a surface band not to exceed one inch in width;
6. Applications made through the use of a coarse, low pressure spray to only those portions of surfaces that are directly above bare soil, lawn, turf, mulch or other vegetation, as listed on this label, and not over an impervious surface, drainage or other condition that could result in runoff into storm drains, drainage ditches, gutters, or surface waters, in order to control occasional invaders or aggregating pests."

The aforementioned non-agricultural uses of pyrethroids may result in exposure to non-target species and a reasonable upper bound value of the exposure is derived. This is done using an urban exposure conceptual model (based on EPA's residential exposure conceptual model) as described below (**Section 5.3**, "Modeling Approach"). For application rates, methods of application, number of applications, refer to the **Section 5.4** ("Description of Model Inputs").

5.2 Environmental Fate of Synthetic Pyrethroids and Pyrethrins

A brief discussion about some environmental fate properties of the pyrethroids was provided in the **Section 1.2.1** (*Risk Conclusions, Environmental Fate and Transport*). A comprehensive review about the physicochemical and environmental fate properties of several pyrethroids was published back in 2002 (Laskowski, 2002). Since then, during the Registration Review process, new environmental fate studies were requested and submitted to the Agency. See the **Attachment I** for the nomenclature (*e.g.*, common names, chemical names), CAS numbers, as well as structures of the pyrethroids and pyrethrins; refer to the **Attachment III** for detailed environmental fate assessments for individual synthetic pyrethroids and pyrethrins.

5.2.1 Structures and Physicochemical Properties

Many of the pyrethroids consist of racemic mixtures of stereoisomers, or isomer enriched mixtures. The pyrethrins consist of six different compounds derived from certain flowers, and all pyrethrins share the same basic backbone structure. The pyrethrins and synthetic pyrethroids are hydrophobic and/or nonpolar compounds, showing relatively low solubility in water. The octanol/water partition coefficients (K_{OW}'s) for the pyrethroids are high. For example, the range of *Log* K_{OW} values across pyrethroid chemicals (excluding the pyrethrins), from Laskowski (2002) is 4.53 – 7.00; however, in a recently submitted study the range is even higher in magnitude (6.40 – 7.48; MRID 49314702). Based on these properties, there would be a potential to bioconcentrate in fish tissue for these chemicals; however, the fish bioconcentration factors (BCFs) for majority of these compounds are lower than would be predicted based on K_{OW} alone. With certain exceptions, it appears that these compounds undergo metabolism in fish tissue and, undergo relatively rapid depuration.

5.2.2 Persistence

Most pyrethroids are persistent to hydrolysis at pH 7 or lower. With certain exceptions, they are more prone to hydrolyze at higher pH values (*i.e.*, pH = 9). Some of the pyrethroids resist aqueous and soil photolysis (*e.g.*, the aqueous photolysis half-lives for bifenthrin, deltamethrin and permethrin range from 49-94 days); the photolytic behavior depends on the specific pyrethroid (for cypermethrin, esfenvalerate and cyhalothrins the half-lives range from 9-36 days, while for cyfluthrins, pyrethrins and fenpropathrin the half-lives are < 1 day). For the pyrethroids and pyrethrins, the aqueous photolysis component in the overall dissipation of the chemical appears to depend on the level of spray drift, as compared to the erosion and runoff. Pyrethroid in eroded material and runoff may be bound to particulate or dissolved organic matter, reducing their availability for direct aqueous photolysis. For example, fenpropathrin is one of the most persistent pyrethroids in soil and sediment; however, it photolyzes relatively rapidly in water. Aqueous photolysis occurs typically in the surficial level of bodies of water.

Other routes of dissipation of pyrethroids are aerobic soil and aquatic metabolism, and soil binding. Pyrethroids are moderately to relatively highly persistent to metabolism (half-lives used as input parameters are usually ≥60 days in soil and sediment/water systems[4]). Pyrethroids are usually more persistent in anaerobic than aerobic aquatic environments (exceptions are cyfluthrin and fenpropathrin). **Table 14** gives a comparative summary of the aerobic soil, aerobic aquatic, and anaerobic aquatic metabolism input values used in the aquatic model PWC, derived using current input parameter guidance. For additional details, see the tables of input values for each pyrethroid and pyrethrins in **Section 5.4** (*Description of Model Inputs*). Based on the table's input values, the most persistent

[4] Although EFED has not adopted a definitive persistence criteria, the one by the PBT profiler was used as a broad reference: at http://www.pbtprofiler.net/details.asp (accessed April 4, 2016). PBT = persistent, bioaccumulative, toxic. It should be noted that the use of the PBT Profiler criteria in this document does not mean that pyrethroids are PBT compounds.

pyrethroid under aerobic soil metabolism conditions is fenpropathrin; under aerobic aquatic metabolism conditions, the most persistent pyrethroids are bifenthrin and fenpropathrin; and finally, under anaerobic aquatic metabolism conditions, the most persistent pyrethroids are bifenthrin, *lambda*-cyhalothrin and fenpropathrin. For sediment dwelling organisms, the zone that they live in and churn remains mainly aerobic because of the organisms' activity. From **Table 14**, it should be noted that the pyrethrins are less persistent than the eight synthetic pyrethroids included in this assessment. Pyrethrins are also the least persistent compounds to aerobic soil and aerobic aquatic metabolism conditions. Even though it appears that the pyrethrins show persistence under anaerobic conditions, it should be noted that the input value of 258 days is the result of application of a 3X uncertainty factor, since there is only one value available (86 days x 3).

Table 14. Comparison of aerobic soil, aerobic aquatic and anaerobic aquatic metabolism half-lives for Pyrethroids and Pyrethrins

Chemical	Aerobic Soil Half-lives (days); No. of Obs.[1]	Aerobic Aquatic Half-lives (days); No. of Obs.[1]	Anaerobic Aquatic Half-lives (days); No. of Obs.[1]
Aerobic aquatic metabolism half-life is less than the anaerobic aquatic metabolism:			
Pyrethrin 1[2]	7.26 (0.525-9.5); n=4	10.3 (5.37-10.5); n=3	258 (86); n=1
Bifenthrin	169 (97-250); n=7	466 (92.9-276); n= 2	650 (587-618); n=2
Deltamethrin	50.5 (22-54.6); n=6	86.1 (9.29-120); n=4	139 (60.7-98.9); n=2
Permethrin	211 (8.70-305); n=4	56.7 (6.91-63.0); n=4	193 (82.0-185); n=3
Cypermethrin	219 (73); n=1	25.5 (9.5); n=1	53.1 (17.7) n=1
Lambda-cyhalothrin	52.0 (28.2-60.5); n=5	47.9 (21.1-52.9); n=4	6080 (57.7-6320); n=3
Esfenvalerate	225 (75); n=1	80.4 (17.2-48.2); n=2	138 (11.5-73.7); n=2
Aerobic aquatic metabolism half-life is greater than the anaerobic aquatic metabolism:			
Cyfluthrin	72.7 (14.4-123) n=9	44.6 (8.44-44.8) n=3	25.6 (9.41-26.2) n=3
Fenpropathrin	497 (155-709); n=4	1168 (88.7-618); n=2	674 (67-1250); n=3

1 Half-lives in these cells provide the input value used in the aquatic modeling, followed by the range of individual values in parenthesis, and the number of observations (n). The majority of these half-lives are at 20 or 25°C.

2 Pyrethrin 1 is one of six pyrethrins, which was used as a surrogate for all the pyrethrins in the environmental fate laboratory studies.

It has been found that for the pyrethroids and pyrethrins, their metabolites are usually the product of the broken ester link: an acid and an alcohol as a result of the ester hydrolysis. These metabolites are usually less persistent and less toxic than the parent compound. The degradates are not considered stressors of concern. Therefore, for the pyrethroids, only the parent compound is considered the stressor in this assessment.

In a number of the pyrethroid metabolism studies, relatively high levels of unextracted radioactivity were observed. In this PRA, fenpropathrin was considered an example chemical for modelling the total potentially toxic residues that include the unextracted residues besides the parent compound alone. Due to their large sorption coefficients, high levels of unextracted residues may be expected for these chemicals.

5.2.3 Mobility and Transport

The pyrethroids and pyrethrins show high organic carbon partition coefficients (K_{OC}s) in laboratory experiments, suggesting a high tendency to sorb with organic carbon in soil, sediments, and dissolved organic carbon, or particulate matter in the water environment. According to Laskowski (2002), the mean K_{OC} values range from 39,100 to 704,000 L/kg$_{OC}$, for seven of the pyrethroids, excluding esfenvalerate (for which no data was available at the time). Since then, a study is now available that yielded a mean K_{OC} of 252,000 L/kg$_{OC}$ for esfenvalerate. For pyrethrin 1 (the representative pyrethrin used in the environmental fate studies, the mean K_{OC} was 35,200 L/kg$_{OC}$. In a newer supplemental batch equilibrium study (MRID 49544001), K_{OC}s were measured for nine synthetic pyrethroids supported by PWG, in two sediments that were also used in a number of laboratory sediment toxicity studies: one sediment from Glenn Charlie Pond (GCP) and an OECD formulated sediment. Three types of K_{OC}s were derived from the available data as follows: (1) standard liquid-liquid extraction method, which measures the total dissolved pyrethroid concentration in water (K_{OC_LLE}); (2) measurement using solid phase micro-extraction (SPME), which yields the freely dissolved pyrethroid concentration in water ($K_{OC_SPME_FREE}$), and finally (3) one in which the concentrations of the pyrethroid and its deuterated analog internal standard (pyrethroid-d_6) are measured/compared, using SPME. Their ratio is proportional to the total pyrethroid concentration ($K_{OC_SPME_TOTAL}$). The K_{OC_LLE} and the $K_{OC_SPME_TOTAL}$ are the same in theory. The K_{OC_LLE} and $K_{OC_SPME_TOTAL}$ values from this study were higher than the ones reported in Laskowski (2002) and studies available in house. The $K_{OC_SPME_FREE}$ were even higher, compared against the K_{OC_LLE} and $K_{OC_SPME_TOTAL}$ values in all cases (exception for tefluthrin in the GCP sediment, for which the K_{OC_TOTAL} was slightly higher than the $K_{OC_SPME_FREE}$, but of the same order of magnitude). For the pyrethroids tested (excluding tefluthrin, which is not included in this assessment), the mean $K_{OC\ SPME_FREE}$ ranged from 1,124,000 to 6,069,000 L/kg$_{OC}$. Note that these K_{OC}s are about one order of magnitude higher than previously reported by Laskowski (2002). In the study, samples were measured at a single concentration, in triplicate, in lieu of a series of concentrations (*i.e.*, no Freundlich isotherms were generated).

Pyrethroids have a low vapor pressure and Henry's law constants. Given the fact that they sorb strongly to soil particles and to organic matter, volatilization from water and soil surfaces is likely further reduced. In addition, the predicted hydroxyl radical reaction half-lives for pyrethroids is low (< 1 day)[5]. It appears that these short half-lives preclude the potential for long range transport *in the vapor phase* for these compounds. Certain chemicals can travel long distances when bound to air particles, however, to date EFED has not found any evidence in the open literature of long range transport for pyrethroids and pyrethrins.

Once a pyrethroid reaches surface water, the fate of the chemical is of concern since they are highly toxic to fish and aquatic invertebrates. EFED believes that pyrethroids, due

[5] For the pyrethroids, the OH radical reaction is usually ≤0.5 days, with the following exception: cyfluthrin 0.856 days, and fenpropathrin 0.599 days, based on EPI Suite's model estimates (which in turn is based on the assumption of 12-hour days, and 1.5×10^6 OH/cm^3). For the pyrethroids, the ozone reaction is much greater than the OH radical reaction. For pyrethrins the OH radical reaction is only 0.036 days and the ozone reaction is 0.012 days.

to their high level of binding, would remain mainly bound to the sediments, suspended organic and particulate matter, and would dissolve slowly into the water column. The amount of pyrethroid or pyrethrins bioavailable in the water column and pore water is lower than for other classes of chemicals. Organisms that live near the sediments (*i.e.*, benthic organisms) could be particularly at risk. The sediments may serve as reservoirs of pyrethroids, where it appears that they will persist, as shown in an aquatic field dissipation studies conducted with some of the pyrethroids. Further, pyrethroids are not likely to reach subsurface soil environments or ground waters. Terrestrial field dissipation studies conducted with pyrethroids confirm that they remain mostly in the upper soil levels.

For specific environmental fate properties of each of the pyrethroids and pyrethrins used to calculate EECs, refer to the tables in the **Section 5.4** (*Description of Model Inputs*).

5.3 Modeling Approach

EFED currently obtains estimated exposure concentrations (EECs) for uses in residential and commercial areas by modeling the residential and impervious scenarios in the Pesticide in Water Calculator (PWC v.1.5)[6]. The PWC is also used to obtain EECs for turf and nursery uses. For agricultural and certain non-agricultural uses, exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models Pesticide Root Zone Model (PRZM) and Varying Volume Water Body Model (VVWM). A graphical user interface PWC v.1.5 (December 8, 2015), developed by the EPA, was used to facilitate inputting chemical and use specific parameters into the appropriate input files and chemical files. The PWC estimates pesticide concentrations in surface or ground water bodies that result from pesticide applications to land. The calculator was designed for regulatory applications as applied in the Office of Pesticide Programs, USEPA, as well as PMRA, Health Canada. The PWC calculator uses PRZM v.5.02 (December 8, 2015) and the VVWM v.1.02 (December 8, 2015), a replacement for the older EXAMS model. Additional information about EFED's aquatic models is provided in the Agency's website at http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment (accessed June 30, 2016).

5.3.1 Conceptual Model for Residential and Commercial Uses

In order to simulate applications to residential and commercial areas, where the entire field size will not be treated and where the land will be covered by both pervious and impervious surfaces, multiple PWC simulations are performed and the time series are combined (each daily EEC from different time series outputs are added) from the simulations to obtain a final set of exposure estimates for the simulated area. The scenarios simulated and combined and the application rates assumed are described in more detail below.

[6] A new version of the PWC (v.1.52) was issued since the modeling of the pyrethroids was conducted.

The "residential" and various other "urban" use patterns (*e.g.*, commercial) require the PRZM residential, right-of-way (ROW), and impervious scenarios for modeling. The PRZM impervious scenario may be used in the Tier 2 coupled aquatic models PRZM/VVWM (using the PWC v.1.5 graphical user interface) along with the residential and/or other appropriate pervious scenario such as ROW to obtain EECs. Each of the scenarios is run separately. This approach assumes that no watershed is completely covered by either the ¼ acre lot (the basis for the residential scenario) or undeveloped land (the basis for the ROW scenario), for residential and ROW use patterns, respectively. By modeling a separate scenario for impervious surfaces, it is also possible to estimate the amount of exposure that could occur when the pesticide is applied or over-sprayed onto this surface. Using two (*e.g.*, impervious and ROW, or impervious and residential) or three scenarios (*e.g.*, impervious, residential and ROW) in tandem requires post-processing of the modeled output in order to derive a weighted EEC that represents the contribution of both the pervious (*i.e.*, residential and ROW) and the impervious surfaces. Daily EECs from these scenarios can also be weighted and aggregated. The residential pervious and impervious scenarios are parameterized to represent certain California or Texas urban sites. Therefore, for modeling uses in other metropolitan regions not located in California or Texas, the residential pervious (residential, ROW) and impervious scenarios can be run with meteorological files from other locations of the U.S.

5.3.1.1 Homeowner/Residential Urban Exposure Modelling Assumptions

The USEPA developed a standard residential exposure scenario using a quarter acre residential lot (10,890 ft^2), with houses with a 1000 ft^2 footprints, based upon certain Organophosphate Endangered Species Assessments (OP ESAs) work being developed by the Agency. Houses are assumed to be square with sides of 31.6 feet and a 15 feet wide driveway to the house (**Figure 5**).

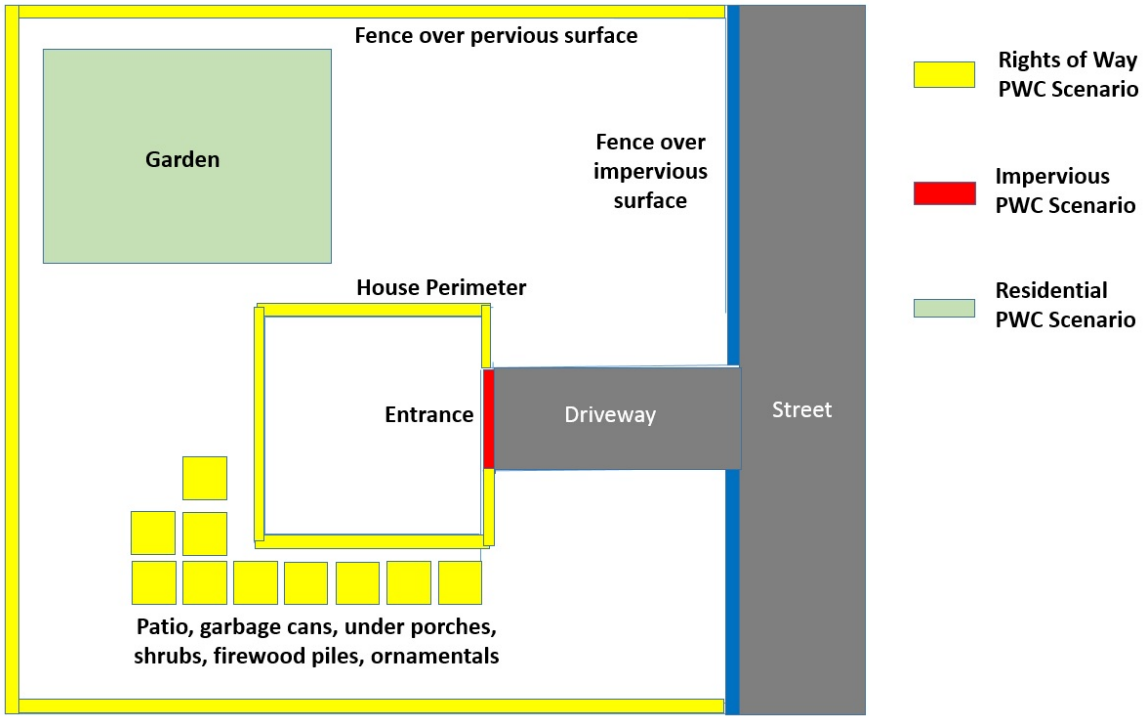


Figure 5. Residential conceptual model of pyrethroids applications (not to scale). PRZM scenarios are represented in green (Residential), yellow (Rights-of-Way), red (Impervious), and white is non-treated area that may be for example, turf. The street is not part of the quarter acre lot.

The perimeter of the house that is treated on sod or lawn (pervious surfaces) within 10 feet of the house foundation is defined by the following equation.

$$\text{Area of the perimeter of the house} = (31.6\text{ ft} \times 2\text{ sides} + (31.6\text{ ft} + 20\text{ ft}) \times 2\text{ sides} - 15\text{ ft driveway}) \times 10\text{ ft} = 1{,}514\text{ ft}^2$$

Where 31.6 ft is the length of the house; and 20 ft is twice the perimeter widths to account for the additional corner areas of the perimeter. There is an additional 3 ft of the walls of the house that is treated which has the potential to wash-off to this same pervious surface area, except for the driveway portion of the wall. Therefore, the area of the wall that is treated is as shown in the following equation.

$$\text{Area of the walls above pervious surfaces} = (31.6\text{ ft} \times 4\text{ sides} - 15\text{ ft driveway}) \times 3\text{ ft} = 334.2\text{ ft}^2$$

Therefore the total area of treatment that may drain through pervious area from perimeter treatment is 1,514 ft^2 + 334.2 ft^2 = 1,848 ft^2 (17.0% of the quarter acre lot). It is assumed that treatment to both horizontal and vertical surfaces (lawn, flower beds, driveway, walls, and garage door) are available to run off the treated area.

Pyrethroids' homeowner use, however, is not limited to perimeter treatment and also

includes patios, garbage cans, under porches, shrubbery, along fences, firewood piles, ornamental vegetation, and gardens. To address these additional uses, additional treated surfaces have been added to the standard residential exposure scenario. To address applications to patios, garbage cans, under porches, shrubbery, firewood piles, and ornamental vegetation, simplifying assumptions were made. It is assumed that the sum of the list of uses encompasses 1,000 ft^2 on a quarter acre lot (9.18% area treated). This is represented in **Figure 5** by ten 100 ft^2 squares and is modeled using the Rights-of-Way scenario.

To address applications along fences, a fence is assumed to surround the quarter acre lot aside from a 15 foot area for driveway access and pyrethroids are assumed to be applied in a two foot swath. Fence along property lines is assumed to be in contact with grass or other pervious surfaces, however, fence facing a road is assumed to be in direct contact with an impervious surface and per current restrictions, should not be treated using broadcast spray. Fences in contact with pervious surfaces are modeled using the PRZM Rights-of-Way scenario (Curve number = 93), to represent surfaces from turf to loose soil to packed soil, while those in contact with impervious surfaces are modeled using the PRZM Impervious scenario (Curve number = 98). Therefore, area of application on a given lot along fences with pervious surfaces modeled using the Rights-of-Way scenario is presented in the following equation. (The area is 608 ft^2, which is 5.58% area treated of the quarter acre lot.)

$$\text{Area of the fence with pervious surface} = (2\text{ ft} \times 104\text{ ft}) + (2 \times 2\text{ ft} \times 100\text{ ft}) = 608\text{ ft}^2$$

For the Impervious scenario, modeled area of application on a given lot along the potential pest entrance points to buildings near the driveway (area shaded red in the figure) with impervious surfaces limited to 1 inch width band, according to the January 2013 restrictions imposed to the labels[7]. According to those restrictions, "All outdoor applications, if permitted elsewhere on this label, must be limited to spot or crack-and-crevice treatments only, except for the following permitted uses, if allowed elsewhere on this label…" Item 5 following the previous sentence is: "5. Applications around potential pest entry points into buildings, when limited to a surface band not to exceed one inch in width…" Therefore, the area for the Impervious scenario is defined by the equation below for pest entry point band treatments. It is acknowledged that crack-and-crevice applications are also possible and were not accounted for in the calculation. (As shown in the equation, the area is only 1.25 ft^2 or 0.0115% area treated of the quarter acre lot.)

$$\text{Area treated at the pest entry point} = 1\text{ in} \times \left(\frac{1\text{ ft}}{12\text{ in}}\right) \times 15\text{ ft} = 1.25\text{ ft}^2$$

To address applications to home gardens, the Health Effects Division's (HED) recommended point estimate for garden size of 1,200 ft^2 is used (USEPA, 2012). This

[7] See the following site accessed November 20, 2015: http://www2.epa.gov/ingredients-used-pesticide-products/environmental-hazard-and-general-labeling-pyrethroid-and. This restriction excludes spot and crack & crevice.

garden size fits reasonably within the established quarter acre lot seen in **Figure 5** and is modeled using the PRZM Residential scenario (Curve number = 83).

For modeling purposes, all uses with like scenarios and like application rates are summed. House perimeter treatments, fences over pervious surfaces, patios, garbage cans, porches, shrubs, firewood piles, and ornamentals are modeled with the Rights-of-Way scenario. As calculated above, house perimeter treatment accounts for 17.0% of the quarter acre lot. Fences over pervious surfaces account for 608 ft^2 of treated area or 5.58% of the quarter acre lot. Patios, garbage cans, porches, shrubs, firewood piles, and ornamentals account for 1,000 ft^2 of treated area or 9.18% of the quarter acre lot. Together, these Rights-of-Way PRZM scenario uses account for 31.8% of the total area of the quarter acre lot. The point of entry band treatment over impervious surfaces account for 1.25 ft^2 of treated area or 0.0115% of the quarter acre lot. The garden use accounts for 1,200 ft^2 of treated area or 11.0% of the quarter acre lot, which is the only use modelled by the Residential PRZM scenario. **Table 15** summarizes theses uses and adjusted percent area treated or percent use areas.

Table 15. Percent area treated for each of the available scenarios, and uses included, for the Residential lot, based on the quarter acre lot

ID\PRZM Scenario	Residential	Rights-of-Way	Impervious
Included uses	Garden/ Ornamentals	House perimeter (perimeter + walls above the perimeter = 17.0%), along fences over pervious surfaces (5.58%), patios, garbage cans, under porches, shrubbery, firewood piles, ornamental vegetation (9.18%)	Along the point of entry over impervious surfaces
Percent Area Treated	11.0%	31.8%	0.0115%

5.3.1.2 Commercial/Institutional Urban Exposure Modelling Assumptions

An urban exposure conceptual model was developed to assess exposure to pyrethroids from urban use sites where applications may occur. Use of this conceptual model is considered more realistic than assuming that the entire watershed is treated with pyrethroids (*e.g.*, the entire watershed consists of an impervious surface and it is treated at the maximum rate for impervious surfaces). Instead, specific areas of the quarter acre lot are treated. For the commercial lots, the assumption is that the commercial non-agricultural buildings or areas (*i.e.*, the footprint) may also be represented by a scenario resembling the residential lots previously described (**Figure 6**). Exposure estimates for each non-agricultural use are derived individually. In some cases, an aggregation of multiple scenarios (developed or pervious, and impervious) was used in a summation approach. The summation is done by means of an Excel spreadsheet file. An explanation of the assumptions for building perimeter, utilities, and trash bins for model simulation is provided below. It is possible that multiple urban pyrethroids may occur within an urban watershed. The contribution of other pyrethroid uses such as run-off and erosion from ornamentals that may also occur in urban environments are not considered in the urban exposure model. These applications, could result from treatment over a larger area such as a park or nursery. Therefore, such uses are considered separately and are expected to provide a higher exposure estimate on a broader scale than the uses aggregated as part of

this urban exposure model.

The urban exposure conceptual model (**Figure 6**.) consists entirely of quarter acre (10,890 ft^2; 104.36 ft x 104.36 ft) lots. Each lot contains one 1000 ft^2 commercial or institutional building. The building is assumed to be a square with sides of 31.6 feet, with three doors, one of which is in the back of the building, leading to the trash storage area as depicted in **Figure 6**. The building is surrounded by grassy landscape 3 ft wide, which in turn is surrounded by a parking lot and a driveway. In addition, adjacent to the building's back door is a trash storage area that is assumed to be 15 ft x 25 ft. Behind the lot is a utility easement, 10 feet wide, that runs the entire length of the property. The contribution or adjusted percent area treated of each of the corresponding pyrethroid uses is described below.

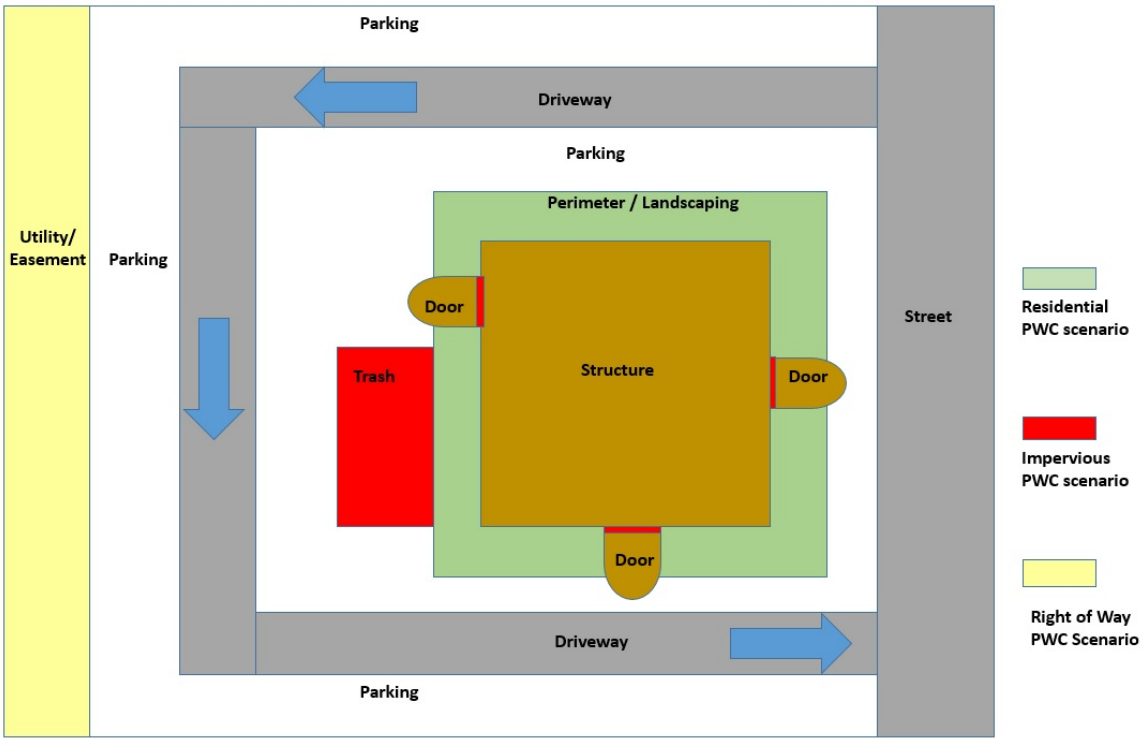


Figure 6. Urban lot conceptual model of pyrethroids applications (not to scale). PRZM scenarios are represented in green (Residential), yellow (Rights-of-Way), red (Impervious), and white is the non-treated area. The street is not part of the quarter acre lot.

Calculation of the adjusted percent area treated for outdoor commercial applications of pyrethroids is based on a 3 feet perimeter band (soil broadcast; pervious surface) treatment adjacent to a building along with a 3 feet high of the wall treatment as shown in the following equation.

<u>Perimeter</u>

$$[(31.6\text{ ft} \times 2\text{ sides}) + ((31.6\text{ ft} + 6\text{ ft}) \times 2\text{ sides}) - 2.5\text{ ft} \times 3\text{ doors})] \times 3\text{ ft} = 392.7\text{ ft}^2$$

Percent area treated = 392.7 ft^2/10,890 ft^2 = 0.0361 = 3.61%

Walls (Foundation)

$$(31.6 \text{ ft} \times 4 \text{ sides} - 2.5 \text{ ft} \times 3 \text{ doors}) \times 3 \text{ ft} = 356.7 \text{ ft}^2$$

Percent area treated = 356.7 ft^2/10,890 ft^2 = 0.0328 = 3.28%

The total area that may be treated with perimeter treatment of pyrethroids, and drain through a perimeter and foundation area, is 392.7 ft^2 + 356.7 ft^2 = 749.4 ft^2, assuming that 100% of the pyrethroids applied to both horizontal (soil/lawn) and vertical surfaces (walls/foundation) are available to run off the treated area. The perimeter treatment and the foundation application were assessed using a post processing strategy to combine contributions that result from application to developed (pervious) and impervious areas, adjusting by the percent area treated. Adjusted percent areas treated are summarized in **Table 16** by use site and urban scenario [impervious or pervious (residential or right-of-way)].

The contribution of a targeted pyrethroids spray application to trash storage area in an urban setting is derived using the calculation below (impervious surface) and the percent area treated is provided in **Table 16**. No over spray to adjacent areas is assumed.

Impervious (doors)

$$(2.5 \text{ ft} \times 3 \text{ doors storage area}) \times 1 \text{ in} \times \left(\frac{1 \text{ ft}}{12 \text{ in}}\right) = 0.625 \text{ ft}^2$$

Percent area treated = 0.625 ft^2/10,890 ft^2 = 5.74×10^{-5} = 0.00574%

Where 2.5 ft x 3 is the doors. These distances are multiplied by 1 inch band to get the surface area treated.

Impervious (trash treated as spot treatment)[8]

$$25 \text{ ft} \times 15 \text{ ft} = 375 \text{ ft}^2$$

Percent area treated = (375 ft^2/10,890 ft^2) = 0.0344 = 3.44%

The total impervious area treated is 0.625 ft^2 + 375 ft^2 = 375.6 ft^2. The adjusted percent area treated is 375.6 ft^2/10,890 ft^2 = 0.0345 = 3.45%.

Certain pyrethroids may be applied to utility/easement or similar areas. Applications to a 10 feet utility pad or easement the length (104.36 ft) of the property with a 2 ft spray buffer on either side of the easement is estimated based on the equation below and the adjusted percent area treated also provided in **Table 16**.

$$(104.36 \text{ ft} \times (10 \text{ ft} + 4 \text{ ft})) = 1461 \text{ ft}^2 \text{ (developed or ROW scenario)}$$

Percent area treated = 1461 ft^2 / 10,890 ft^2 = 0.134 =13.4%

[8] A spot treatment is defined here as an application to a small, localized area (generally not to exceed 1000 ft^2 per acre) where pests are found). Even though the area treated per acre will be 1500 ft^2, the results will be considered as upper bound values.

Table 16. Percent area treated for each of the available scenarios, and uses included, for the Commercial lot, based on quarter acre lots

ID\PRZM Scenario	Residential	Impervious	Rights-of-Way
Included uses	Area in the perimeter of the building (12.5%), foundation/ wall over the lawn (2.65%).	Doors area surrounding the trash (0.00574%), trash areas treated as spot treatments (3.44%)	Utility/ easement (13.4%)
Percent Area Treated	15.2%	3.45%	13.4%

5.3.1.3 Number of Quarter Acre Lots in a 10 ha Watershed

An estimate of the number of residential lots in a 10 ha watershed has been previously evaluated for California Red Legged Frog (CRLF) and other endangered species assessments [*i.e.*, Appendix G of "*Potential Risks of Alachlor Use to Federally Threatened California Red-legged Frog (Rana aurora draytonii) and Delta Smelt (Hypomesus transpacificus)*", USEPA 2009]. The assumption previously made was 58 lots arranged in 10 lot blocks. See **Figure 7** for a general conceptual model of the 10 ha watershed containing 58 lots.

There are 10,890 ft^2/lot x 58 lots in 10 ha = 631,620 ft^2 out of a total of 1,076,391 ft^2/ watershed (*i.e.*, 10 ha), the adjustment factor is 0.587. For simplicity, the same adjustment factor is assumed for the commercial lots. The adjusted percent area treated presented in **Table 17** is based on the correction for a factor of 0.587 (*i.e.*, 58.7%).

Table 17. Adjusted percent area treated of the watershed for each of the available scenarios, and uses included, for the Residential and Commercial lots, assuming 58 quarter acre lots in the 10-ha watershed

ID \ PRZM Scenario	Residential	Rights-of-Way	Impervious
Adjusted Percent Area Treated Assuming 58 Residential Lots in the Watershed	6.45%	18.6%	0.00674%
Adjusted Percent Area Treated Assuming 58 Commercial Lots in the Watershed	8.89%	7.87%	2.03%

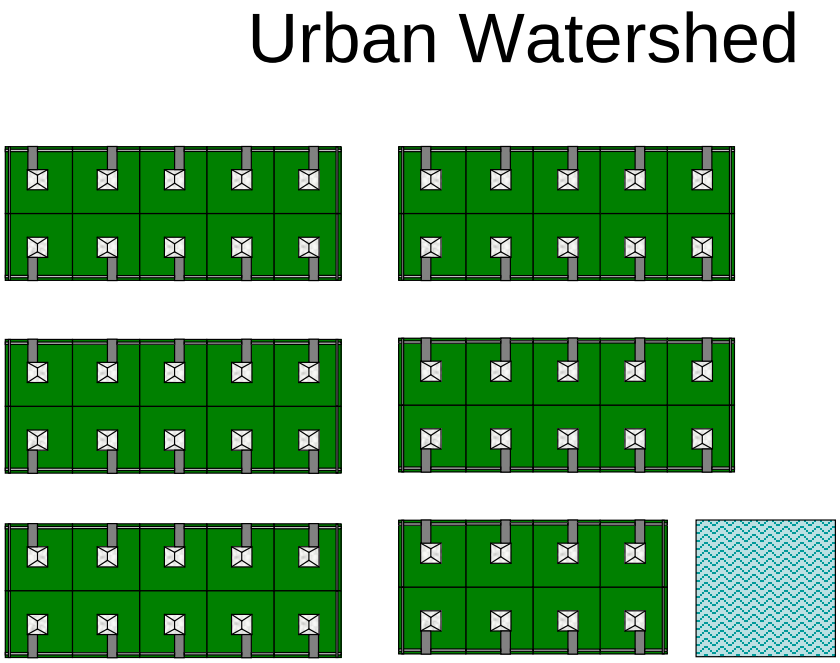


Figure 7. Schematic for a representative suburban watershed for use in assessing risks to the Pyrethroids and Pyrethrins ecological risk assessment

5.3.2 Pathway Identification Study

The main objective of this study (Davidson *et al.* in MRID 49137401; and Davidson *et al.* 2014) was to identify the major transport mechanisms of pyrethroids from a range of outdoor residential applications and determine the effects of mitigation measures put in place by the USEPA to control off-site transport. The study was conducted at a test facility which represented typical California residential developments. It consisted of six replicate house lots which included front lawns, stucco walls, garage doors, driveways and residential lawns. The off-site movement of different pyrethroids applied to these surfaces (representing pervious and impervious surfaces) was assessed using irrigation and simulated artificial rainfall to complement the natural rainfall events. The results showed that natural and simulated rainfall events contributed to the majority of mass loss compared to the mass loss due to lawn irrigation. Runoff losses expressed as a percentage of chemical applied were highest for the driveway and garage door surfaces compared to grass lawn, grass perimeter and house wall surfaces. Also, a comparison of historic applications with revised application due to label changes showed that the amount of losses from garage and driveway were dramatically reduced (40 times lower) using the revised application practices.

5.3.3 Washoff/Runoff Study from Impervious Surfaces

This study's objective was to examine the potential for simulated rain to washoff of a representative pyrethroid (cypermethrin) that had been applied to different external building materials using two different representative formulations (Trask *et al.* in MRID 48072902). The building materials selected were those typically used for construction of residential/urban structures in California that may receive applications of pyrethroids. These included: clean painted/unpainted concrete, clean painted/unpainted stucco, clean painted/unpainted wood with a dusty surface, clean vinyl/aluminum siding and clean asphalt. Washoff quantified as percent of applied mass of cypermethrin ranged from <0.01/0.07 to 16.8/11.3% for the two representative formulations. Clean vinyl siding had the highest percent of applied cypermethrin in runoff whereas clean unpainted stucco had the least amount of cypermethrin in washoff. All building materials had similar runoff volumes except for the clean asphalt which was lower in comparison.

5.3.4 Runoff Losses from Treated Turfgrass

In a 2008 study, the authors examined the potential of pyrethroid insecticide use on turf to contribute to residue detections in Sacramento, CA urban sediments, particularly due to over irrigation (*i.e.*, irrigation producing excess runoff) (Hanzas *et al.* 2011; and MRID 47647801). Model pyrethroids included bifenthrin and *beta*-cyfluthrin in both granular and liquid formulations. Four treated turf plots were prepared, using normal irrigation or three over irrigation events. Runoff flow was measured during the irrigation events and runoff samples taken and analyzed for bifenthrin and *beta*-cyfluthrin. For the bifenthrin over irrigated plots, during the first irrigation event, 0.052-0.081% of the applied chemical was found in runoff, while no reported bifenthrin was found in the non-over irrigated plots. Meanwhile, for *beta*-cyfluthrin, 0.23-0.58% of the applied was found in runoff of the first over irrigation, with no runoff in the non-over irrigated plots. During the normal simulated rainfall event, simulating a winter storm, the amount of chemical present in runoff was much smaller (≤0.011% of the applied for all chemicals and formulations). It was noted that for *beta*-cyfluthrin, the majority of the chemical loss occurred during the first over irrigation event while for bifenthrin the loss was more evenly distributed across three over irrigation events, particularly for the granular formulation.

5.3.5 Potential Refinement for Modelling EECs

The EPA considers the modeling approaches described above and resultant EECs as conservative ("high end") estimates of exposure that consider many factors that affect pesticide concentrations in aquatic systems (*e.g.*, application rates, timing, frequency, weather pattern, soil characteristics, chemical fate properties). However, as they are intended for use in national level assessment, they do not address all relevant factors which may be important in affecting pesticide concentrations on a site-specific basis. There are in addition uncertainties regarding variability in site characteristics that govern runoff, effect of different formulations, types of impervious surfaces, application methods and

timing and national representation of regions with varied landscape, housing density and hydrological features. Therefore, refinement of residential and impervious surface exposure scenarios is needed. This can be done by incorporating recent findings that could be used to accurately parameterize the residential and impervious scenarios used in modeling. This information helps in refinement by providing data necessary to establish national representative scenarios for vulnerable sites. The conceptual model for establishing these standard scenarios involves the following steps:

1. Identify vulnerable urban watersheds based on available monitoring data and different climatic conditions, pesticide pressure, and hydrology;
2. Understand the hydrology of the chosen watersheds especially the drainage system inputs and outputs;
3. Classify each of the chosen watersheds according to land use (commercial, industrial, mixed and others), determine fractions of pervious, impervious surfaces and drainage systems for urban runoff waters;
4. Choose 10-hectare vulnerable areas of the watershed that represent typical residential, commercial, industrial and mixed developments (that is the catchment area for PRZM);
5. Specify the types of surface areas, in the chosen catchments, that would be treated for various label use patterns (*i.e.*, home perimeters patios, driveways, *etc.*) and the fraction of that area that would be treated (*i.e.*, fraction treated for home perimeters patios, driveways, *etc.*);
6. Determine the application rates for the residential and impervious surface exposure scenarios;
7. Adjust the rate for varied impervious surfaces based on available washoff studies (this adjustment would be dependent on the modeled chemicals);
8. Establish a pattern for timing of application within the chosen watershed; and
9. Run PRZM simulations with outputs processed through mixing cells into varied receiving water bodies (urban streams, lakes and rivers) to arrive at exposure EEC averages needed for risk assessment.

Some of these refinements will be considered in the risk characterization section of this Preliminary Risk Assessment.

5.4 Description of Model Inputs

Model input parameters for the synthetic pyrethroids lie in two categories: use information parameters, and environmental fate input parameters. The use information includes the application rate, number of applications, interval between applications, method of application and associated value of spray drift and application efficiency, *etc.* Additionally, the specific modeling scenario for each of the modeled uses: residential, commercial, turf and ornamentals, nursery, and meteorological file are presented. For simplicity, *a single application is assumed* in this assessment, at the maximum labeled application rate or the registrant-proposed maximum application rate, when available from the use summary tables, were used in all simulations for residential and commercial areas. It should be noted that this single application to all lots may be considered conservative,

since even though treatments with pyrethroids may occur more than once per year in a given lot, they would not occur to all lots at the same time. All modelled uses are ground applications. Since in residential and commercial lots hand-held or back pack equipment are generally used, as per the most current guidance, drift was assumed to be negligible. For turf and ornamentals, which could be larger scaled applications, drift may be expected, except for granular applications. As some labels allow for multiple applications, multiple applications were simulated for an example pesticide and for uses (*e.g.*, nursery uses) where a more traditional pesticide modeling simulation would be used.

Additionally, the fate input parameters include for example, the pH 7 hydrolysis, aqueous photolysis, aerobic soil metabolism, aerobic aquatic metabolism, and anaerobic aquatic metabolism representative half-lives, vapor pressure, and solubility.

The tables below provide model input parameters used in this assessment, the sources and justification for the selected values. The first table for each of the chemicals gives information about maximum application rate, number of applications, interval between application, etc. ***Even though the input tables give the maximum number of applications allowed for each chemical, for all chemicals a single application was modeled. The only exception was fenpropathrin, for which a single and multiple applications were modelled.***

Table 18. Pyrethrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): [Non-residential Lawns]	G	0.0071[1]	0.99	0.366 (0.0075 lb/ 1000 ft^2 = 0.327 lb/A)	NS	NS	01-06	0
02 FL turf (TN met file, W13882): [Non-residential Lawns]	G	0.0071[1]	0.99	0.366 (0.327)	NS	NS	01-06	0
RESIDENTIAL								
03 CA residential: [Garden Crops]	G	0	0.99	0.0560 (0.050)	10	3	01-06	0
04 CA ROW: Perimeter Treatment – [Nonagricultural Rights-of-Way; Paths; Patios]	G	0	0.99	0.098 (0.002 lb/ 1000 ft^2 = 0.087 lb/A)	NS	NS	01-06	0
05 CA impervious: Point of Entry – [Doors]	G	0	0.99	0.098 (0.087)	NS	NS	01-06	0
06 BSS residential: [Garden Crops]	G	0	0.99	0.0560 (0.050)	10	3	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment [Nonagricultural Rights-of-Way; Paths; Patios]	G	0	0.99	0.098 (0.087)	NS	NS	01-06	0

Table 18. Pyrethrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
08 BSS impervious: Point of Entry - Doors	G	0	0.99	0.098 (0.087)	NS	NS	01-06	0
09 CA residential (PA met file, W14751): Garden Crops	G	0	0.99	0.0560 (0.050)	10	3	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment [Nonagricultural Rights-of-Way; Paths; Patios]	G	0	0.99	0.098 (0.087)	NS	NS	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry - Doors	G	0	0.99	0.098 (0.087)	NS	NS	01-06	0
COMMERCIAL								
12 CA residential: (FL met file, W12839): [Non-residential Lawn]	G	0	0.99	0.366 (0.0075 lb/ 1000 ft^2 = 0.327 lb/A)	NS	NS	01-06	0
13 CA ROW (FL met file, W12839): Outdoor Institutional [Nonagricultural Rights-of-Way]	G	0	0.99	0.366 (0.327)	NS	NS	01-06	0
14 CA impervious (FL met file, W12839): [Outside Surfaces of Commercial Buildings; Garbage Bins]	G	0	0.99	0.366 (0.327)	NS	NS	01-06	0
NURSERY								
15 OR nursery: Non-residential Ornamentals, Flowering and Foliage Plants	G	0.0045[2]	0.99	0.366 (0.0075 lb/ 1000 ft^2 = 0.327 lb/A)	NS	NS	01-06	0
16 NJ nursery: Non-residential Ornamentals, Flowering and Foliage Plants	G	0.0045[2]	0.99	0.366 (0.327)	NS	NS	01-06	0

Comments: ROW=rights-of-way; G=ground
[1]Assumptions: high boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone.
[2]Assumptions: low boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone.

Table 19. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Pyrethrin 1[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	328.4 g/mole	USEPA 2006[2]
Vapor Pressure	2 x 10^{-5} torr	USEPA 2006[2]
Solubility in Water	0.2 mg/L	USEPA 2006[2]
Photolysis in Water (34°N)	0.49 days	MRID 43096601, 43567501, 43567601 11.8 days for the combination of pyrethrin and the (E)-Isomer of pyrethrin 1; irradiated with sunlight in Irvine, California (33º41' N, 117º15' W)

Table 19. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Pyrethrin 1[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Aerobic Soil Metabolism Half-lives (25°C)	7.26 days	MRID 43499803, 49687101 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 9.5 days at 25ºC, and 5.53, 3.51, 0.742 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 9.5, 3.91, 2.48, 0.525 days; average 4.1038 days; standard deviation 3.8558 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Hydrolysis Half-life at pH 7	0	MRID 43188201, 43567502 Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 10.25 days	MRID 43499802; 49123501 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 10.5 days at 25ºC, and 6.44, 5.37 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 10.5, 3.85, 3.80 days; average 6.050 days; standard deviation 3.8539 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	258 days	MRID 43499801 Single available value multiplied by 3 (86 days x 3).
Soil Water Partition Coefficient (K_F)	301.5 mL/g	MRID 43096603 Average of the following four values: 198, 268, 430, 310 mL/g. The K_F model represents the mobility better than the K_{FOC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_F dataset is less than for the K_{FOC} dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1" dated October 22, 2009.
2 USEPA 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 20. Bifenthrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): Commercial/Industrial Lawns (Non-residential Lawns)	GR	0	1.00	0.448 (0.4)	1	N/A	01-06	0
02 FL turf (TN met file, W13882): Recreation Area Lawns and Recreational Areas (Lawn)	G	0.0071[1]	0.99	0.247 (0.22)	12	7	01-06	0
RESIDENTIAL								
03 CA residential: Residential Lawn	G	0	0.99	0.247 (0.22)	12	7	01-06	0
04 CA ROW: Outdoor Residential Perimeter Treatment	G	0	0.99	0.247 (0.22)	12	7	01-06	0
05 CA impervious: Point of Entry	G	0	0.99	0.247 (0.22)	12	7	01-06	0

Table 20. Bifenthrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
06 BSS residential: Residential Lawn	GR	0	1.00	0.224 (0.2)	2	30	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment	GR	0	1.00	0.448 (0.4)	1	N/A	01-06	0
08 BSS impervious: Point of Entry								
09 CA residential (PA met file, W14751): Residential Lawn	G	0	0.99	0.247 (0.22)	12	7	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment	G	0	0.99	0.247 (0.22)	12	7	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry	G	0	0.99	0.247 (0.22)	12	7	01-06	0
COMMERCIAL								
12 CA residential (FL met file, W12839): Commercial Storage/Warehouse Premises (Lawn)	G	0	0.99	0.247 (0.22)	12	7	01-06	0
13 CA ROW (FL met file, W12839): Outdoor Institutional	G	0	0.99	0.247 (0.22)	12	7	01-06	0
14 CA impervious (FL met file, W12839): Outdoor Institutional, Perimeter Treatment	G	0	0.99	0.247 (0.22)	12	7	01-06	0
NURSERY								
15 OR nursery: Ornamentals	G	0.0045[2]	0.99	0.224 (0.2)	6	7	01-06	0
16 NJ nursery: Ornamentals	G	0.0045[2]	0.99	0.224 (0.2)	6	7	01-06	0

Comments: ROW=rights-of-way; G=ground; GR=granular
[1]Assumptions: high boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone.
[2]Assumptions: low boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone.

Table 21. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Bifenthrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	422.9 g/mole	Laskowski 2002[2]
Vapor Pressure (25°C)	1.80×10^{-7} torr	Laskowski 2002[2]
Solubility in Water (22ºC)	1.4×10^{-4} mg/L	Laskowski 2002[2] (MRID 00132518, Acc. No. 251725)
Photolysis in Water (40°N)	49 days	MRID 48882501
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 169.2 days	Accession No.: 073174, 073225, 141502, 251278, 251728, 254401, 254411, 264642, 532540; MRID 00132540, 00141202, 00152266, 48882502. Represents the 90th percentile of the upper confidence bound on the mean for the following seven values: 97, 116, 155, 128, 132, 250, 111 days at 25°C; average 141.286 days; standard deviation 51.296 days; one sided student's t value $t_{90,n-1}$ = 1.440.
Hydrolysis Half-life at pH 7	0	MRID 00132539, 49138403; Stable

Table 21. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Bifenthrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 466.2 days	MRID 48882504 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 276, 92.9 days at 20°C; average 184.45 days; standard deviation 129.5 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 650.2 days	MRID 49364001 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 587, 618 days at 20°C; average 602.5 days; standard deviation 21.92 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Soil water partition coefficient (K_d)	3104 mL/g	MRID 49175401 Average of the following six values: 3966, 3823, 2458, 2384, 2744, 3250 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset).
Foliar half-life	35	Default value.
Post-harvest foliar pesticide disposition	Surface applied	Default value.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 22. Deltamethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): Commercial/Industrial Lawns (Non-residential Lawns)	G	0.0071[1]	0.99	0.146 (0.13)	10	14	01-06	0
02 FL turf (TN met file, W13882): Recreation Area Lawns and Recreational Areas (Lawn)	G	0.0071[1]	0.99	0.146 (0.13)	10	14	01-06	0
RESIDENTIAL								
03 CA residential: Residential Lawn	G	0	0.99	0.235 (0.21)	6	7	01-06	0
04 CA ROW: Outdoor Residential Perimeter Treatment	G	0	0.99	0.235 (0.21)	6	7	01-06	0
05 CA impervious: Outdoor Residential, Perimeter Treatment	G	0	0.99	0.235 (0.21)	6	7	01-06	0
06 BSS residential: Residential Lawn	GR	0	1.00	0.235 (0.21)	6	7	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment	GR	0	1.00	0.235 (0.21)	6	7	01-06	0
08 BSS impervious								

Table 22. Deltamethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
09 CA residential (PA met file, W14751): Residential Lawn	G	0	0.99	0.235 (0.21)	6	7	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment	G	0	0.99	0.235 (0.21)	6	7	01-06	0
11 CA impervious (PA met file, W14751): Outdoor Residential, Perimeter Treatment	G	0	0.99	0.235 (0.21)	6	7	01-06	0
COMMERCIAL								
12 CA residential (FL met file, W12839): Commercial Storage/Warehouse Premises (Lawn)	G	0	0.99	0.235 (0.21)	6	7	01-06	0
13 CA ROW (FL met file, W12839): Outdoor Institutional	G	0	0.99	0.235 (0.21)	6	7	01-06	0
14 CA impervious (FL met file, W12839): Outdoor Institutional, Perimeter Treatment	G	0	0.99	0.235 (0.21)	6	7	01-06	0
NURSERY								
15 OR nursery: Ornamentals	GR	0	1.00	0.146 (0.13)	10	7	01-06	0
16 NJ nursery: Ornamentals	GR	0	1.00	0.146 (0.13)	10	7	01-06	0

Comments: ROW=rights-of-way; G=ground; GR=granular
[1]Assumptions: high boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone.

Table 23. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Deltamethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	505.2 g/mole	Laskowski 2002[2]
Vapor Pressure (25ºC)	9.32×10^{-11} torr	Laskowski 2002
Solubility in Water (20ºC)	0.000200 mg/L	Laskowski 2002
Photolysis in Water (40°N)	86 days	MRID 42114818 Highest available value. Artificial light was compared to natural sunlight, but the latitude was not stated in the DER. Assumed to be 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 50.5 days	MRID 41677404, 41677405, 42114820 Represents the 90th percentile of the upper confidence bound on the mean for the following six values: 52.5, 54.6, 46.2, 50.2, 22, 26 days at 25°C; average 41.917 days; standard deviation 14.212 days; n = 6; one sided student's t value $t_{90,n-1}$ = 1.476.
Hydrolysis Half-life at pH 7	0	MRID 41651038; Stable
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 86.1 days	MRID 44977005, 48988201 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 25.9, 120.3, 21.2, 9.29 days at 20°C; average 44.1725 days; standard deviation 51.2309 days; one sided student's t value $t_{90,n-1}$ = 1.638. Half-lives based on the sum of deltamethrin plus the *alpha*-R-isomer.
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 138.6 days	MRID 49114109 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 98.9, 60.7 days at 20°C; average 79.8 days; standard deviation 27.011 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	449,000 mL/g_{OC}	MRID 41651039, 42976501 Average of the following four values: 317000, 255000, 516000, 708000 mL/g. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

[1] Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 24. Permethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
TURF								
01 CA turf (MI met file, W14840): [Commercial/Industrial Lawns; Recreation Area Lawns]	G	0.0071[1]	0.99	1.12 (1)	2	NS	01-06	0
02 FL turf (TN met file, W13882): [Golf Course Turf]	G	0.0071[1]	0.99	0.885 (0.7894)	NS	NS	01-06	0
RESIDENTIAL								
03 CA residential: [Residential Lawn]	G	0	0.99	20.2 (18)	NS	NS	01-06	0
04 CA ROW: Outdoor Residential Perimeter Treatment [Household/ Domestic Dwellings Outdoor Premises]	G	0	0.99	19.3 (17.2)	NS	NS	01-06	0
05 CA impervious: Point of Entry [Household/Domestic Dwellings Outdoor Premises]	G	0	0.99	19.3 (17.2)	NS	NS	01-06	0
06 BSS residential: [Ornamental Lawn and Turf]	GR	0	1.00	0.732 (0.6533)	NS	NS	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment [Household/ Domestic Dwellings Outdoor Premises]	GR	0	1.00	0.732 (0.6533)	NS	NS	01-06	0
08 BSS impervious: Point of Entry								
09 CA residential (PA met file, W14751): [Residential Lawn]	G	0	0.99	20.2 (18)	NS	NS	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment [Household/Domestic Dwellings Outdoor Premises]	G	0	0.99	19.3 (17.2)	NS	NS	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry [Household/Domestic Dwellings Outdoor Premises]	G	0	0.99	19.3 (17.2)	NS	NS	01-06	0
COMMERCIAL								
12 CA residential (FL met file, W12839): [Ornamental Lawn and Turf]	G	0	0.99	1.12 (1)	2	NS	01-06	0
13 CA ROW (FL met file, W12839): [Commercial/ Institutional/Industrial Premises/Equipment (Outdoor)]	G	0	0.99	20.4 (18.2)	NS	NS	01-06	0
14 CA impervious (FL met file, W12839): [Commercial/ Institutional/ Industrial Premises/Equipment (Outdoor)]	G	0	0.99	20.4 (18.2)	NS	NS	01-06	0
NURSERY								

Table 24. Permethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
15 OR nursery: [Ornamental/ Herbaceous Plants]	G	0.0045[2]	0.99	0.562 (0.5015)	4	7	01-06	0
16 NJ nursery: Ornamentals	G	0.0045[2]	0.99	0.562 (0.5015)	4	7	01-06	0
Comments: ROW=rights-of-way; G=ground; GR=granular [1]Assumptions: high boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone. [2]Assumptions: low boom height, droplets ASABE Fine to Medium/Course, 90th percentile, 25-ft buffer zone.								

Table 25. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Permethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	391.3 g/mole	Laskowski 2002[2]
Vapor Pressure	1.48×10^{-8} torr	Laskowski 2002[2]; MRID 42109801
Solubility in Water	0.0055 mg/L	Laskowski 2002[2]
Photolysis in Water (40°N)	94 days	MRID 40242801, 49542801 Highest available value.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 211 days	MRID 42410002, 49622001 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 37 days at 25ºC, and 12.3, 50.4, 431 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 37, 8.70, 35.6, 305 days; average 96.575 days; standard deviation 139.559 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Hydrolysis Half-life (at pH 6)	0	MRID 00102043; Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 56.7 days	MRID 43938201, Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 38.18, 42.88 days at 25ºC, and 89.1, 9.77 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 38.18, 42.88, 63.0, 6.91 days; average 37.743 days; standard deviation 23.203 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 193 days	MRID 43982001 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 144 days at 25ºC, and 262, 116 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 144, 185, 82.0 days; average 137.00 days; standard deviation 51.856 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Soil Water Partition Coefficient (K_d)	3186.8 mL/g	MRID 45170102, 49624901 Average of the following nine values: 1450, 1970, 2710, 2530, 5877, 2991, 3373, 411, 7369 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset). Study 41868001 was not found to be appropriate for use in risk assessment.
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

Table 25. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Permethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 26. Esfenvalerate Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): Commercial/Industrial Lawns (Lawn/Turf)	G	0.0616[1]	0.99	0.206 (0.184)	26	14	01-06	0
02 FL turf (TN met file, W13882): Recreation Area Lawns and Recreational Areas (Lawn/Turf)	G	0.0616[1]	0.99	0.206 (0.184)	26	14	01-06	0
RESIDENTIAL								
03 CA residential: Residential Lawn (Lawn/Turf)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
04 CA ROW: Outdoor Residential (Perimeter Treatment)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
05 CA impervious: Point of Entry (Use the Perimeter App Rate)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
06 BSS residential: Residential Lawn (Lawn/Turf)	GR	0	0.99	0.206 (0.184)	26	14	01-06	0
07 BSS ROW: Outdoor Residential (Perimeter Treatment)	GR	0	0.99	0.206 (0.184)	26	14	01-06	0
08 BSS impervious: Point of Entry (Use the Perimeter App Rate)	GR	0	0.99	0.206 (0.184)	26	14	01-06	0
09 CA residential (PA met file, W14751): Residential Lawn (Lawn/Turf)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential (Perimeter Treatment)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry (Use the Perimeter App Rate)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
COMMERCIAL								
12 CA residential (FL met file, W12839): Commercial Storage/Warehouse Premises (Lawn/Turf)	G	0	0.99	0.206 (0.184)	26	14	01-06	0

Table 26. Esfenvalerate Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
13 CA ROW (FL met file, W12839): Outdoor Institutional (Perimeter Treatment)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
14 CA impervious (FL met file, W12839): Outdoor Institutional, Perimeter Treatment (Use the Perimeter App Rate)	G	0	0.99	0.206 (0.184)	26	14	01-06	0
NURSERY								
15 OR nursery: Ornamentals	G	0.0616[1]	0.99	0.108 (0.096)	52	7	01-06	0
16 NJ nursery: Ornamentals	G	0.0616[1]	0.99	0.108 (0.096)	52	7	01-06	0
Comments: ROW=rights-of-way; G=ground; GR=granular [1]Assumptions: high boom height, droplets ASABE Very Fine to Fine, 90th percentile, no buffer zone.								

Table 27. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Esfenvalerate[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	419.9 g/mole	USEPA 2010
Vapor Pressure (25ºC)	4.7 x 10^{-7} torr	46725304, Comb 2002 (6.3 x 10^{-5} Pa, OECD 109)
Solubility in Water	0.006 mg/L	Open Lit., (Laskowski 2002), (European Commission 2005)
Photolysis in Water (40°N)	9 days (all isomers)	MRID 40443801 Use the highest available value among the following: 6 days @ pH 5, SS-isomer, and 9 days, for all isomers. Assumed to be 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	225 days (SS-isomer)	MRID 00146578 Represents EFED's conservative assumption value due to limited studies (based on 1 soil, 75 days x 3)[1].
Hydrolysis Half-life	0	MRID 40999303 Minimal degradation in 30 days for all isomers @ pH 5, 7, 9
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 80.4 days	MRID 49140401 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 17.2 & 48.2 days; average 32.7 days; standard deviation 21.92 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 138.3 days	MRID 49140402 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 11.5, 73.7 days at 20°C; average 42.6 days; standard deviation 43.98 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	251,717 mL/g_{OC}	MRID 45555102 Average of the following six values: 85700, 140000, 141700, 171700, 375000, 596200 mL/g. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

Table 27. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Esfenvalerate[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 28. Cypermethrin (Including *Alpha-*, *Zeta-*) Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): Commercial/Industrial Lawns (Institutional Lawns)	G	0.0616[1]	0.99	0.403 (0.36)	7	2	01-06	0
02 FL turf (TN met file, W13882): Recreation Area Lawns and Recreational Areas (Institutional Lawns)	G	0.0616[1]	0.99	0.403 (0.36)	7	2	01-06	0
RESIDENTIAL								
03 CA residential: Residential Lawn (Outdoor Broadcast)	G	0	0.99	0.403 (0.36)	7	2	01-06	0
04 CA ROW: (Residential Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
05 CA impervious: Point of Entry (Residential Perimeter Treatment)	G	0	0.99	0.90	7	2	01-06	0
06 BSS residential: Residential Lawn (Outdoor Broadcast)	G	0	0.99	0.403 (0.36)	7	2	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment (Residential Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
08 BSS impervious: Point of Entry (Residential Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
09 CA residential (PA met file, W14751): Residential Lawn (Outdoor Broadcast)	G	0	0.99	0.403 (0.36)	7	2	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment (Residential Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry (Residential Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
COMMERCIAL								

Table 28. Cypermethrin (Including *Alpha-*, *Zeta-*) Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
12 CA residential (FL met file, W12839): Commercial Storage/Warehouse Premises (Institutional Turf)	G	0	0.99	0.403 (0.36)	7	2	01-06	0
13 CA ROW (FL met file, W12839): Outdoor Non-Residential (Institutional Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
14 CA impervious (FL met file, W12839): (Outdoor Institutional, Perimeter Treatment)	G	0	0.99	1.01 (0.90)	7	2	01-06	0
NURSERY								
15 OR nursery: Ornamentals (Nursery)	G	0.0616[1]	0.99	0.0538 (0.048)	12	7	01-06	0
16 NJ nursery: Ornamentals (Nursery)	G	0.0616[1]	0.99	0.0538 (0.048)	12	7	01-06	0
Comments: ROW=rights-of-way; G=ground; GR=granular [1]Assumptions: high boom height, droplets ASABE Very Fine to Fine, 90th percentile, no buffer zone.								

Table 29. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cypermethrin and *Zeta*-cypermethrin		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	416.3 g/mole	http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm [2]
Vapor Pressure (@25°C)	1.7×10^{-9} torr	http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm [2]
Solubility in Water (@20°C)	0.009 mg/L	http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm [2]
Photolysis in Water (40°N, @25°C)	36.2 days	MRID 42395701 Assumed latitude of 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	73 days x 3 = 219 days	MRID 42129001 IORE value reported
Hydrolysis Half-life (at pH 7)	210 days	MRID 42620501 Alkaline (pH 9) hydrolysis rate extrapolated to pH 7
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	9.5 days x 3 = 25.5 days	MRID 45920801 Represents the average of two labels (cyclopropyl and phenyl) in one system
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	17.7 x 3 = 53.1 days	MRID 44876105 Represents the combination of two labels (phenyl and cyclopropyl) in one system (clay loam sediment): IORE result
Soil Water Partition Coefficient (K_{OC})	141,700 mL/g_{OC}	MRID 42129003 Average of the following four values: 328,500 (sand), 134,900 (sandy loam), 82,600 (silty loam), 20,800 (clay loam)
Foliar Half-life	35 days	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

Table 29. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cypermethrin and *Zeta*-cypermethrin		
Fate Property	**Value (unit)**	**Source/Comment[1]**

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2. Lewis, K.A., Green, A., Tzilivakis, J. and Warner, D. (2015). The Pesticide Properties Data Base (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2015.
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 30. Cyfluthrin and *Beta*-cyfluthrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): Commercial/Industrial Lawns (Outdoor – Broadcast Turf)	G	0.0616[1]	1.00	0.213 (0.19)	6	7	01-06	0
02 FL turf (TN met file, W13882): Recreation Area Lawns and Recreational Areas (Outdoor – Broadcast Turf)	G	0.0616[1]	0.99	0.213 (0.19)	6	7	01-06	0
RESIDENTIAL								
03 CA residential: Residential Lawn (Residential Turf)	G	0	0.99	0.215 (0.192)	6	7	01-06	0
04 CA ROW: Outdoor Residential Perimeter Treatment (Building Perimeter, Lawn & Ornamentals)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
05 CA impervious: Point of Entry (Building Perimeter)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
06 BSS residential: Residential Lawn (Residential Turf)	G	0	0.99	0.215 (0.192)	6	7	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment (Building Perimeter, Lawn & Ornamentals)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
08 BSS impervious: Point of Entry (Building Perimeter)	G	0	0.99	0.101 (0.09)	24	7	01-06	
09 CA residential (PA met file, W14751): Residential Lawn (Residential T	G	0	0.99	0.215 (0.192)	6	7	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment (Building Perimeter, Lawn & Ornamentals)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry (Building Perimeter)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
COMMERCIAL								

Table 30. Cyfluthrin and *Beta*-cyfluthrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
12 CA residential (FL met file, W12839): Commercial Storage/Warehouse Premises (Commercial Turf)	G	0	0.99	0.215 (0.192)	6	7	01-06	0
13 CA ROW (FL met file, W12839): Outdoor Institutional, Perimeter Treatment (Building Perimeter, Lawn & Ornamentals)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
14 CA impervious (FL met file, W12839): Outdoor Institutional (Building Perimeter)	G	0	0.99	0.101 (0.09)	24	7	01-06	0
NURSERY								
15 OR nursery: Ornamentals (Nursery)	G	0.0616[1]	0.99	0.0538 (0.048)	12	3	01-06	0
16 NJ nursery: Ornamentals (Nursery)	G	0.0616[1]	0.99	0.0538 (0.048)	12	3	01-06	0
Comments: ROW=rights-of-way; G=ground [1]Assumptions: high boom height, droplets ASABE Very Fine to Fine, 90th percentile, no buffer zone.								

Table 31. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cyfluthrin and *Beta*-cyfluthrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1,2,3]**
Molecular Weight	434.29 g/mole	Product Chemistry
Vapor Pressure (25ºC)	1.5×10^{-8} torr	Laskowski (2002)[4]
Henry's Law Constant (25°C)	3.7×10^{-6} Atm·m^3/mol	Laskowski (2002)[4]
Solubility in Water (25ºC)	2.32×10^{-3} ppm	Laskowski (2002)[4] Solubility is low in water and varies between stereoisomers.
Photolysis in Water (38°N)	0.7 days	MRID 45022102 Cyfluthrin degraded with an EFED-calculated first order kinetics nonlinear half-life ($t_{1/2}$) of 0.7 days ($r^2 = 0.93$; linear $t_{1/2} = 4.5$ days, $r^2 = 0.75$). Natural sunlight, 38°N.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ Combined t_{input} = 72.68 days	MRID 00131494, 48350602, 49272603, 49272605, 49272606 Represents the 90th percentile of the upper confidence bound on the mean for the following nine values: 73.5 (cyfluthrin), 94.8 days (cyfluthrin) at 25°C, and 174 (DFOP, *beta*-cyfluthrin), 39.7 (IORE, cyfluthrin), 105 (IORE, cyfluthrin), 25.7 (IORE, *beta*-cyfluthrin), 69.2 (IORE, *beta*-cyfluthrin), 20.6 (IORE, *beta*-cyfluthrin), 20.3 (IORE, *beta*-cyfluthrin) at 20°C; the corrected half-lives at 25°C, are as follows[5]: 73.5, 94.8, 123, 28.1, 74.2, 18.2, 48.9, 14.6, 14.4; average 54.4111 days; standard deviation 39.2291 days; n = 9; one sided student's t value $t_{90,n-1} = 1.397$.
Hydrolysis Half-life	0	00131493, 00137539, 45022101 Stable at pH 5 and 7; 2.1 days at pH 9.

Table 31. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cyfluthrin and *Beta*-cyfluthrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1,2,3]**
Aerobic Aquatic Metabolism[2,3] Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ Combined t_{input} = 44.58 days	MRID 46824101, 49272609 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 10.4 (IORE, cyfluthrin), 55.2 (DFOP, cyfluthrin) days at 22°C; and 27.8 days (IORE, *beta*-cyfluthrin) at 20°C; the corrected half-lives at 25°C, are as follows[5]: 8.44, 44.8, 19.7 days; average 24.3133 days; standard deviation 18.6138 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Anaerobic Aquatic Metabolism[2,3] Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ Combined t_{input} = 25.59 days	MRID 49272610 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 26.2, 10.3, 9.41 days (all half-lives IORE, *beta*-cyfluthrin) at 20°C; average 15.3033 days; standard deviation 9.4473 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	184,864 mL/g_{oc}	MRID 00131495, 00137544, 45022103, 49272602 Average of the following nine values: 124,000, 180,290, 117,946, 73,484, 274,149, 253,221, 226,230, 230,000, and 184,458 mL/g_{oc}. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, and the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35 days	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

[1] Inputs determined in accordance with EFED *"Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-calculate-representative-half-life-values#current
[3] http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/standard-operating-procedure-using-nafta-guidance
[4] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
[5] USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 32. Cyhalothrin (both *Lambda*- and *Gamma*-) Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month)	Incorp. depth (cm)
TURF								
01 CA turf (MI met file, W14840): Commercial/Industrial Lawns (Non-residential Lawns)	GR	0	1.00	0.0874 (0.078)	6	NS	01-06	0
02 FL turf (TN met file, W13882): Recreation Area Lawns and Recreational Areas (Lawn)	GR	0	1.00	0.0874 (0.078)	6	NS	01-06	0
RESIDENTIAL								
03 CA residential: Residential Lawn	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
04 CA ROW: Outdoor Residential Perimeter Treatment	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
05 CA impervious: Point of Entry	G	0	0.99	0.269 (0.24)	7	NS	01-06	0

Table 32. Cyhalothrin (both *Lambda*- and *Gamma*-) Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Non-crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month)**	**Incorp. depth (cm)**
06 BSS residential: Residential Lawn	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
07 BSS ROW: Outdoor Residential Perimeter Treatment	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
08 BSS impervious: Point of Entry	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
09 CA residential (PA met file, W14751): Residential Lawn	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
10 CA ROW (PA met file, W14751): Outdoor Residential Perimeter Treatment	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
11 CA impervious (PA met file, W14751): Point of Entry	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
COMMERCIAL								
12 CA residential (FL met file, W12839): Commercial Storage/Warehouse Premises (Lawn)	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
13 CA ROW (FL met file, W12839): Outdoor Institutional	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
14 CA impervious (FL met file, W12839): Outdoor Institutional, Perimeter Treatment	G	0	0.99	0.269 (0.24)	7	NS	01-06	0
NURSERY								
15 OR nursery: Ornamentals	GR	0	1.00	0.0874 (0.078)	6	NS	01-06	0
16 NJ nursery: Ornamentals	GR	0	1.00	0.0874 (0.078)	6	NS	01-06	0
Comments: ROW=rights-of-way; G=ground; GR=granular								

Table 33. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for *Lambda*- and *Gamma*-cyhalothrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	449.86 g/mole	TOXNET/ HSDB
Vapor Pressure (20°C)	1.56×10^{-9} torr	Laskowski 2002[2]
Solubility in Water (pH 6.5 and 20ºC)	5×10^{-3} mg/L	Laskowski 2002[2]
Photolysis in Water (40°N)	13 days	MRID 46394702
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 52.0 days	MRID 00151607, 44861504, 45447410, 45447411, 45447410. Represents the 90th percentile of the upper confidence bound on the mean for the following five values: 28.2, 36.9, 46.2, 46.8, 60.5 days at 25°C; average 43.72 days; standard deviation 12.09 days; one sided student's t value $t_{90,n-1}$ = 1.533.
Hydrolysis Half-life at pH 7	0	MRID 00151604, 45447409; Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 47.87 days	MRID 44861506, 45447412, 44367402 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 21.1, 34.1, 40.1, 52.9 days at 25°C; average 37.05 days; standard deviation 13.21 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 6084 days	MRID 44367401, 49540101 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 142, 6320, 57.7 days at 25°C; average 2173 days; standard deviation 3591 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Soil water partition coefficient (K_d)	2673 mL/g	MRID 44861503, 45447413 Average of the following 18 K_d values: 3810, 1970, 5880, 2100, 4490, 6890, 7610, 3470, 2400, 4870, 672, 751, 826, 239, 555, 601, 630, 355 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset).
Foliar half-life	35 days	Default value.
Post-harvest foliar pesticide disposition	Surface applied	Default value.

[1] Inputs determined in accordance with EFED *"Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 34. Fenpropathrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC[1]

Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App. (day-month) ***	**Incorp. depth (cm)**	**PHI**
1-7 CA, FL, MI, NJ, OR, TN nursery, TX nursery: Ornamentals (trees, plants, shrubs and vines)	Foliar, G and AB	0.007[2]	0.99	0.34 (0.30)	3	7		0	NA
8-14 CA, FL, MI, NJ, OR, TN nursery, TX nursery: Ornamentals (trees, plants, shrubs and vines)	Foliar, G and AB	0.007[2]	0.99	0.34 (0.30)	24	7		0	NA

Table 34. Fenpropathrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC[1]

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App. (day-month) *	Incorp. depth (cm)	PHI
15 CA residential with w12834 (FL met file): Ornamentals in Commercial/Industrial Areas[3]	Foliar, G	0[2]	0.99	0.0425 (0.04)	3	7		0	NA
16 CA residential with w12834 (FL met file): Ornamentals in Commercial/Industrial Areas[3]	Foliar, G	0[2]	0.99	0.0425 (0.04)	24	7		0	NA
17 CA residential with w12834 (FL met file): Ornamentals in Commercial/Industrial Areas[3]	Foliar, G	0[2]	0.99	0.0425 (0.04)	1	7		0	NA
18-24 CA, FL, MI, NJ, OR, TN nursery, TX nursery: Ornamentals (trees, plants, shrubs and vines)	Foliar, G and AB	0.007[2]	0.99	0.34 (0.30)	1	7		0	NA

Comments: ROW=rights-of-way; G=ground; AB=airblast
*Refer to results tables for specific dates of application.
[1] This table was developed based on the EFED Table 1 report provided by BEAD and dated 1/4/2013 and supplemented with information directly from the label.
[2] While the label currently allows for use of ground boom and airblast equipment, it was assumed that for commercial areas, backpack sprayers or hand-held equipment would be used and no spray drift was assumed. For applications to ornamentals in nurseries, the spray drift fraction reflects spray drift fraction for a ground application, 25-foot buffer between the application and aquatic water body, and a medium to coarse DSD.
[3] Simulation for commercial areas growing ornamentals. Assumed 12.5 percent area treated. The final EEC was not combined with other runs because only one use pattern was applicable to the commercial scenario.

Table 35. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Fenpropathrin[1]

Fate Property	Value (unit)	Source/Comment[1]
Molecular Weight	349.43 g/mole	Laskowski 2002[2]
Vapor Pressure (25°C)	1.39 x 10^{-8} torr	Laskowski 2002[2]
Solubility in Water (22ºC)	10.3 µg/L	MRID 44370001
Photolysis in Water (40°N)	0.125	MRID 49491401 indicates a 3 hour (0.125 day) half-life. MRID 4397227 indicated that fenpropathrin was stable when exposed to natural sunlight in a solution buffered with 8% acetonitrile. The value from the newest available study was used as the model input.

Table 35. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Fenpropathrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 497 days fenpropathrin = 1146 fenpropathrin plus unextracted residues	MRID 15525902, 49316001 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 155 (SFO) at 25ºC, and 386 (Slow DFOP), 709 (Slow DFOP), 702 (slow DFOP) days at 20°C; average (temperature corrected to 25ºC) 356 days; standard deviation 171 days; one sided student's t value $t_{90,n-1}$ = 1.64. For parent plus unextracted residues the corresponding values are 248 at 25ºC, and 633, 1060, and 2030 at 25ºC. Mean=720; standard deviation=520.
Hydrolysis Half-life at pH 7	0	MRID 131438, 141320, 42599901; stable
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 1,168 days for fenpropathrin =87,432 days for fenpropathrin plus unextracted residues	MRID 49316003 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 88.7 (SFO), 618 (T_{IORE}) days for fenrpropathrin (days at 20°C; average 353 days; standard deviation 374 days; one sided student's t value $t_{90,n-1}$ = 3.07; 43,300 (T_{IORE}) and 818 (Slow DFOP) days for fenrpropathrin plus unextracted residues (days at 20°C; average 22,059 days; standard deviation 30,039 days; one sided student's t value $t_{90,n-1}$ = 3.07
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 674 days for fenpropathrin	MRID 49370003, 44370004, 49316004 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 78 and 67 days at 25°C and 1250 at 20ºC. Temperature corrected values for 25ºC; average 129 days; standard deviation 307 days; one sided student's t value $t_{90,n-1}$ = 1.88. Unextracted residues were less than 10% in all systems.
Organic-carbon normalized solid-water distribution coefficient (K_{OC})	207,560 mL/g_{OC}	MRID 49541801 Average of the following five values: 114640, 296784, 136916, 303212, and 186248 mL/g_{OC}. The K_{OC} model represents the mobility better than the $K_d$model (binding does correlate with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset). Values from MRID 44370002 were not used because the equilibrium solution was $Ca(NO_3)_2$.
Foliar half-life	35 days	Value recommended for T-REX model. Deviation from the 2009 input parameter guidance.
Post-harvest foliar pesticide disposition	Surface applied	Default value.
Air Diffusion Coefficient (Cm^2/day)	0	This function was not utilized because significant volatilization was not expected.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. *Rev. Environ. Contam. Toxicol.* 2002; 174:49-170.

5.5 Model Results

The modeling results are presented in **Tables 36 to 45**. The water column and pore water EECs are the freely dissolved pyrethroid or pyrethrin concentrations. This is the fraction of the chemical that is bioavailable.

Table 36. Water Column, Pore Water, and Sediment EECs for Pyrethrins[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
01 CA turf (MI met file, W14840)	G	0.327	01-06	1	N/A	0.132	0.0342	0.0158	0.0105	0.0103	3.17	3.11
02 FL turf (TN met file, W13882)	G	0.327	01-06	1	N/A	0.128	0.0271	0.0126	0.00796	0.00772	2.40	2.33
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.0560, 0.087, 0.087	01-06	1	N/A	2.14×10^{-4}	7.04×10^{-5}	3.68×10^{-5}	2.30×10^{-5}	2.26×10^{-5}	0.00693	0.00681
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	G	0.0560, 0.087, 0.087	01-06	1	N/A	0.0131	0.00394	0.00193	0.00163	0.00157	0.491	0.473
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.0560, 0.087, 0.087	01-06	1	N/A	0.00408	8.92×10^{-4}	4.31×10^{-4}	3.33×10^{-4}	3.50×10^{-4}	0.100	0.106
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.327	01-06	1	N/A	0.0904	0.0210	0.00998	0.00663	0.00646	2.00	1.95
15 OR nursery [Ornamentals]	G	0.327	01-06	1	N/A	0.0895	0.0224	0.0106	0.00749	0.00727	2.26	2.19
16 NJ nursery [Ornamentals]	G	0.327	01-06	1	N/A	0.148	0.0539	0.0288	0.0273	0.0265	8.23	7.99

G=ground

[1] EECs were rounded to three significant figures.

Table 37. Water Column, Pore Water, and Sediment EECs for Bifenthrin[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg-dw)	21-day average EEC (µg/kg-dw)
01 CA turf (MI met file, W14840)	GR	0.4	01-06	1	N/A	0.014 (0.131)*	0.00921	0.00735	0.00738	0.00743	22.9	22.9
02 FL turf (TN met file, W13882	G	0.22	01-06	1	N/A	0.014 (0.0806)*	0.00952	0.00814	0.00783	0.00771	24.4	23.9
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.22	01-06	1	N/A	0.00404	4.57×10^{-4}	3.47×10^{-4}	3.26×10^{-4}	3.25×10^{-4}	1.01	1.01
06, 07 BSS residential, ROW [Residential lots]	GR	0.2, 0.4	01-06	1	N/A	0.014 (0.0652)*	0.00646	0.00478	0.00430	0.00420	13.3	13.0
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.22	01-06	1	N/A	0.014 (0.0193)*	0.00215	0.00211	0.00197	0.00195	6.12	6.04
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.22	01-06	1	N/A	0.014 (0.0203)*	0.00226	0.00185	0.00157	0.00155	4.87	4.81
15 OR nursery [Ornamentals]	G	0.2	01-06	1	N/A	0.014 (0.0498)*	0.00713	0.00630	0.00598	0.00595	18.5	14.4
16 NJ nursery [Ornamentals]	G	0.2	01-06	1	N/A	0.014 (0.593)*	0.014 (0.0597)*	0.014 (0.0477)*	0.014 (0.0449)*	0.014 (0.0444)*	139	138

G=ground; GR=granular

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

Table 38. Water Column, Pore Water, and Sediment EECs for Deltamethrin[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
01 CA turf (MI met file, W14840)	G	0.13	01-06	1	N/A	0.0251	4.25×10^{-4}	2.53×10^{-4}	2.11×10^{-4}	2.03×10^{-4}	95.0	91.4
02 FL turf (TN met file, W13882)	G	0.13	01-06	1	N/A	0.0251	4.57×10^{-4}	2.79×10^{-4}	2.35×10^{-4}	2.25×10^{-4}	106	101
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.21	01-06	1	N/A	1.19×10^{-3}	2.07×10^{-5}	1.40×10^{-5}	1.19×10^{-5}	1.16×10^{-5}	5.34	5.21
06, 07 BSS residential, ROW [Residential lots]	GR	0.21	01-06	1	N/A	0.00904	3.75×10^{-4}	2.11×10^{-4}	1.65×10^{-4}	1.54×10^{-4}	74.0	69.3
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.21	01-06	1	N/A	0.00448	1.23×10^{-4}	9.27×10^{-5}	7.28×10^{-5}	6.99×10^{-5}	32.7	31.3
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.21	01-06	1	N/A	0.200 (0.622)*	0.00828	0.00402	0.00221	0.00211	992	947
15 OR nursery [Ornamentals]	GR	0.13	01-06	1	N/A	0.00311	1.30×10^{-4}	1.13×10^{-4}	9.98×10^{-5}	9.61×10^{-5}	44.9	43.2
16 NJ nursery [Ornamentals]	GR	0.13	01-06	1	N/A	0.121	0.00292	0.00205	0.00172	0.00163	774	734

G=ground; GR=granular

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

Table 39. Water Column, Pore Water, and Sediment EECs for Permethrin[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
01 CA turf (MI met file, W14840)	G	1	01-06	1	N/A	0.378	0.0393	0.0281	0.0262	0.0257	83.5	81.9
02 FL turf (TN met file, W13882)	G	0.7894	01-06	1	N/A	0.286	0.0324	0.0280	0.0240	0.0233	76.5	74.2
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	18, 17.2, 17.2	01-06	1	N/A	0.745	0.0980	0.0757	0.0663	0.0663	211	211
06, 07 BSS residential, ROW [Residential lots]	GR	0.6533	01-06	1	N/A	0.126	0.0124	0.00857	0.00704	0.00687	22.4	21.9
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	18, 17.2, 17.2	01-06	1	N/A	1.70	0.175	0.167	0.148	0.146	472	465
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	1, 18.2, 18.2	01-06	1	N/A	1.04	0.127	0.101	0.0792	0.0775	252	247
15 OR nursery [Ornamentals]	G	0.5015	01-06	1	N/A	0.126	0.0194	0.0172	0.0158	0.0156	50.4	49.7
16 NJ nursery [Ornamentals]	G	0.5015	01-06	1	N/A	1.60	0.157	0.127	0.111	0.109	354	347

G=ground; GR=granular

[1] EECs were rounded to three significant figures.

Table 40. Water Column, Pore Water, and Sediment EECs for Esfenvalerate[1]												
Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
01 CA turf (MI met file, W14840)	G	0.184	01-06	1	N/A	0.0411	0.00111	7.62×10^{-4}	7.2×10^{-4}	7.25×10^{-4}	182	183
02 FL turf (TN met file, W13882)	G	0.184	01-06	1	N/A	0.0355	0.00159	0.00148	0.00119	0.00112	300	283
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.184	01-06	1	N/A	0.00661	3.61×10^{-4}	2.56×10^{-4}	1.92×10^{-4}	1.87×10^{-4}	48.3	47.0
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	GR	0.184	01-06	1	N/A	0.0201	8.33×10^{-4}	5.67×10^{-4}	4.45×10^{-4}	4.15×10^{-4}	112	104
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.184	01-06	1	N/A	0.0140	5.90×10^{-4}	4.10×10^{-4}	3.62×10^{-4}	3.64×10^{-4}	91.1	91.6
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.184	01-06	1	N/A	0.713	0.0131	0.00638	0.00350	0.00336	881	846
15 OR nursery [Ornamentals]	G	0.096	01-06	1	N/A	0.399	0.00879	0.00531	0.0037	0.00361	931	909
16 NJ nursery [Ornamentals]	G	0.096	01-06	1	N/A	0.427	0.0155	0.0117	0.01	0.00954	2520	2400

G=ground; GR=granular

[1] EECs were rounded to three significant figures.

Table 41. Water Column, Pore Water, and Sediment EECs for Cypermethrin[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
01 CA turf (MI met file, W14840)	G	0.36	01-06	1	N/A	0.0942	0.00341	0.00208	0.00172	0.00159	244	225
02 FL turf (TN met file, W13882)	G	0.36	01-06	1	N/A	0.0776	0.00349	0.0037	0.0032	0.00286	453	405
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.36, 0.90, 0.90	01-06	1	N/A	0.0528	3.59×10^{-3}	2.16×10^{-3}	1.53×10^{-3}	1.49×10^{-3}	217	211
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	G	0.36, 0.90, 0.90	01-06	1	N/A	0.126	6.51×10^{-3}	4.29×10^{-3}	2.97×10^{-3}	2.78×10^{-3}	421	394
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.36, 0.90, 0.90	01-06	1	N/A	0.106	5.58×10^{-3}	3.00×10^{-3}	2.08×10^{-3}	2.04×10^{-3}	295	289
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.36, 0.90, 0.90	01-06	1	N/A	4.18	0.110	0.0504	0.0287	0.0264	4067	3741
15 OR nursery [Ornamentals]	G	0.048	01-06	1	N/A	0.124	0.00354	0.0019	0.0012	0.00115	170	163
16 NJ nursery [Ornamentals]	G	0.048	01-06	1	N/A	0.127	0.00553	0.00376	0.00312	0.00286	442	405

G=ground

[1] EECs were rounded to three significant figures.

Table 42. Water Column, Pore Water, and Sediment EECs for Cyfluthrin[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
01 CA turf (MI met file, W14840)	G	0.19	01-06	1	N/A	0.0212	6.1×10^{-4}	3.05×10^{-4}	2.8×10^{-4}	2.15×10^{-4}	51.8	39.7
02 FL turf (TN met file, W13882)	G	0.19	01-06	1	N/A	0.0158	4.71×10^{-4}	2.54×10^{-4}	2.23×10^{-4}	1.82×10^{-4}	41.2	33.6
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.192, 0.09, 0.09	01-06	1	N/A	1.07×10^{-3}	4.15×10^{-5}	2.48×10^{-5}	1.63×10^{-5}	1.51×10^{-5}	3.01	2.79
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	G	0.192, 0.09, 0.09	01-06	1	N/A	7.33×10^{-3}	4.70×10^{-4}	1.97×10^{-4}	2.02×10^{-4}	1.44×10^{-4}	37.3	26.6
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.192, 0.09, 0.09	01-06	1	N/A	5.50×10^{-3}	2.03×10^{-4}	9.00×10^{-5}	6.99×10^{-5}	5.54×10^{-5}	12.9	10.2
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.192, 0.09, 0.09	01-06	1	N/A	0.387	8.05×10^{-3}	3.18×10^{-3}	2.08×10^{-3}	1.58×10^{-3}	385	292
15 OR nursery [Ornamentals]	G	0.048	01-06	1	N/A	0.115	0.00242	0.00108	6.55×10^{-4}	5.62×10^{-4}	121	104
16 NJ nursery [Ornamentals]	G	0.048	01-06	1	N/A	0.115	0.00311	0.00187	0.00118	8.91×10^{-4}	218	165

G=ground

[1] EECs were rounded to three significant figures.

Table 43. Water Column, Pore Water, and Sediment EECs for *Lambda*-Cyhalothrin[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
01 CA turf (MI met file, W14840)	GR	0.24	01-06	1	N/A	0.0153	0.00338	0.00304	0.00294	0.00293	7.85	7.82
02 FL turf (TN met file, W13882)	GR	0.24	01-06	1	N/A	0.00672	0.00253	0.00244	0.00237	0.00237	6.33	6.33
03, 04, 05 CA residential, ROW, impervious [Residential lots]	G	0.24	01-06	1	N/A	1.88×10^{-3}	7.86×10^{-4}	7.83×10^{-4}	7.77×10^{-4}	7.77×10^{-4}	2.09	2.09
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	G	0.24	01-06	1	N/A	0.0256	6.38×10^{-3}	6.36×10^{-3}	6.28×10^{-3}	6.26×10^{-3}	16.9	16.8
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	G	0.24	01-06	1	N/A	0.0127	4.03×10^{-3}	3.79×10^{-3}	3.70×10^{-3}	3.70×10^{-3}	9.93	9.89
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	G	0.24	01-06	1	N/A	0.0195	4.32×10^{-3}	4.10×10^{-3}	3.86×10^{-3}	3.87×10^{-3}	10.3	10.3
15 OR nursery [Ornamentals]	GR	0.078	01-06	1	N/A	0.276	0.055	0.0497	0.0473	0.0473	127	127
16 NJ nursery [Ornamentals]	GR	0.078	01-06	1	N/A	0.317	0.0958	0.0919	0.0896	0.0894	241	240

G=ground; GR=granular

[1] EECs were rounded to three significant figures.

Table 44. Water Column, Pore Water, and Sediment EECs for Fenpropathrin[1]												
						Water Column			Pore Water		Sediment	
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
01 CAnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	3	7	2.05	0.126	0.106	0.0979	0.0972	20300	20200
02 FLnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-6	3	7	1.51	0.157	0.147	0.139	0.137	28900	28400
03 MInurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-9	3	7	1.20	0.190	0.182	0.179	0.178	37200	36900
06, 07 NJnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	3	7	2.04	0.206	0.182	0.173	0.171	35900	35500
06 ORnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-11	3	7	0.422	0.057	0.054	0.0532	0.053	11040	11000
07 TNnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-7	3	7	1.66	0.191	0.18	0.179	0.179	37400	37400
08 NurseryBSS_V2/ ornamentals	Foliar, GR	0.3	1-5	3	7	0.695	0.063	0.058	0.0545	0.0539	11300	11200
09 CAnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	24	7	9.80	0.805	0.744	0.709	0.704	147000	146000
10 FLnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-6	24	7	10.3* (13.4)	1.19	1.09	1.05	1.04	218000	216000
11 MInurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-9	24	7	7.56	1.44	1.38	1.36	1.36	282000	282000
12 NJnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	24	7	10.3* (19.1)	1.69	1.59	1.51	1.5	313400	311400
13 ORnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-11	24	7	2.53	0.400	0.384	0.374	0.373	77600	77400
14 TNnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-7	24	7	9.57	1.36	1.27	0.098	0.097	20300	20100
15 NurseryBSS_V2/ ornamentals	Foliar, GR	0.3	1-5	24	7	3.66	0.412	0.378	0.139	0.137	28900	28400
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	Foliar, H	0.02	1-6	3	7	0.151	0.009	0.008	0.008	0.008	1660	1660

Table 44. Water Column, Pore Water, and Sediment EECs for Fenpropathrin[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
17 FLresidentialPYR (CAresidential with FL met file W12839)	Foliar, H	0.02	1-6	24	7	0.963	0.072	0.063	0.060	0.060	12500	12500
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	Foliar, H	0.02	1-6	1	NA	0.049	0.003	0.003	0.003	0.003	623	623
19 CAnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	1	NA	0.817	0.0529	0.0421	0.0401	0.0398	8320	8260
20 FLnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-6	1	NA	0.537	0.0527	0.0493	0.0467	0.0462	9690	9590
21 MInurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-9	1	NA	0.388	0.0648	0.0621	0.0614	0.0613	12700	12700
22 NJnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	1	NA	0.669	0.069	0.061	0.0581	0.0577	7410	7360
23 ORnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-11	1	NA	0.133	0.0189	0.0178	0.0177	0.0176	3670	3650
24 TNnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-7	1	NA	0.601	0.0641	0.0594	0.0593	0.0592	12300	12300
25 NurseryBSS_V2/ ornamentals	Foliar, GR	0.3	1-5	1	NA	0.235	0.0215	0.0194	0.0184	0.0182	3820	3780

G=ground; GR=granular; H=handheld or backpack sprayer; NA=not applicable

* EECs marked with an asterisk were set to 10.3 µg/L because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling (solubility from MRID 44370001). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] Water column and pore-water EECs were rounded to three significant figures.

Table 45. Water Column, Pore Water, and Sediment EECs for Fenpropathrin plus Unextracted Residues[1]												
						Water Column			Pore Water		Sediment	
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
01 CAnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	3	7	2.32	0.154	0.130	0.121	0.120	25100	24900
02 FLnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-6	3	7	2.00	0.189	0.175	0.166	0.164	34500	34040
03 MInurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-9	3	7	1.59	0.271	0.260	0.259	0.260	53800	53970
06, 07 NJnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	3	7	2.54	0.254	0.222	0.212	0.210	44000	43600
06 ORnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-11	3	7	0.563	0.084	0.079	0.077	0.077	16000	16000
07 TNnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-7	3	7	1.99	0.235	0.222	0.220	0.219	45700	45400
08 NurseryBSS_V2/ ornamentals	Foliar, GR	0.3	1-5	3	7	0.959	0.092	0.085	0.081	0.080	16800	16600
09 CAnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	24	7	10.3* (12.5)	0.961	0.895	0.851	0.845	176700	175400
10 FLnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-6	24	7	10.3* (19.5)	1.45	1.31	1.25	1.24	259500	257400
11 MInurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-9	24	7	10.3* (11.6)	2.10	2.00	1.98	1.97	411000	408900
12 NJnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	24	7	10.3* (22.9)	2.07	1.92	1.82	1.80	377800	373600
13 ORnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-11	24	7	3.91	0.611	0.584	0.569	0.568	118100	117900
14 TNnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-7	24	7	10.3* (13.0)	1.77	1.64	1.59	1.58	330100	328000
15 NurseryBSS_V2/ ornamentals	Foliar, GR	0.3	1-5	24	7	5.76	0.635	0.591	0.570	0.569	118300	118100

Table 45. Water Column, Pore Water, and Sediment EECs for Fenpropathrin plus Unextracted Residues[1]												
						Water Column			Pore Water		Sediment	
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	Foliar, H	0.02	1-6	3	7	0.218	0.018	0.015	0.015	0.015	3110	3110
17 FLresidentialPYR (CAresidential with FL met file W12839)	Foliar, H	0.02	1-6	24	7	1.60	0.140	0.122	0.117	0.117	24300	24300
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	Foliar, H	0.02	1-6	1	NA	0.071	0.006	0.005	0.005	0.005	1040	1040
19 CAnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	1	NA	0.939	0.063	0.051	0.048	0.048	9960	9960
20 FLnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-6	1	NA	0.765	0.063	0.058	0.055	0.055	11400	11400
21 MInurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-9	1	NA	0.520	0.091	0.088	0.088	0.088	18300	18300
22 NJnurserySTD_V2/ ornamentals	Foliar, GR	0.3	15-3	1	NA	0.831	0.085	0.074	0.071	0.070	14700	14500
23 ORnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-11	1	NA	0.186	0.028	0.026	0.026	0.026	5400	5400
24 TNnurserySTD_V2/ ornamentals	Foliar, GR	0.3	1-7	1	NA	0.700	0.079	0.073	0.073	0.073	15200	15200
25 NurseryBSS_V2/ ornamentals	Foliar, GR	0.3	1-5	1	NA	0.319	0.031	0.029	0.027	0.027	5600	5600

G=ground; GR=granular; H=handheld or backpack sprayer; NA=not applicable

* EECs marked with an asterisk were set to 10.3 µg/L because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling (solubility from MRID 44370001). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] Water column and pore-water EECs were rounded to three significant figures.

5.6 Monitoring Data

Part of the available information on the occurrence of pyrethroids in U.S. urban surface waters was reviewed and is summarized here with a focus on the following questions:

Which pyrethroids are commonly detected in urban surface waters?

How does this relate to their intended uses?

This section deals firstly with only few examples of targeted surface water/sediment monitoring data for pesticides used outdoors. Therefore, selected chemistry data are included herein with emphasis on pesticides used in urban areas and reaching surface waters mainly by urban runoff into surface waters (urban creeks and lakes and rivers passing through urban areas). Urban runoff water, contaminated with urban pesticides, is usually pumped, drained and/or undergoes natural flow into these water bodies. Many factors will affect detected concentrations in these water bodies such as the pesticide physical/chemical and fate properties; labeled use patterns; pattern of timing of the application; application procedure; usage intensity (depends mainly on pest pressure which is associated with many factors such as climate); hydrological setting, urban drainage (sources/quantities); and characteristics of urban areas/receiving waters, and climatic conditions. Effects of these factors will be included when reported.

5.6.1 Monitoring of Stormwater Discharges and Affected Water Bodies

Urban area stormwater discharges and affected water bodies have been extensively monitored in California. Targeted monitoring data in these studies were for stormwater discharges and affected water bodies (water and underlying sediment). In the first study, monitoring data were for eight pyrethroids and the organophosphate insecticide chlorpyrifos. In the second study, monitoring data were for 63 insecticides/ herbicides/degradates in the water column plus nine pyrethroids and chlorpyrifos in water and underlying sediment. For northern California, the first study included the city of Vacaville and urban areas along the American River, Sacramento River and San Joaquin River (the cities of Folsom, Cordova, Sacramento and Stockton) while the second study included the cities of Roseville, Martinez/Pleasant Hill, Stockton and Dublin. For southern California, the second study included urban areas of Laguna Nigel, Aliso Viejo, San Diego, and Lakeside (**Figure 8**). Sampling events took place during or shortly after rain events (Rain) and during the dry season (Dry). Sources of pesticides contamination were stormwater run-off from treated residential areas during the rainy season and landscape water run-off from treated landscaped areas during the dry season.

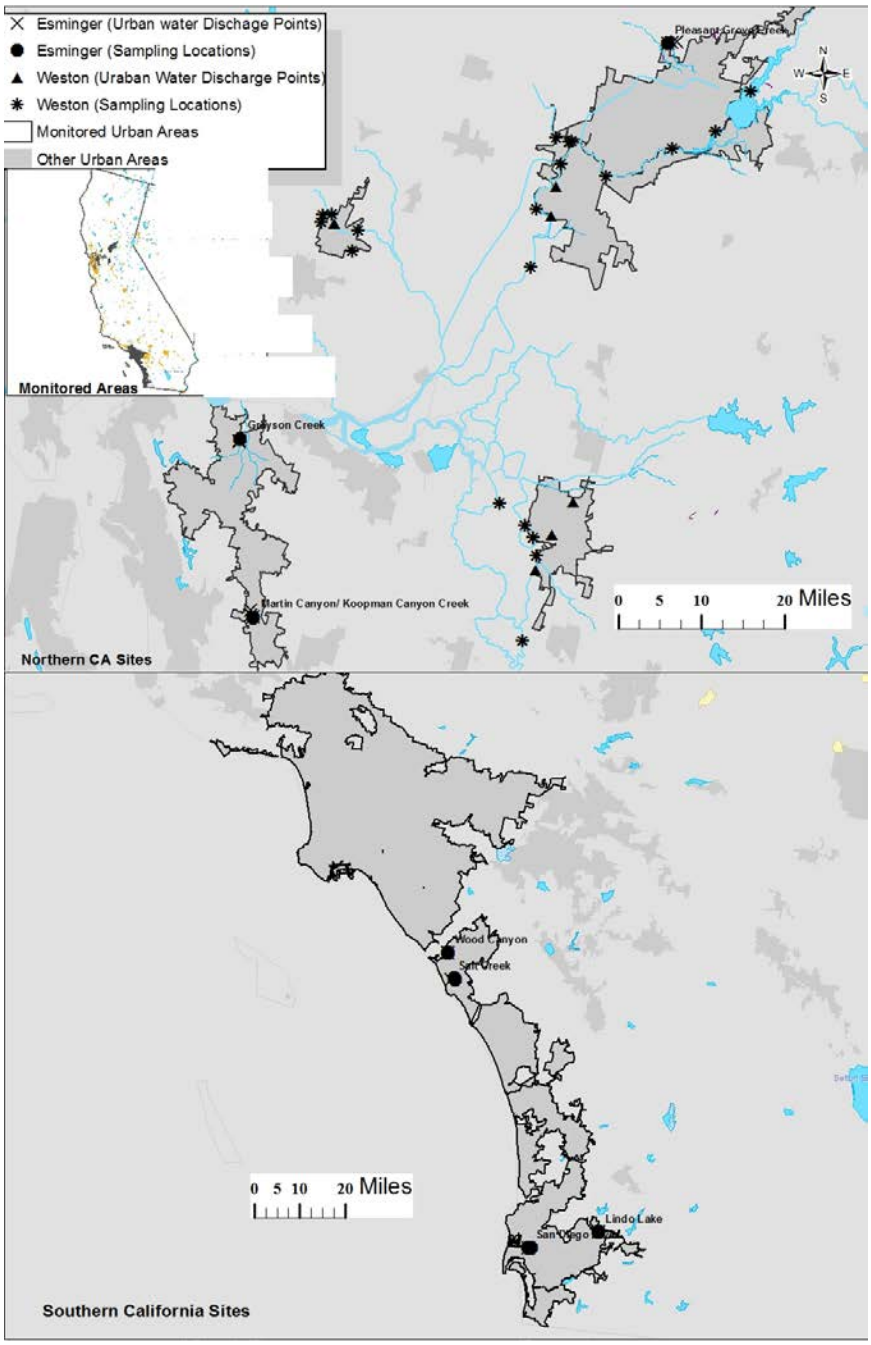


Figure 8. Monitored urban areas in Northern and Southern California (Weston and Lydy, 2010; and Ensminger and Kelley, 2011)

In the Weston and Lydy (2010) study, concentrations detected in sump waters were high enough to be of toxic concern and were found to be related to either the pyrethroids or chlorpyrifos based on the toxicity identification evaluation (TIE) data. This was also confirmed by chemical analyses and comparison to known toxicity thresholds. Chemical analyses of 33 sump water samples show that the overall percentage of samples containing concentrations exceeding 1 ng/L ranged from 3 to 79% for eight pyrethroids and chlorpyrifos. The majority of the samples contained bifenthrin (79%) and chlorpyrifos

(77%) with lesser percentages containing: permethrin (61%), cyfluthrin (55%), λ-cyhalothrin (*lambda*-cyhalothrin, 45%), cypermethrin (33%), deltamethrin (12%), esfenvalerate (6%) and fenpropathrin (3%). As expected, pesticides in sump waters that were discharged (by pumping) into receiving creeks and rivers were diluted to lower levels. Varied levels of pesticides and toxicity were found in receiving creeks and rivers as it passed through the urban areas of Sacramento (the Sacramento River), Stockton (the American River) and Vacaville (two urban creeks). Water column toxicity, related to the pyrethroid bifenthrin, was not observed in the Sacramento River but was evident along the urban creeks, the American river, and at only one site in the San Joaquin River. For example, no evidence of contamination with pyrethroids and toxicity was observed upstream in the water as the creeks enter the city of Vacaville while a high level of toxicity was observed in waters leaving the city downstream. In these water samples, pyrethroid concentrations were 4-10 times the toxicity, with bifenthrin and cyfluthrin providing most of the toxic units (TU). The level of pesticide contamination in receiving waters appeared to be related to the intensity of rain events. For example, no toxicity was observed in water samples taken from the San Joaquin River near Stockton just after the first rain event, but toxicity was evident, in one location at the edge of the city, following a more intense second rain event. Again, water toxicity was established to be related to pyrethroids as it contained 0.7 TU of bifenthrin and 0.3 TU of permethrin.

Monitoring data from the Ensminger and Kelley (2011) study may be considered as an example of concentrations and detection frequencies (DFs) for registered and extensively used pesticides in urban areas. Therefore, data from this study are summarized herein for reported DFs and concentrations of insecticides, herbicides and special focus on pyrethroids detected in urban drain waters (DRNs) and receiving water bodies (RWBs) during dry (Dry) and rainy (Rain) seasons. **Table 46** contains reported sampling information and abbreviations used in this summary and associated graphs. In the summary, statewide data reported for all locations in the study are used to obtain maximum and minimum concentrations and detection frequencies for each pesticide. Detection frequencies are calculated for each pesticide as percent (%) from the number of samples containing that pesticide over the detection limit (number of detects) divided by the total number of samples (number of detects plus non-detects; trace detections were considered, in this summary, as non-detects). The summary includes data on pesticides that were most frequently detected in the samples of urban drain waters and receiving water bodies during Dry and Rain events. The number of samples for each urban area are included in the summary table as it is an important indicator for intensity of sampling (**Table 46**).

Table 46. Reported sampling information and abbreviations used in the summary of Ensminger and Kelley statewide monitoring data

Urban Area	*City (Source of Urban Runoff Water "DRN")*	*Receiving Water body "RWB"*	*Sampling Season*	*Number of Samples (n)* [1]					
				Insect[2]		*Herb*[3]		*Pyreth*[4]	
				DRN	*RWB*	*DRN*	*RWB*	*DRN*	*RWB*
Sacramento **"SAC"**	Roseville	Pleasant Grove Creek	Dry	14	5	12	4	8	3
			Rain	12	4	12	4	9	3
San Francisco Bay **"SFB"**	Martinez/ Pleasant Hill; and Dublin	Grayson Creek; and Martin Canyon/ Koopman Canyon Creek	Dry	20	8	20	8	10	4
			Rain	17	7	17	7	12	5
Greater Los	Laguna Nigel;	Salt Creek; and	Dry	23	9	24	10	9	3

Urban Area	*City (Source of Urban Runoff Water "DRN")*	*Receiving Water body "RWB"*	*Sampling Season*	*Number of Samples (n)* [1]					
				Insect[2]		*Herb*[3]		*Pyreth*[4]	
				DRN	*RWB*	*DRN*	*RWB*	*DRN*	*RWB*
Angeles (Orange County) **"ORN"**	and Aliso Viejo	Wood Canyon Creek	Rain	4	2	4	2	None	None
San Diego **"SND"**	San Diego; and Lakeside	San Diego River; and Lindo Lake	Dry	14	10	14	10	None	None
			Rain	5	2	5	2	None	None
		Statewide	Dry/Rain	8	8	8	8	5	5

[1] ***Number of Samples (n)*** **=** The total number of samples for each sampling event. For example, in the Sacramento area (**SAC**), insecticides were monitored in 14 drain water samples (DRN) during the dry season (Dry) and in 12 drain water samples (DRN) during the rainy season (Rain). Additionally, insecticides were also monitored in 5 receiving water samples (RWB) during the dry season (Dry) and in 4 receiving water samples (RWB) during the rainy season (Rain)

[2] ***Insect*****=** Monitored Insecticides: carbaryl (carb), chlorpyrifos (Chl) diazinon (Diaz), fipronil (Fip), fipronil degradates (FipD= desulfinyl fipronil, desulfinyfepronil amide, fipronil amide, fipronil sulfide, and fipronil sulfone), malathion (Mal), and oxamyl (oxa)

[3] ***Herb*****=** Monitored Herbicides: 2,4-D (2,4-D), ACET, bromacil (Brom), dicamba (Dicam), diuron (Diur), MCPA, oryzalin (Oryzal), oxyfluorfen (Oxyfl), pendimethalin (Pendi), prodiamine (Prodi), prometon (Promet), simazine (Simaz), triclopyr (triclo) and trifluralin (Trifl)

[4] ***Pyreth*****=** Monitored Pyrethroids: bifenthrin (bif), cyfluthrin (Cyf), λ-cyhalothrin (λ-cyh), cypermethrin (cyp), fenvalerate/esfenvalerate (FenEsV) and permethrin (Per= *cis* and *trans*)

In this summary, concentrations and detection frequencies for each pesticide are examined in urban drain waters *vs.* receiving water bodies, Dry *vs.* Rain, and in varied geographical locations. The objectives are to summarize reported data as detection frequencies and concentrations for pesticides detected in urban surface waters and examine the effects of dry flow vs. rainstorm flow and geographic location on these parameters. Although the study provided information about other insecticides and for herbicides, summaries are established for all of the monitored pyrethroids. Other insecticides and herbicides are excluded.

Pyrethroid insecticides that were frequently detected in source and receiving waters included bifenthrin, cyfluthrin, λ-cyhalothrin, cypermethrin, fenvalerate/esfenvalerate and permethrin (**Figure 9**). Bifenthrin was detected in all source and receiving water samples with detection frequencies ranging from 56-100% (N = 3-4), followed by permethrin with a range of 20-33% (N = 1-3). Detection frequencies for the other pyrethroids were much lower than bifenthrin and permethrin as they were in the range of 0-22% (N = 0-1).

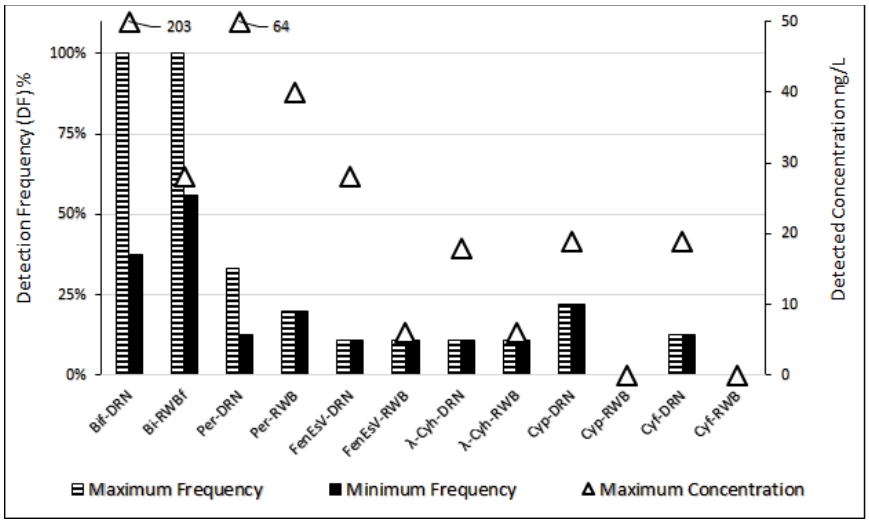


Figure 9. A summary graph for pyrethroid insecticides frequently detected in source drain water (DRN) and receiving water bodies (RWB) in three of the major urban areas in California

Detected concentrations of pyrethroids in source and receiving waters ranged from 0-203 ng/L. In all of the monitoring events, higher pyrethroid concentrations were observed in source waters (drain waters) as compared to receiving water bodies. Source water concentrations were 1.6-7.3 times higher than receiving waters in 4 out of 6 monitoring events, and no pyrethroid was detected in the receiving waters of 2 out of the 6 events. This is probably a result of partitioning of the pyrethroids to the organic carbon in suspended/underlying sediments of receiving water bodies.

5.6.1.1 Variations Associated with Geographical Locations

Variations in both concentrations and detection frequencies are summarized in two ways based on the reported monitoring data for the four major urban areas of California. The first is by comparing maximum detection frequencies of the insecticide in all monitoring events (urban drain waters/Dry, urban drain waters/Rain, receiving water bodies/Dry and receiving water bodies/Rain; referred to as the detection frequencies comparison). The second is by comparing maximum/minimum detection frequencies and maximum concentrations detected in the major source of contamination; that is the storm water drains in the two monitoring events (drain waters/Dry and drain waters/Rain; referred to as the urban drain waters detection frequency/Concentration comparison). The two types of comparisons are conducted herein for pyrethroids.

Analysis was performed on the pyrethroids data which includes only three urban areas Sacramento, San Francisco Bay and Orange County. San Diego was not monitored. Results of the urban drain waters detection frequency/concentration comparison show that bifenthrin was detected in drain waters in the three monitored areas with maximum detection frequencies/concentrations of 56%/26 ng/L, 93%/33 ng/L, and 100%/203 ng/L. The other four pyrethroids were only detected in Sacramento (cyfluthrin with detection frequency/concentration of 13%/18.9 ng/L and cypermethrin with detection frequency/ concentration of 22%/18.9 ng/L), Orange County (λ-cyhalothrin with detection frequency/

concentration of 11%/18.0 ng/L and fenvalerate/esfenvalerate with detection frequency/ concentration of 11%/28.0 ng/L). Additionally, data on the maximum detection frequencies/concentrations observed in source and receiving water are summarized in **Figure 10**.

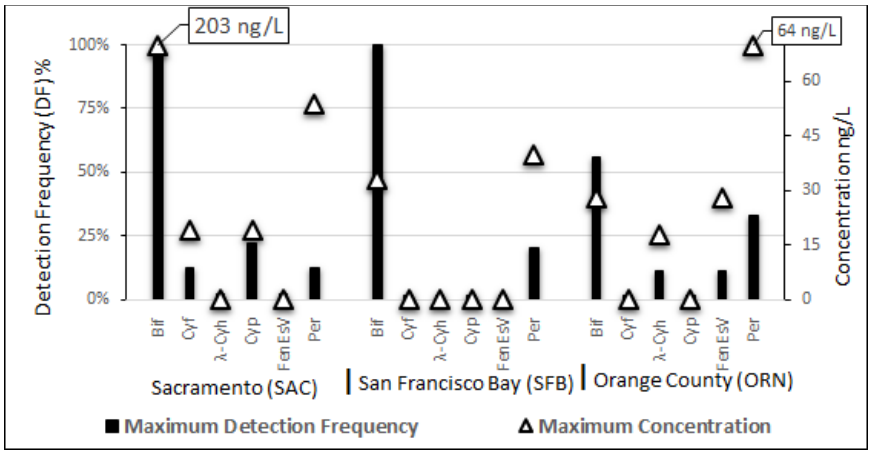


Figure 10. Observed maximum detection frequencies (DFs)/concentrations for pyrethroids detected in source/receiving waters of three major urban areas of California [San Diego (SND) was not monitored]

Summary data indicate that the maximum detection frequencies for bifenthrin were 100% in Sacramento/San Francisco Bay areas and 56% in Orange County area. In the Sacramento area, the maximum observed concentrations of bifenthrin, permethrin, cypermethrin and cyfluthrin were 203, 53.9, 18.9 and 18.9 ng/L, respectively. In San Francisco Bay area, only permethrin and bifenthrin were detected at maximum concentrations of 40 and 33 ng/L, respectively. Finally, in Orange County the maximum observed concentrations were 64 ng/L for permethrin, 28 ng/L for bifenthrin, 28 ng/L for fenvalerate/esfenvalerate and 18 ng/L for λ-cyhalothrin.

5.6.1.2 Variations Associated with Wet/Dry Conditions

Urban pesticides are mainly transported from application sites into surface waters by runoff waters resulting from rain storms and/or irrigation. It is thus expected that detection frequencies and concentrations in drain and receiving waters to be related to pesticide properties (persistence and solubility), water availability (rain and irrigation), and timing of application. Additionally, application rate and frequency of application are expected to play a role in determining expected pesticide concentrations in surface waters as these factors are important in determining the pesticide load in quantity and timing. The latter factors can be deduced from usage data.

The results of the monitoring study indicated that most pesticides were detected during wet rather than dry conditions. Other reported results included among others the following: (1) First rainstorm gave the highest detection frequencies in all of monitored sites except in Orange County; (2) Pesticides used in urban areas may show continuous load, independent of rain; (3) Bifenthrin had high detections associated with rain events although it is mostly applied during the dry season. Furthermore, the authors used the difference

between detection frequencies during wet flow and during dry flow as an indicator for the influence of rain on pesticide detections. The results indicate that most of the pesticides are influenced by rain giving higher detection (with the exception of fipronil degradates). Rain appeared to cause the highest detections for bifenthrin.

5.6.2 Sediment Monitoring

Stream bed sediment samples were collected, during dry flow conditions, in creeks, a river, and a lake receiving waters from identified storm drains of five urban areas in Northern and Southern California (CA-N and CA-S) (Ensminger and Kelley, 2011). The Northern California site was from Grayson creek receiving stormwater from the mixed residential/commercial urban area of Martinez/Pleasant Hill in the San Francisco Bay area. The Southern California sites were from Salt Creek, Wood Canyon Creek, San Diego River, and Lindo Lake receiving storm waters from the mostly residential or mixed residential/commercial urban areas of Laguna Nigel (Orange County), Aliso Viejo (Orange County), San Diego and Lakeside cities, respectively (**Figure 11**). In this study (Ensminger and Kelley, 2011), sediment samples were analyzed for 9 pyrethroids and chlorpyrifos and only 8 pyrethroids were identified. The pyrethroid fenpropathrin and the insecticide chlorpyrifos were not detected.

In another study, occurrences and potential sources of pyrethroids in stream bed sediments from seven U.S. metropolitan areas were assessed. Sediment samples were collected in 2007 from 98 urban streams within the metropolitan areas of Atlanta, GA (ATL); Boston, MA, NH (BOS); Dallas−Fort Worth, TX (DAL); Denver, CO (CO); Milwaukee−Green Bay, WI (MGB); Seattle−Tacoma, WA (SEA); and Salt Lake City, UT (SLC) (**Figure 11**). In this national scale study, sediment samples were analyzed for 14 pyrethroids and reported data were for five pyrethroids (Kuivila *et al*., 2012).

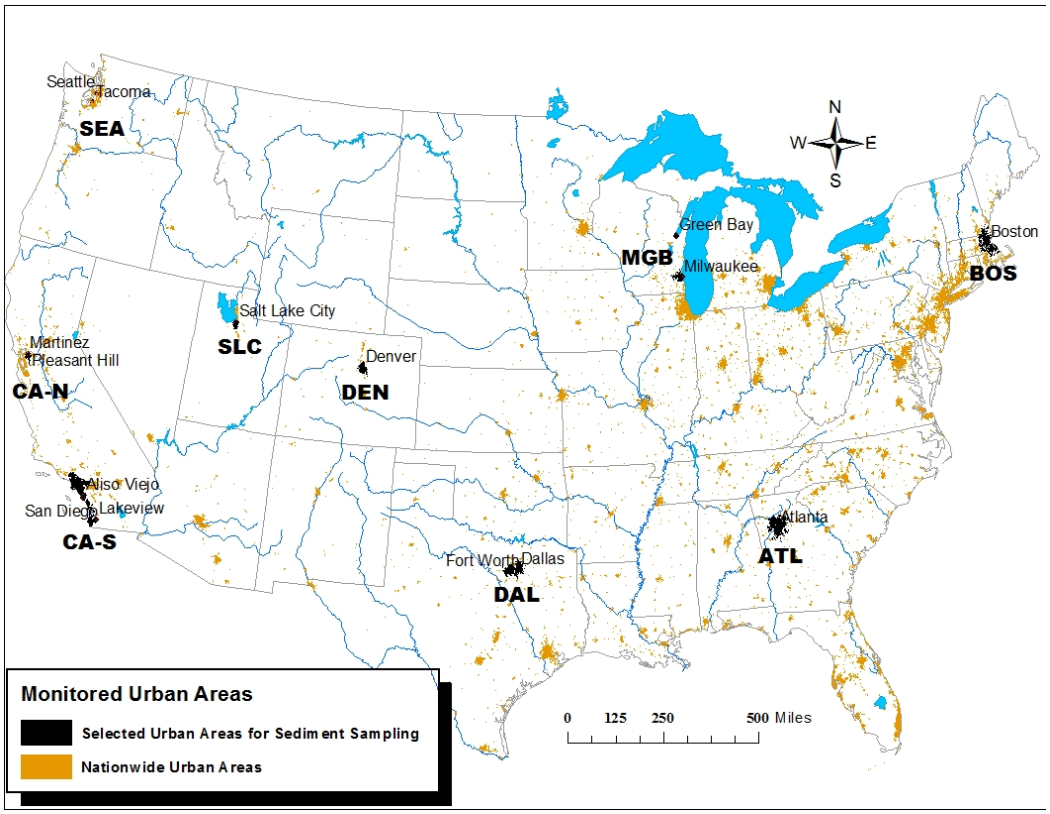


Figure 11. Stream bed sediment sampling sites for the statewide California study by Ensminger and Kelley and the nationwide study by Kuivila *et al*. (2012)

The pyrethroids bifenthrin, λ-cyhalothrin, cypermethrin, permethrin and resmethrin were monitored in both studies. Data from Ensminger and Kelley (2011) included monitoring data for sediments underlying storm drains in addition to receiving water bodies. The data show relatively high detection frequencies for bifenthrin, cyfluthrin, permethrin deltamethrin, λ-cyhalothrin and cypermethrin (41-97%) with maximum concentrations ranging from 32 to 680 µg/kg dry sediment. Fenvalerate/esfenvalerate maximum detection frequency/concentration was reported to be lower (14% and 24 µg/kg). However, of interest in this section is the pyrethroid chemicals data for sediments underlying receiving water bodies as it can be compared with data obtained for the nationwide bed stream sediments study conducted by Kuivila, *et al*. (2012). This will permit comparison between bed sediments obtained nationwide from urban areas varied in hydrology, weather, pesticide use, timing of application and land characteristics/use. **Figure 12** summarizes the concentration and detection frequency data obtained from both studies for bifenthrin, λ-cyhalothrin, cypermethrin, permethrin.

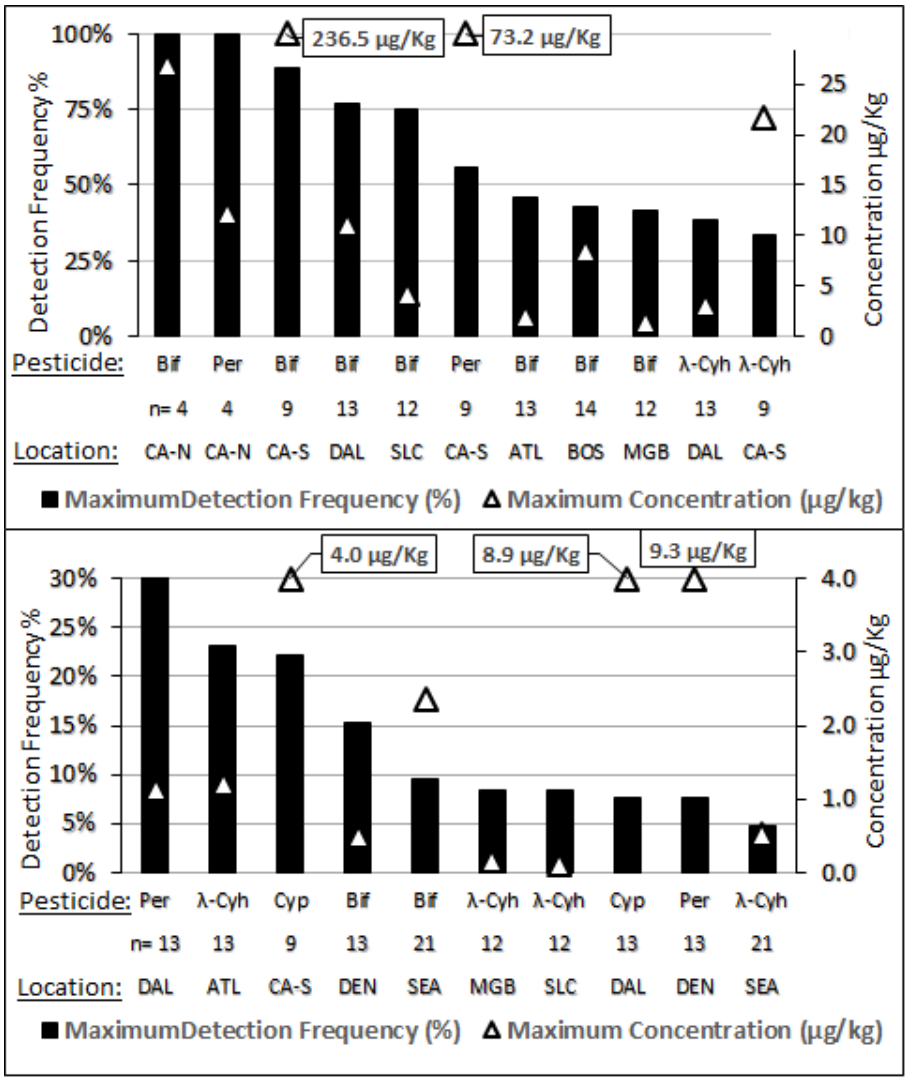


Figure 12. A summary of the sediment concentration/DF data obtained for bifenthrin (bif), λ-cyhalothrin (λ-Cyh), cypermethrin (Cyp) and permethrin (Per) (n = number of samples; for sampling location abbreviation refer to map in Figure 11)

Data show variable occurrence frequencies and concentrations of pyrethroids detected in bed sediment streams across the country. Reported data may be categorized by the frequencies of occurrence into three categories as shown in **Table 47**.

Table 47. Categories for the frequencies of pyrethroid occurrences in bed sediments

Detection Frequencies	*Maximum Concentrations*	*Bed Sediment Location*	*Pyrethroid Detected*	*Exception*	*Reference*
56 - 100%	**11.2 – 237** µg/kg	**CA-S, CA-N, DAL**	Bif	SLC= **4.2** µg/kg	**Figure 12** Top Graph
		CA-N	Per	None	
33- 46%	**1.4 - 8.4** µg/kg	**BOS, ATL, MGB**	Bif		
		DAL	λ-Cyh	CA-S= **22** µg/kg	
5 - 31%	**2.4 - 9.2** µg/kg	**DEN**	Per	None	**Figure 12** Bottom Graph
		DAL, CA-S	Cyp		
		SEA	Bif		
	0.1 - 1.2 µg/kg	**ATL, SEA, MGB, SLC**	λ-Cyh		
		DEN	Bif		

See above for abbreviations of locations.

5.6.3 California Stormwater Quality Association (CASQA) Monitoring Report

Two relatively recent reviews were submitted to the Agency and were available, on monitoring of urban pesticides in receiving water bodies in the United States, especially in California. The first review was conducted for the California Stormwater Quality Association (CASQA) and the County of Sacramento covering monitoring data from California urban watersheds on pyrethroids (and fipronil), and toxicity (Ruby, in MRID 49354001). The report covers the period of 2003 to 2012, with >9200 pyrethroid analyses and >100 studies evaluated, of which ~80 met their selection criteria (*e.g.*, whether the detection limit was appropriately low enough). The report covers pyrethroids other than the eight in this assessment, and fipronil and its degradates, but the brief summary presented herein focuses on data for the eight pyrethroids.

The analysis of the data indicated that the pyrethroids were detected frequently in water and sediment in urban environments. Bifenthrin was the most frequently detected pyrethroid in both, water and sediment, with frequencies of detection of 64 and 69%, respectively. **Table 48** summarizes the frequency of detection, and mean and maximum concentrations in water and sediment for the pyrethroids included in this assessment.

Table 48. Number of Samples, Detection Frequencies, Mean and Maximum Concentrations in the Urban Monitoring in California (Source: MRID 49354001)[1]

Chemical	Water Samples				Sediment Samples			
	No of Samples	% Detects	Mean Conc. (ng/L)	Max. Conc. (ng/L)	No of Samples	% Detects	Mean Conc. (ng/g)[2]	Max. Conc. (ng/g)[2]
Bifenthrin	748	64	26	398	359	69	45.8	744
Cyfluthrin	847	28	14.9	423	324	33	17.4	187
Cyhalothrin	663	22	4.80	243	334	30	4.64	31.9
Cypermethrin	503	31	13.3	519	284	29	10.1	987.5
Deltamethrin[3]	533	5	1.40	252	252	22	5.11	78.0
Esfenvalerate	704	19	1.43	36.8	314	12	1.47	20.3
Fenpropathrin	306	21	4.80	459.9	147	16	0.393	8.8
Permethrin	1146	16	51.2	12652	367	50	27.8	539

[1] Summaries included generally the most recent studies (since 2005), of samples with limits of detections in the ng/L (water) and ng/g (sediment) levels.
[2] These values ***are not*** organic carbon-normalized.
[3] Includes tralomethrin, an associated pyrethroid which is no longer registered.

It should be noted that these concentrations exceed the limit of solubility for many of the pyrethroids. One extreme case of a chemical with a very low solubility is bifenthrin (solubility = 14 ng/L), for which the mean and maximum concentrations exceeded this limit. Additionally, the sediment concentrations are not organic carbon normalized.

The report also indicates that water column and sediment toxicity testing performed in California demonstrated that waters and sediments containing pyrethroids were toxic to a

variety of organisms. Urban waters have shown toxicity to the amphipod *Hyalella azteca*, by means of tests, such as toxicity identification evaluation (TIE), or correlation with pyrethroid concentrations.

5.6.4 Pyrethroid Working Group Monitoring Report

The second review was submitted by the PWG, covering available monitoring data for synthetic pyrethroids in surface water and sediment across the United States as of July 31, 2013 (Giddings, *et al.*, MRID 49314703). The PWG report includes both agricultural and non-agricultural monitoring and an extensive number of sources. Besides the eight pyrethroids involved in this assessment, tefluthrin, which is also supported by PWG, was included. It was reported that the limits of detection and quantitation were variable across studies. Greater than 1000 articles, public records, and databases from the open literature and public reports were evaluated for usability. These reports were classified, according to certain criteria (not discussed herein) as good, usable, or unusable. Only good or usable reports are further described in the report. The report indicated that the following number of analytical results for pyrethroids were recorded, using a variety of analytical methods, from agricultural, urban, mixed or undeveloped sites. The focus of this summary is the urban samples and eight pyrethroids; tefluthrin is excluded from this brief summary (since it is not part of the group of pyrethroids included in the PRA and it does not have urban uses).

- Whole (unfiltered) water: 18,500 analytical results in 4,900 whole (unfiltered) water samples (referred hereafter as *whole water* samples), of which 98% are from CA. Of the 4,786 whole water samples with suitable results (*e.g.*, not expressed as a range or as 'trace'), 1186 (25%) were from urban land use sites (1167 from flowing water, 18 static, and 1 marine).
- Filtered water: 2,500 analytical results in 308 filtered water samples, of which 74% are from CA; only a few of the detections are from urban sites.
- Suspended sediment: 1,629 analytical results in 200 suspended sediment samples, all from CA.
- Sediment samples: 12,500 analytical results in about 1,850 sediment samples, of which 76% are from CA. Of the 1,797 sediment samples with suitable results and for which organic carbon normalized concentrations were available or calculated, 798 (44%) were from urban land use sites (640 flowing water, 1 static, and 157 marine).

5.6.4.1 Whole Water (Unfiltered)

In the whole water samples *overall* (*i.e.*, including agricultural, urban, mixed and undeveloped land use), the most frequently detected pyrethroid, and the one with the highest concentrations was bifenthrin (21% detection frequency overall, 95th percentile concentration = 41 ng/L). Other pyrethroids' detection frequencies were ≤5%.

The following table and figure summarize the pyrethroid concentrations in whole water

samples from ***urban*** *flowing water*-sites. Bifenthrin was the most frequently detected pyrethroid in urban flowing whole water samples, with 50% detections. (By contrast, in agricultural settings the detection frequency was 7%.) Even though their frequency of detections were not as high as for bifenthrin, for permethrin, cypermethrin, *lambda*-cyhalothrin and cyfluthrin the detections reached significant levels at 6-12% (for five out of eight of the pyrethroids, the detection frequency was ≥6%).

Table 49. Pyrethroid Concentration Distributions in Whole (Unfiltered) Water Samples from Urban Flowing Water Sites

Chemical	Number of Samples	Detections (%)	Concentrations (ng/L)				
			90th	95th	99th	Maximum	Limit of Solubility
Bifenthrin	650	50	38	55	142	5209	14
Cyfluthrin	534	12	3.9	11	85	498	2320
L-Cyhalothrin	576	6	<RL	1.3	18	64	5000
Cypermethrin	557	8	<RL	7.2	55	451	3970
Deltamethrin	420	2	<RL	<RL	16	231	200
Esfenvalerate	494	2	<RL	<RL	4.3	28	6000
Fenpropathrin	419	1	<RL	<RL	0.56	7.9	10300
Permethrin	1,033	8	<RL	15	61	611	5500

RL = reporting limit

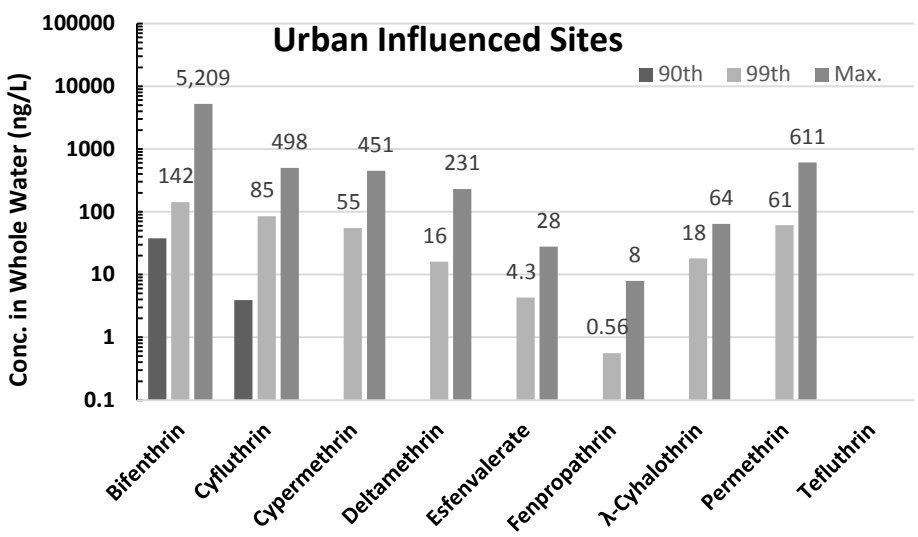


Figure 13. Graphic Depiction of the Pyrethroid Concentration Distributions in Whole (Unfiltered) Water Samples from Urban Flowing Water Sites

The last column in the **Table 49** above shows the limit of solubility for each of the pyrethroids in ng/L. It was noted that the maximum whole water bifenthrin concentrations greatly exceeded this limit, and for deltamethrin it exceeds the solubility sligthly. The study authors commented that whole water samples (including both urban and agricultural), contain varying amounts of suspended particulate matter (*e.g.*, soils/ sediments). Since pyrethroids tend to sorb to organic matter, the concentrations in whole water are likely dominated by the particulate bound material.

Regarding whole water samples from static bodies of water, only three publications were included, of which one presented data in urban bodies of water. In Lee (2009), sampling was performed of the inlet and outlet of four California urban stormwater retention ponds after rain events (18 samples). "Pyrethroid detections included bifenthrin (13 samples, maximum 96 ng/L); cyfluthrin (8 samples, maximum 81 ng/L); cypermethrin (2 samples, maximum 32 ng/L); *lambda*-cyhalothrin (4 samples, maximum 32 ng/L); and permethrin (2 samples, maximum 26 ng/L)." Two whole water samples from an estuary in California were tested for esfenvalerate and permethrin; these two compounds were not detected.

5.6.4.2 Filtered Water

In the PWG submission, there are seven reports that provide results of filtered water samples. The USGS had investigated whether filtering water samples using their Standard Operating Procedure (SOP) could cause loss of dissolved pyrethroid onto glass fiber filters. They found that less than 5% was lost and it was presumed that the concentrations in filtered water would depict dissolved pyrethroid concentrations. It is noted, however, that filtering does not remove dissolved organic matter, which can decrease the bioavailable pyrethroid by a fraction dependent on the concentration of dissolved organic carbon, and K_{DOC}. The frequency of non-detections was reported to be 95%, and a total of only 23 pyrethroid detections, all in CA, were reported (0.9% of the analyses and 5% of the samples). The majority of the detections were from agriculturally dominated sites (**Table 50**). Unfortunately, urban site detections were few and reported only for bifenthrin and cyfluthrin. The highest concentrations were lower than those reported in **Table 49** by orders of magnitude.

Table 50. All Detections in Filtered Water Samples

Chemical	No. of Detections	Highest Concentration (ng/L)	Site of Highest Concentration	Source
Bifenthrin	9	15	Urban creek, Roseville	Urban
Cyfluthrin	2	7	Urban creek, Roseville	Urban
L-Cyhalothrin	2	64.7	Vegetated tailwater ditch, Salinas Valley	Ag
Cypermethrin	1	11.6	Vegetated tailwater ditch, Salinas Valley	Ag
Deltamethrin	0	--	--	--
Esfenvalerate	1	1.29	Vegetated tailwater ditch, Salinas Valley	Ag
Fenpropathrin	0	--	--	--
Permethrin	8	15	Irrigation tailwater, Pajaro R. estuary upper	Ag

Ag = agricultural; -- = no detections

5.6.4.3 Sediment Samples

For each pyrethroid there are between 1,100 and 1,700 individual sediment analyses, of which between 430 and 600 are from urban flowing water sites in the PWG report. The pyrethroid frequency of detections was much higher than in water. The most frequently detected chemical was bifenthrin in urban flowing water sites (75% detects), but all the

remaining pyrethroids were detected in between 28 and 56% of the sediment samples, excluding fenpropathrin, which has no urban uses (19% detects, **Table 51**). According to the study, the majority of the flowing water site sediments were from depositional areas, and the concentrations are likely to overestimate the concentrations that would be observed in non-depositional areas, which are the preferred habitat for many species. The authors also compared the sediment concentrations in California urban flowing water sites against other states. They found that the 95th percentile concentration was higher in California than in other states, with the exception of *lambda*-cyhalothrin (0.24 and 0.39 µg/g_{OC}, respectively). Furthermore, for all eight pyrethroids, including *lambda*-cyhalothrin, the frequency of detections in California was higher than in other states.

Table 51. Pyrethroid Concentration Distributions in Sediment Samples from Urban Flowing Water Sites

Chemical	Number of Samples	Detections (%)	Sediment Concentrations (µg/g_{OC})			
			90th	95th	99th	Maximum
Bifenthrin	573	75	1.4	2.3	6.3	10
Cyfluthrin	587	42	0.35	0.71	3.0	7.0
L-Cyhalothrin	584	46	0.18	0.34	1.0	2.9
Cypermethrin	588	36	0.26	0.57	2.3	12
Deltamethrin	509	36	0.12	0.24	0.98	2.8
Esfenvalerate	600	28	0.02	0.05	0.19	1.9
Fenpropathrin	429	19	0.002	0.009	0.66	2.3
Permethrin	573	56	1.1	2.2	6.8	196

RL = reporting limit

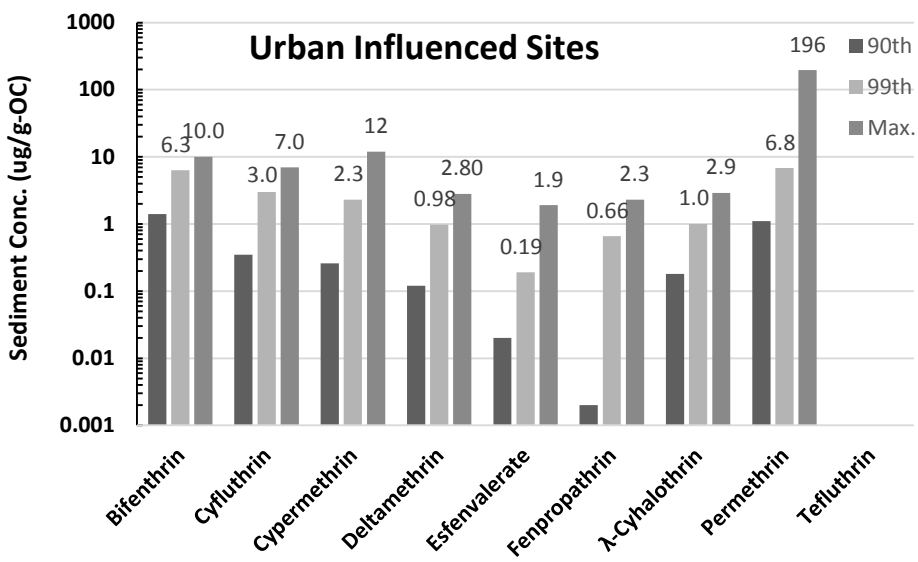


Figure 14. Graphic Depiction of the Pyrethroid Concentration Distributions in Sediment Samples from Urban Flowing Water Sites

The number of sediment samples from static bodies of water sites was limited, compared to flowing water sites, but the authors concluded that the sediment

concentrations were lower and the detections were less frequent in static bodies of water sites than in flowing water sites. Additionally, 204 estuarine/marine sediment samples were included in the report, from three studies, many of which are from urban sites. Based on the limited number of samples, compared to sediments from flowing water sites, the authors concluded that "[f]or the 3 studies combined, bifenthrin was detected in 27% of samples, cyfluthrin in 13%, permethrin in 5%, cypermethrin 4%, and deltamethrin, esfenvalerate, fenpropathrin, and lambda-cyhalothrin in less than 3%." The highest concentrations for all of the pyrethroids were bifenthrin at 5.9 $\mu g/g_{OC}$ in a California coastal site receiving urban runoff, permethrin at 5.1 $\mu g/g_{OC}$ in Switzer Creek, and cyfluthrin at 6.9 $\mu g/g_{OC}$ in Switzer Creek (San Diego Bay), all of which are urban use sites. These highest concentrations are lower than for the flowing water samples.

5.6.4.4 Suspended Sediments

Finally, there are 200 samples of suspended sediments in the PWG report, all from California and with pyrethroids detected in 53% of the samples. The most frequently detected pyrethroids were permethrin and bifenthrin (35-37% detects). For 120 of the 200 samples, organic carbon content was available. Permethrin and bifenthrin were also the most frequently detected pyrethroids (45 and 35%, respectively) when these samples were taken separately. The highest concentration was for permethrin, with 7.0 $\mu g/g_{OC}$; however, these samples were not categorized by use site in the report (*i.e.*, urban *vs.* agricultural).

5.6.5 Comparison of Monitored and Modeled Concentrations

Targeted monitoring data, similar to those discussed earlier, are an important resource for regulators of urban pesticides. These type of data are available for pesticides that have been in use for many years. Quality monitoring data can be used to supplement modeling EECs developed using the PWC. Monitoring results are not expected to be similar to modeled EECs, as the waters where samples are collected are not the same as the conceptual model simulated, and usage where the samples are collected may be different from that simulated; however, monitoring data provide evidence on how conservative modeled EECs are and of the potential for exposure to pesticides. In addition, the monitoring is usually not designed to capture the real peak concentration. In order to capture it, sampling needs to be intensive, when the pesticide is applied.

In the case of pesticides used in urban setting, monitoring data are much more important due to the usually high uncertainties associated with modeling surface water exposure in the urban environment. In some cases, it was necessary to use concentrations from monitoring data instead of modeling due to lack of scenarios that would represent application of a given pesticide and associated processes. For example, application rate/acre, number of applications and timing are required to perform PRZM/VVWM modeling. Label information alone is often not enough and assumptions have to be made to estimate these key parameters. For example, in the case of house perimeter treatment the label usually gives application rate in lb a.i/1000 ft^2 and possibly a recommended treatment of 3 ft up and 10 ft around the perimeter of the house. A residential area factor is usually estimated in order to arrive at a reasonable application rate for modeling which

needs estimates of housing density/acre and area that would be treated. There is also a need to assume house dimensions. The assumptions should be reasonably conservative and represent the area where the pesticide is to be applied. The task of arriving at reasonable estimates becomes much more difficult when the pesticide is to be used on a national scale. Many scenarios would be needed to represent varying housing densities across the U.S. Additionally, other needed parameters, such as timing of application, is assumed conservatively to happen the same day for all houses within a 10-hectare area. PRZM calculates daily load of pesticide transported by water run-off and erosion into 20,000 m^3 pond 2 m deep with no outlet to further simulate degradation. In contrast, urban runoff waters transports pesticides, through urban drainage/pumping systems (in some cases through POTWs), into surface water bodies such as urban creeks, lakes, and rivers. Pesticides arriving to these water bodies may then be transported via running water rather being held into a pond with no outlet. EECs estimated in pond, by VVWM, are expected to be conservative, but adding too much additional conservatism may result in unrealistic estimates especially with highly persistent pesticides that accumulate in the pond yielding high EECs.

5.6.5.1 Comparison of Monitored and Modeled Water Column Concentrations

A comparison of water monitored and modelled concentrations, based on CASQA and PWG data is presented in **Table 52**.

Table 52. Comparison of Maximum and 90th Percentile Monitored Whole, and Filtered Water Concentrations in Urban Environments, against Modelled Water Column EECs

Chemical	Maximum Whole Water Samples Monitored Conc. PWG (ng/L)[1]	90th Percentile Whole Water Monitored Conc. PWG (ng/L)[1]	Maximum Filtered Water Monitored Conc. PWG (ng/L)[2]	Maximum Water Monitored Conc. CASQA (ng/L)[3]	Maximum Water Column Modeled EEC (ng/L)[4]
Bifenthrin	5,209	38	15	398	14[5]
Cyfluthrin	498	3.9	7	423	127
L-Cyhalothrin	64	<RL	NA	243	25.6
Cypermethrin	451	<RL	NA	519	1370
Deltamethrin	231	<RL	NA	252	200[5]
Esfenvalerate	28	<RL	NA	36.8	234
Fenpropathrin	7.9	<RL	NA	459.9	963
Permethrin	611	<RL	NA	12,652	1,700

[1] Based on flowing whole (unfiltered) water samples from PWG report, see **Table 49**.
[2] Based on the urban filtered water samples from PWG report, see **Table 50**.
[3] From the CASQA report, see **Table 48**.
[4] Maximum EEC for the urban uses of pyrethroids (residential and commercial).
[5] Concentration was capped at the limit of solubility of the chemical.

In a comparison of the concentrations from whole (unfiltered) water it was found that the monitored concentrations were higher than the modelled concentrations for the following six chemicals: bifenthrin, cyfluthrin, *lambda*-cyhalothrin, deltamethrin, fenpropathrin, and permethrin. The comparison included PWG and CASQA data. The

cases where the maximum monitored concentration was lower than the modeled concentration were cypermethrin and esfenvalerate. However, this type of comparison is of limited value, since the whole water concentrations include pyrethroids in the water, suspended particulate or sediment, and dissolved organic matter (*i.e.*, since these are unfiltered water samples). Meanwhile the modelled EECs represent freely dissolved chemical.

There are limited number of concentrations in filtered water available for bifenthrin and cyfluthrin. The maximum bifenthrin concentration (15 ng/L) was slightly above the limit of solubility for the chemical and very similar to the maximum EEC (14 ng/L). Meanwhile, the maximum cyfluthrin concentration was below the modeled concentration, but within about one order of magnitude of the EEC.

Given that the monitored values are whole water (unfiltered) concentrations, EFED investigated further how to estimate freely dissolved pyrethroid concentrations in U.S. unfiltered water. Equation 2 in the Appendix A of the KABAM User's Guide (USEPA 2009b) describes the calculation of Φ, the fraction of the overlying water (or water column) concentration of the pesticide that is freely dissolved, which depends on the particulate organic carbon (POC), dissolved organic carbon (DOC) and the octanol/water partition coefficient (K_{OW}). **Table 53** shows the definitions of each parameter of the equation, and units.

$$\textit{Equation 2} \quad \Phi = \frac{1}{1 + (X_{POC} * \alpha_{POC} * K_{OW}) + (X_{DOC} * \alpha_{DOC} * K_{OW})}$$

Table 53. Derivation of available pesticide fraction in water (Φ; unitless) and its associated parameters (Based on Table *A*2 of the KABAM manual and Arnot and Gobas (2004)).

Symbol	Definition	Value	Units
X_{POC}	Concentration of particulate organic carbon in water	user defined	kg/L
X_{DOC}	Concentration of dissolved organic carbon in water	user defined	kg/L
K_{OW}	Octanol water partition coefficient	user defined	none
α_{POC}	Proportionality constant to describe the similarity of phase partitioning of POC in relation to octanol	0.35	none
α_{DOC}	Proportionality constant to describe the similarity of phase partitioning of DOC in relation to octanol	0.08	none

Furthermore, EFED searched the National POC/DOC Database (USEPA, 2003) for typical POC and DOC concentrations in U.S. waters. **Table 54** shows some of the values for streams/rivers (based on n = 69,589).

Table 54. National Values for Streams/Rivers in the U.S.: Median, 10th and 90th Percentile, POC and DOC[1]

Stream/Rivers	DOC (mg/L)	POC (mg/L)
Median	3.8	0.6
10th	1	0.1[2]
90th	11.6	3.1

[1] Based on the National POC/DOC Database (USEPA, 2003).
[2] Estimated POC, since 10th value was reported as 0 mg/L.

Tables 55 to 57 show estimated freely dissolved monitored concentrations, assuming the 10th, median, and 90th POC and DOC values presented in **Table 54**, and the monitored concentrations presented in **Table 52**. Dark shaded cells mean EECs are within one order of magnitude of the estimated freely dissolved concentration. Light shaded cells mean the EEC is less than the estimated freely dissolved concentration by greater than a 10x factor. Cells with no shade mean the freely dissolved estimated concentration is below the EEC by a factor of greater than 10x. In all three tables, except for bifenthrin, the ratio of EEC/Freely Dissolved concentration (maximum and 90th from PWG study or maximum from CASQA report), indicated that each of the freely dissolved concentrations were within one order of magnitude of the maximum EEC or below the EEC. For bifenthrin, the modelled EEC was limited by the extremely low solubility of the chemical, while for these calculations initially the monitored concentrations were not limited (footnote 4 in each table).

Table 55. Comparison of Maximum and 90th Percentile Monitored Whole Water Concentrations, Estimated as Freely Dissolved Concentrations, in Urban Environments, against Modeled Water Column EECs (*Assuming 10th Percentile DOC = 1 mg/L, and estimated POC = 0.1 mg/L*)

Chemical	Maximum Water Column Monitored Conc. FD PWG (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD PWG (ng/L)[1]	Maximum Water Column Monitored Conc. FD CASQA (ng/L)[2]	Maximum Water Column Modeled EEC FD (ng/L)[3]	EEC/ Maximum Water Column Conc. FD PWG [1]	EEC/ 90th Percentile Water Column Conc. FD PWG [1]	EEC/ Maximum Water Column Conc. FD PWG [2]
Bifenthrin	1,165[4] (14)	8.5	14 (89.0[4])	14[5]	0.012 (1.0)	1.65	0.16 (1.0)
Cyfluthrin	272	2.1	231	127	0.47	59.69	0.55
L-Cyhalothrin	28	<RL	105	25.6	0.93	N/A	0.24
Cypermethrin	259	<RL	298	1370	5.29	N/A	4.60
Deltamethrin	109	<RL	119	200[4]	1.84	N/A	1.69
Esfenvalerate	10	<RL	13.6	234	22.57	N/A	17.17
Fenpropathrin	6.1	<RL	357	963	157.11	N/A	2.70
Permethrin	256	<RL	5310	1,700	6.63	N/A	0.32

FD = freely dissolved; DOC = dissolved organic carbon; POC = particulate organic carbon. Dark shaded cells mean EECs are within 10x of the estimated freely dissolved concentration. Light shaded cell means EEC is less than the estimated freely dissolved concentration by greater than a 10x factor (in this instance, the freely dissolved concentration was estimated to be above the limit of solubility). Cells with no shade mean the freely dissolved estimated concentration is below the EEC by a factor of greater than 10.
[1] Based on flowing whole (unfiltered) water samples, see **Table 49** (PWG report).

[2] From the CASQA report, see **Table 48**.
[3] Maximum EEC for the urban uses of pyrethroids (residential and commercial).
[4] Concentration exceeded the limit of solubility of the chemical.

Table 56. Comparison of Maximum and 90th Percentile Monitored Whole Water Concentrations, Estimated as Freely Dissolved Concentrations, in Urban Environments, against Modeled Water Column EECs (*Assuming Median DOC = 3.8 mg/L, and POC = 0.6 mg/L*)

Chemical	Maximum Water Column Monitored Conc. FD PWG (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD PWG (ng/L)[1]	Maximum Water Column Monitored Conc. FD CASQA (ng/L)[2]	Maximum Water Column Modeled EEC FD (ng/L)[3]	Max. EEC/ Maximum Water Column Conc. FD PWG [1]	Max. EEC/ 90th Percentile Water Column Conc. FD PWG [1]	Max. EEC/ Maximum Water Column Conc. FD CASQA [2]
Bifenthrin	315[4] (14)	2.3	14 (24.1[4])	14[4]	0.044 (1.0)	6.09	0.58 (1.0)
Cyfluthrin	105	0.83	89.6	127	1.20	153.82	1.42
L-Cyhalothrin	9.3	<RL	35.2	25.6	2.76	N/A	0.73
Cypermethrin	104	<RL	120	1370	13.12	N/A	11.40
Deltamethrin	38.4	<RL	41.8	200[4]	5.21	N/A	4.78
Esfenvalerate	3.3	<RL	4.3	234	71.89	N/A	54.70
Fenpropathrin	3.4	<RL	201	963	279.28	N/A	4.80
Permethrin	85.1	<RL	1,762	1,700	19.98	N/A	0.96

FD = freely dissolved; DOC = dissolved organic carbon; POC = particulate organic carbon. Dark shaded cells mean EECs are within 10x of the estimated freely dissolved concentration. Light shaded cell means EEC is less than the estimated freely dissolved concentration by greater than a 10x factor (in this instance, the freely dissolved concentration was estimated to be above the limit of solubility). Cells with no shade mean the freely dissolved estimated monitored concentration is below the EEC by a factor of greater than 10.

[1] Based on flowing whole (unfiltered) water samples, see **Table 49** (PWG report).
[2] From the CASQA report, see **Table 48**.
[3] Maximum EEC for the urban uses of pyrethroids (residential and commercial).
[4] Concentration exceeded the limit of solubility of the chemical.

Table 57. Comparison of Maximum and 90th Percentile Monitored Whole Water Concentrations, Estimated as Freely Dissolved Concentrations, in Urban Environments, against Modeled Water Column EECs (*Assuming 90th Percentile DOC = 11.6 mg/L, and POC = 3.1 mg/L*)

Chemical	Maximum Water Column Monitored Conc. FD PWG (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD PWG (ng/L)[1]	Maximum Water Column Monitored Conc. FD CASQA (ng/L)[2]	Maximum Water Column Modeled EEC FD (ng/L)[3]	EEC/ Maximum Water Column Conc. FD PWG [1]	EEC/ 90th Percentile Water Column Conc. FD PWG [1]	EEC/ Maximum Water Column Conc. FD CASQA [2]
Bifenthrin	84.3[4] (14)	0.61	6.4	14[4]	0.17 (1.0)	22.8	2.17
Cyfluthrin	32.0	0.25	27.1	127	3.97	507	4.68
L-Cyhalothrin	2.7	<RL	10.1	25.6	9.64	N/A	2.54
Cypermethrin	32.2	<RL	37.1	1370	45.5	N/A	36.9

Chemical	Maximum Water Column Monitored Conc. FD PWG (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD PWG (ng/L)[1]	Maximum Water Column Monitored Conc. FD CASQA (ng/L)[2]	Maximum Water Column Modeled EEC FD (ng/L)[3]	EEC/ Maximum Water Column Conc. FD PWG [1]	EEC/ 90th Percentile Water Column Conc. FD PWG [1]	EEC/ Maximum Water Column Conc. FD CASQA [2]
Deltamethrin	11.2	<RL	12.2	200[4]	17.9	N/A	16.4
Esfenvalerate	0.91	<RL	1.2	234	257	N/A	196
Fenpropathrin	1.3	<RL	75.9	963	738	N/A	12.7
Permethrin	24.2	<RL	502	1,700	70.1	N/A	3.39

FD = freely dissolved; DOC = dissolved organic carbon; POC = particulate organic carbon. Dark shaded cells mean EECs are within 10x of the estimated freely dissolved concentration. Light shaded cells mean that the freely dissolved estimated concentration is below the EEC by a factor of greater than 10.

[1] Based on flowing whole (unfiltered) water samples, see **Table 49** (PWG report).

[2] From the CASQA report, see **Table 48**.

[3] Maximum EEC for the urban uses of pyrethroids (residential and commercial).

[4] Concentration exceeded the limit of solubility of the chemical.

5.6.5.2 Comparison of Monitored and Modeled Sediment Concentrations

A comparison of sediment monitored and modeled concentrations, based on PWG data is presented below. Comparison of the modeled and the maximum monitored concentration shows that for all the pyrethroids, except for fenpropathrin the OC-normalized sediment monitored concentrations were above the modeled concentrations. This could be due to the fact that in modeling all these pyrethroids a single application was assumed. Fenpropathrin, which was the exception, was considered an example chemical with modeling at single, three and up to 24 applications/year and the maximum modeled concentration was greater than the maximum monitored concentration. The urban uses of fenpropathrin are limited to commercial ornamentals. Comparison of the 90th percentile monitored concentration against the modelled EEC indicated that they were within one order of magnitude difference of each other, with the exception of fenpropathrin.

Table 58. Comparison of Maximum and 90th Percentile Sediment Monitored Concentration in Urban Environments against Modeled EECs

Chemical	Maximum Sediment Monitored Conc. PWG[1] (µg/kg$_{OC}$)	90th Percentile Sediment Monitored Conc. PWG[1] (µg/kg$_{OC}$)	Maximum Sediment Modeled EEC[2] (µg/kg$_{OC}$)	90th Percentile Sediment Monitored Conc. Is Within One Order of Magnitude Difference of the Maximum Sediment Modeled EEC?
Bifenthrin	10,000	1,400	333	Yes
Cyfluthrin	7,000	350	126	Yes
Lambda-Cyhalothrin	2,900	180	423	Yes
Cypermethrin	12,000	260	1,360	Yes
Deltamethrin	2,800	120	324	Yes
Esfenvalerate	1,900	20	300	Yes
Fenpropathrin	2,300	2	623-12,500[3]	No
Permethrin	196,000	1,100	11,800	Yes

[1] Based on sediment samples from urban flowing water use sites in PWG report, see **Table 51**.
[2] Maximum EEC for the urban uses of pyrethroids (residential and commercial). When the EEC was expressed in µg/kg-dw, it was approximated to µg/kg_{OC} by dividing by 0.04, which is the fraction of organic carbon in the sediment of the standard pond.
[3] A range is provided, since in this assessment 1-24 applications per year were modeled.

The above examples of comparison between monitored and modeled data is at best an approximation due to many factors such as (1) Modeled EECs may not have been conservative enough since a single application was assumed; (2) The summary focused mainly on the maximum observed concentrations in order to identify sites having the highest concentrations indicating their vulnerability, noting that these values may have been influenced by contamination from other sources such as spills and transported pesticides from areas upstream or with airborne particles and/or drift; (3) Ideally, only targeted monitoring data, for an identified vulnerable site, may be compared to modeling data using parameters representing the same site. Monitoring data needed for comparison should represent only one area and should be extensive (*e.g.*, daily or weekly); (4) It is important to point out that the ultimate maximum exposure EECs in receiving water bodies are dependent on the mass of pesticide transferred into the water body. Winter stormwater high flow with low concentration is expected to contribute more pesticide mass to receiving waters than summer low flow with high concentration; (5) In flowing waters, such as rivers and streams, observed concentrations are expected to be influenced by the flow status of the rivers and streams because higher dilution will occur at high flow compared to low flow; and (6) EECs are also influenced by the pesticide fate and transport properties as well as the receiving water characteristic such as type of suspended matter (content of dissolved/suspended organic carbon and other colloidal materials). Such content may additionally influence the bioavailability of the pesticide and its toxic effects.

6 Aquatic Receptors and Ecological Effects Characterization

In ecological risk assessments, effects characterization describes the types of effects a pesticide can produce in an aquatic (or terrestrial) organism. This characterization is based chiefly on registrant-submitted studies that describe acute and chronic effects toxicity information for various aquatic and terrestrial animals and plants. Data from the open literature are also considered; in this case, when updated ECOTOX queries were available, papers were screened to verify if data from any of those studies were more sensitive than available data from submitted studies and, if so, reviewed according to approved procedures (USEPA, 2011). Toxicity testing reported in this section does not represent all species of aquatic organisms. Only a few surrogate species for freshwater fish are used to represent all freshwater fish (2000+) species in the United States, although the most sensitive useable endpoints available are used in risk calculation. Estuarine/marine testing is usually limited to a crustacean, a mollusk, and a fish. Also, amphibians are not usually tested. The risk assessment assumes that freshwater fish serve as a surrogate for aquatic-phase amphibians.

Acute and chronic laboratory studies with pyrethroids and pyrethrins with aquatic organisms provide information regarding survival, growth, and reproduction. Data on the technical grade active ingredient (TGAI) and the effects on freshwater and estuarine/marine fish and invertebrates, aquatic vascular and nonvascular plants (algae), and freshwater and estuarine/marine sediment dwelling organisms are used to evaluate the potential risk from aquatic exposure resulting from runoff or spray drift from the assessed uses.

A comparison of freshwater and estuarine/marine fish most sensitive endpoints is provided in **Table 59**. A comparison of freshwater and estuarine/marine invertebrates' most sensitive endpoints is provided in **Table 61**. A comparison of freshwater and estuarine/marine benthic invertebrates' most sensitive endpoints is provided in **Table 62**. Vascular and non-vascular plant toxicity data is summarized in **Table 63**. In comparing the endpoints, it should be taken into account that a number of species are tested for each chemical, and only the most sensitive endpoints are included in these tables; as a result, species may vary across chemicals. Further information about the endpoints listed below (which are the most sensitive ones across species tested), including selected species, study identification, and effects observed, is presented in the **Attachment II**.

For freshwater fish, the most sensitive acute toxicity endpoint is for cyfluthrin (0.068 µg/L) and the least sensitive endpoint for pyrethrins (5.1 µg/L). On a chronic basis, the most sensitive NOAEC is for bifenthrin [0.004 µg/L, noted however that this is an estimated value, based on the most sensitive pyrethroid (*i.e.*, tefluthrin, which is not included in this assessment)] and the least sensitive endpoint for pyrethrins (1.9 µg/L).

It appears that, *in general*, the estuarine/marine fish are less sensitive than freshwater fish to pyrethroids. On an acute basis, for estuarine/marine fish the lowest endpoint is for cypermethrin (0.58 µg/L) and the highest is for esfenvalerate (>19.3 µg/L). For bifenthrin,

the acute endpoint is 1270 times higher than the limit of solubility for the chemical (17.8 µg/L compared to a solubility of 0.014 µg/L). On a chronic basis, the most sensitive NOAEC belongs to deltamethrin (0.024 µg/L), followed very closely by cyfluthrin (0.025 µg/L). The least sensitive NOAEC is for fenpropathrin (0.81 µg/L).

Table 59. Comparison of Freshwater and Estuarine/Marine Fish Most Sensitive Endpoints for Pyrethroids and Pyrethrins

	Freshwater Fish / (µg/L)		Estuarine/Marine Fish / (µg/L)	
Chemical	**96-hr LC_{50}**	**NOAEC/LOAEC**	**96-hr LC_{50}**	**NOAEC/LOAEC**
Bifenthrin	0.15	0.004 (estimate[1])/NA	17.8	0.1/0.14
Cyfluthrin	0.068	0.0042/0.008	4.05	0.025/0.084
Lambda-cyhalothrin	0.029	0.031/0.062	0.807	0.25/0.38
Cypermethrin	0.39	0.051/0.077	0.95	0.125 (ACR[2])
Deltamethrin	0.15	0.017/0.035	0.58	0.024/0.049
Esfenvalerate	0.142	0.017/0.036	>19.3	0.63/1.3
Fenpropathrin	2.2	0.06/0.091	3.1	0.81/2.0
Permethrin	0.79	0.052[2]/NA	2.2	0.143[2]/NA
Pyrethrins	5.1	1.9/3.0	16	0.7/1.7

For additional details and MRID citations, refer to **Attachment II**. NA=not available.
1 Estimated based on the most sensitive pyrethroid (tefluthrin).
2 Estimated value, based on acute-to-chronic ratio (ACR).

Table 60 shows the limit of solubility of the eight pyrethroids in this comparative assessment, plus pyrethrins. For freshwater and estuarine/marine fish, the acute endpoints exceed the limit of solubility of some of the pyrethroids. This is the case for bifenthrin (both freshwater and estuarine/marine fish acute endpoints), cyfluthrin (only estuarine/marine fish), deltamethrin (estuarine/marine fish), and esfenvalerate (only estuarine/marine fish). Endpoints measured at above the limit of solubility appear to indicate lower toxicity; however, these measurements are uncertain. The pyrethroids are highly hydrophobic, and should not be bioavailable above the limit of solubility.

Table 60. Solubility Values for Synthetic Pyrethroids and Pyrethrins

Chemical	Water Solubility (µg/L)
Bifenthrin	0.0140
Cyfluthrin	2.32
Lambda-cyhalothrin	5.00
Cypermethrin	3.97
Deltamethrin	0.200
Esfenvalerate	6.00
Fenpropathrin	10.3
Permethrin	5.50
Pyrethrins	200 – 9,000[1]

[1] Range given for pyrethrin 1 – pyrethrin 2.

Freshwater and estuarine/marine invertebrates are more sensitive to pyrethroids and pyrethrins than freshwater and estuarine/marine fish. For example, for freshwater invertebrates, the least sensitive acute endpoint belongs to the pyrethrins (0.76 µg/L), while the most sensitive endpoint is for *lambda*-cyhalothrin (0.00008 µg/L). Note that the range of endpoints is very wide (four orders of magnitude). On a chronic basis, the least sensitive endpoint is for pyrethrins (0.04 µg/L), and the most sensitive NOAEC belongs to

deltamethrin (0.000026 µg/L).

For estuarine/marine invertebrates, the most sensitive acute endpoint is for cyfluthrin (0.0022 µg/L), and the least sensitive acute endpoint is for the pyrethrins (1.4 µg/L). Meanwhile, on a chronic basis, the most sensitive NOAEC also belongs to cyfluthrin (0.00007 µg/L) and the least sensitive belongs to the pyrethrins (0.25 µg/L).

In general, the chemical showing the lowest toxicity to fish and invertebrates are the pyrethrins, *with the exception of* estuarine/marine fish, for which the acute endpoints for bifenthrin and esfenvalerate are less sensitive than for pyrethrins, and the chronic NOAEC for fenpropathrin is less sensitive than for pyrethrins.

Table 61. Comparison of Freshwater and Estuarine/Marine Invertebrates Most Sensitive Endpoints for Pyrethroids and Pyrethrins

	Freshwater Inverts / (µg/L)		Estuarine/Marine Inverts / (µg/L)	
Chemical	**96-hr EC_{50}**	**NOAEC/LOAEC**	**96-hr EC_{50}**	**NOAEC/LOAEC**
Bifenthrin	0.000493	0.000050/0.00009	0.00397	<0.0006/0.0006[2]
Cyfluthrin	0.025	0.00012/0.00025	0.0022	0.00007/0.00017
Lambda-cyhalothrin	0.00008	0.00022/0.00031	0.00491	0.0002/0.0008
Cypermethrin	0.00056	<0.00005/0.00005	0.0054	0.000781/0.00197
Deltamethrin	0.0002	0.000026/0.000050	0.0037	0.00047/0.00073
Esfenvalerate	0.000848	0.0000309/NA[1]	0.00466	0.00017/0.00025
Fenpropathrin	0.00305	<0.0015/0.0015	0.021	0.012/0.024
Permethrin	0.0066	0.0042/0.0074	0.018	0.0024/0.0046
Pyrethrins	0.76	0.04/0.10	1.4	0.25/0.64

For additional details and MRID citations, refer to **Attachment II**.
1 Estimated value, based on acute-to-chronic ratio (ACR).

Many of the chemicals had data available from both sub-chronic (10-day) and chronic (longer-term studies capturing reproduction endpoints, and emergence for the chironomid) studies. Surprisingly, in many cases, the sub-chronic data were more sensitive. For example, in esfenvalerate studies with *Hyalella azteca*, for the freely dissolved pore water concentration endpoints yielded a 10-d NOAEC of 0.70 ng a.i./L (MRID 48593610), compared to the 42-d NOAEC of 0.83 ng a.i./L (MRID 49054201), contrary to the expectation that a longer-term study would produce a more sensitive endpoint. This same trend was seen in several of the other pyrethrins/pyrethroids in this group, as well, and in some cases the difference was of a larger magnitude. The likely explanation is two-fold—that the discrepancy is largely due to differences in the sediment used in the studies and partly due to the inherent variability of the study results. Focusing on the former, artificial sediment was used in the 10-d studies while natural sediment was used in the longer-term chronic studies. For the esfenvalerate example, the artificial formulated sediment used in the 10-d study contained 6% sphagnum peat, resulting in a total organic carbon (TOC) content of 2.1%, while the natural sediment used in the 42-d chronic study had a TOC content of 3.7%. Given the high affinity of pyrethrins/ pyrethroids for organic substrates, this difference, not only in the percent, but perhaps the type of organic substrate, likely played a role in the availability of the test substance. See the comprehensive list of toxicity data in **Attachment IV** for more detailed information on a particular chemical in the group. The measured pore water endpoints are uncertain. Instead of measured concentrations,

they were calculated based on the sediment concentration and the K_{OC} for the chemical. However, the calculated endpoint is uncertain, since the measured K_{OC}s vary across soils and sediments. This estimation was done this way because EECs from the PWC represent freely dissolved concentrations and NOAECs were below the level that freely dissolved concentrations could be detected analytically.

Regardless of the sediment type or duration, the most sensitive endpoints were selected for use in risk calculation. For freshwater benthic organisms, deltamethrin had the most sensitive freshwater benthic organisms NOAEC of 0.000026 µg a.i./L based on freely-dissolved pore water, with cypermethrin and bifenthrin being in a similar range (<0.00005 µg a.i./L and 0.000050 µg a.i./L, respectively). For estuarine/marine benthic organisms, the pore water most sensitive endpoint was for cyfluthrin, with 0.00007 µg a.i./L. Sediment based endpoints are expressed either in µg a.i./kg_{OC} or µg a.i./kg_{dw}, depending on the modelling input value (K_{OC} or K_d, respectively); therefore the table was divided into two sections and the sediment units are marked with ***italics*** font in **Table 62**. For more discussion, see **Section 7.2.5** (*Use of K_d instead of K_{OC} in the PWC*). For the saltwater taxon (*Leptocheirus*), several of the chemicals lacked data, but of those available, bifenthrin was the most sensitive and fenpropathrin the least.

Table 62. Comparison of Freshwater and Estuarine/Marine Benthic Invertebrates Most Sensitive Chronic Endpoints for Pyrethroids and Pyrethrins

	Freshwater Inverts		Estuarine/Marine Inverts	
Chemical	**NOAEC/LOAEC Pore Water (µg/L)**	**NOAEC/LOAEC Sediment (*µg/kg$_{OC}$*)**	**NOAEC/LOAEC Pore Water (µg/L)**	**NOAEC/LOAEC Sediment (*µg/kg$_{OC}$*)**
Cyfluthrin	0.00012/0.00025	22/46	0.00007/0.00017	<34/34[1]
Cypermethrin	<0.00005/0.00005[1]	<7.7/7.7[1]	0.0002/0.0008	34/110
Deltamethrin	0.000026/0.000055	12/25	0.00047/0.00073	NA
Esfenvalerate	0.00070/0.00120	176/314	0.003/0.0103	830/2600
Fenpropathrin	<0.0015/0.0015[1]	<310/310[1]	0.012/0.024	3200/6800
Chemical	**NOAEC/LOAEC Pore Water (µg/L)**	**NOAEC/LOAEC Sediment (*µg/kg$_{dw}$*)**	**NOAEC/LOAEC Pore Water (µg/L)**	**NOAEC/LOAEC Sediment (*µg/kg$_{dw}$*)**
Bifenthrin	0.000050/0.000090	0.25/0.45	<0.0006/0.0006[1]	<5.4/5.4[1]
Lambda-cyhalothrin	0.00022/0.00031	0.31/0.44	0.0002/0.0008	<2.40/2.40[1]
Permethrin	0.0042/0.0074	7.4/13	0.0024/0.0046	38/97
Pyrethrins	0.04/0.10	41/95	0.25/0.64	NA

For additional details and MRID citations, refer to **Attachment II**.
NA = No available toxicity data.
[1] Non-definitive endpoint.

Although no plant toxicity data were readily available for some of the chemicals, it can be concluded that aquatic plants are much less sensitive to pyrethroids than freshwater and estuarine/marine fish and invertebrates. In many cases, the endpoints were non-definitive, meaning that it was expressed as a greater than value, and at the highest tested concentration, the desired EC_{50} effect has not been reached.

Table 63. Comparison of Vascular and Non-vascular Plants Most Sensitive Endpoints for Pyrethroids and Pyrethrins

Chemical	Vascular Plants / (µg/L)		Non-vascular Plants / (µg/L)	
	EC_{50}	**NOAEC**	**EC_{50}**	**NOAEC**
Bifenthrin	>330	330	>290[1]	290
Cyfluthrin	NA	NA	>2[1]	NA
Lambda-cyhalothrin	>0.508[1]	0.508	>310[1]	≥310[1]
Cypermethrin	>1.62	1.62	25000	60
Deltamethrin	>779[1]	779	>3.1[1]	3.1
Esfenvalerate	>8.6[1]	8.6	>5.6[1]	5.6
Fenpropathrin	>1000[1]	1000	63	24
Permethrin	>3.2[1]	3.2	>4.4[1]	0.65
Pyrethrins	1230	850	105	29

NA = No available toxicity data.
For additional details and MRID citations, refer to **Attachment II**.
[1] Non-definitive estimate; no effects seen at the highest test concentration.

The endpoints selected for RQ calculations are presented in the footnotes to each of the RQ tables in **Section 7.1** (*Risk Estimation*).

7 Risk Characterization

Risk characterization provides the final step in the risk assessment process. In this step, exposure and effects characterization are integrated to provide an estimate of risk relative to established levels of concern (LOCs; **Section 7.1**). The results are then interpreted for the risk manager through a risk description and synthesized into an overall conclusion (**Sections 7.2**). In addition, the risk description also contains a discussion of relevant sources of uncertainty in the risk assessment and sensitivity of the risk assessment findings to important methodological assumptions.

7.1 Risk Estimation

Results of the exposure modelling and toxicity effects data are used to evaluate the likelihood of adverse ecological effects on non-target species. For the assessment of pyrethroids and pyrethrins, the risk quotient (RQ) method is used to compare exposure and measured toxicity values (refer to **Appendix A**). Estimated environmental concentrations (EECs) are divided by the most sensitive acute and chronic toxicity values. The RQs are then compared to the Agency's levels of concern (LOCs). These LOCs, summarized in **Appendix A**, are the Agency's interpretive policy and are used to analyse potential risk to non-target organisms and the need to consider regulatory action. These criteria are used to indicate when a pesticide's use as directed on the label has the potential to cause adverse effects on non-target organisms. LOCs currently address the following risk presumption categories:

Aquatic Animals:

- **Acute risk** - potential for acute risk to non-target organisms which may warrant regulatory action in addition to restricted use classification,
- **Acute risk, listed species** – listed species may be potentially affected by use,
- **Chronic risk** – potential for chronic risk may warrant regulatory action, listed species may potentially be affected through chronic exposure.

7.1.1 Freshwater and Estuarine/Marine Fish Risk Quotients

For bifenthrin, the majority of the acute freshwater fish RQs exceeded the listed (endangered and/or threatened) species LOC (0.05), but none of these RQs exceed the non-listed species LOC (0.5). Many of the acute EECs were limited by the solubility of bifenthrin, which is quite low. At this concentration, the acute RQ = 0.09. [For both turf scenarios, the residential lots located in TX and PA, and both nursery scenarios, the acute EEC was capped at the limit of solubility of bifenthrin.] The chronic LOC (1.0) was exceeded for both turf scenarios (CA turf with MI weather file, and FL turf with TN weather file), the residential lot with TX weather file, and both nursery scenarios (OR and NJ), with RQs ranging from **1.2** to **3.5**. For the remaining scenarios, the RQs were below the LOC.

For estuarine/marine fish exposed to bifenthrin there were no exceedances of any of the acute or chronic listed and/or non-listed LOCs for estuarine/marine fish. On an acute basis, the RQs were <0.01 for all the scenarios. The highest chronic RQ = 0.14 for the NJ nursery scenario.

Table 64. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Bifenthrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.014 (0.131)*	0.00735	*0.09*	**1.8**	<0.01	0.07
02 FL turf (TN met file, W13882	0.014 (0.0806)*	0.00814	*0.09*	**2.0**	<0.01	0.08
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00404	3.47×10^{-4}	0.03	0.09	<0.01	<0.01
06, 07 BSS residential, ROW [Residential lots]	0.014 (0.0652)*	0.00478	*0.09*	**1.2**	<0.01	0.05
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.014 (0.0193)*	0.00211	*0.09*	0.53	<0.01	0.02
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.014 (0.0203)*	0.00185	*0.09*	0.46	<0.01	0.02
15 OR nursery [Ornamentals]	0.014 (0.0498)*	0.00630	*0.09*	**1.6**	<0.01	0.06
16 NJ nursery [Ornamentals]	0.014 (0.593)*	0.014 (0.0477)*	*0.09*	**3.5**	<0.01	0.14

Generally, EECs were rounded to three significant figures and for the RQs no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.15 ppb [for Rainbow Trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 0.004 ppb [no acceptable data were submitted or found in the open literature on the chronic toxicity of bifenthrin to freshwater fish; the value used is based on the

most sensitive chronic NOAEC reported for pyrethroids (*i.e.*, tefluthrin, MRID 41705101)].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 17.8 ppb [for Sheepshead Minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.1 ppb [for Sheepshead Minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to deltamethrin, on an acute basis, only the RQs for the commercial lots with FL weather, and the NJ nursery scenarios, exceeded the listed species and non-listed species LOCs (0.05 and 0.5, respectively). The RQs for these scenarios were 1.3 for the commercial lots and 0.81 for the NJ nursery scenario. Three additional scenarios exceeded the listed species LOC: CA and FL turf, and residential lots in TX. None of the chronic RQs exceeded the LOC (1.0). The highest chronic RQ was only 0.12, for the NJ nursery scenario.

For estuarine/marine fish exposed to deltamethrin there were only two exceedances of the acute listed species LOC (LOC = 0.05): commercial lots using a FL weather file, and NJ nursery (RQ = 0.34 in both instances). None of the chronic RQs exceeded the LOC of 1.0. On an acute basis, the RQs were <0.01 to 0.34 and the chronic RQs were <0.01 to 0.09.

Table 65. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0251	2.53×10^{-4}	*0.17*	0.01	0.04	0.01
02 FL turf (TN met file, W13882)	0.0251	2.79×10^{-4}	*0.17*	0.02	0.04	0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.19×10^{-3}	1.40×10^{-5}	0.01	<0.01	<0.01	<0.01
06, 07 BSS residential, ROW [Residential lots]	0.00904	2.11×10^{-4}	*0.06*	0.01	0.02	0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.00448	9.27×10^{-5}	0.03	0.01	0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.200 (0.622)*	0.00402	**1.3**	0.24	*0.34*	0.16
15 OR nursery [Ornamentals]	0.00311	1.13×10^{-4}	0.02	0.01	0.01	<0.01
16 NJ nursery [Ornamentals]	0.121	0.00205	**0.81**	0.12	*0.21*	0.09

Generally, EECs were rounded to three significant figures and for the RQs no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.15 ppb [for Rainbow trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 0.017 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.58 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.024 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

For the pyrethrins and freshwater fish, none of the scenario RQs exceeded the listed or non-listed acute or chronic LOCs for pyrethrins. The highest acute RQ was 0.03, for the following three scenarios: CA and FL turf (using MI and TN weather files, respectively), and NJ nursery. The highest chronic RQ was only 0.02 for the NJ nursery scenario.

For estuarine/marine fish exposed to pyrethrins there were no RQs exceeding any of the acute or chronic listed and/or non-listed LOCs. On an acute basis, the RQs were ≤0.01 for all the scenarios. The chronic RQs ranged from <0.01 to 0.04 for all the scenarios.

Table 66. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.132	0.0158	0.03	0.01	0.01	0.02
02 FL turf (TN met file, W13882)	0.128	0.0126	0.03	0.01	0.01	0.02
03, 04, 05 CA residential, ROW, impervious [Residential lots]	2.14×10^{-4}	3.68×10^{-5}	<0.01	<0.01	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0131	0.00193	<0.01	<0.01	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.00408	4.31×10^{-4}	<0.01	<0.01	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.0904	0.00998	0.02	0.01	0.01	0.01
15 OR nursery [Ornamentals]	0.0895	0.0106	0.02	0.01	0.01	0.02
16 NJ nursery [Ornamentals]	0.148	0.0288	0.03	0.02	0.01	0.04

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 5.1 ppb [for Rainbow Trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 1.9 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 16 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.7 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to permethrin, there were multiple exceedances of LOCs (listed and/or non-listed). Both turf scenarios acute RQs exceeded the listed species LOC (0.05). Two of three residential and the commercial scenario RQs exceeded the acute non-listed LOC (non-listed LOC = 0.5). Of the nursery scenarios, the OR scenario RQ exceeded only the listed species LOC while the NJ scenario RQ exceeded the listed and non-listed species LOC. On a chronic basis, the following scenarios RQs exceeded the non-listed LOC of 1.0: residential scenario using CA and PA weather files (but not in TX), the commercial scenario using a FL weather file, and the NJ nursery scenario.

For estuarine/marine fish exposed to permethrin, on an acute basis all the RQs exceeded the listed species LOC (0.05), and in two cases the non-listed species LOC (0.5). The two scenario RQs that exceeded the non-listed species LOC were the residential scenario using a PA weather file and the NJ nursery scenario. The remaining scenarios exceeded only the acute listed species LOC. The acute RQs ranged from 0.06 to 0.77. Only the residential scenario using a PA weather file exceeded the chronic LOC by a slight margin (RQ = 1.17; LOC = 1.0).

Table 67. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.378	0.0281	*0.48*	0.54	*0.17*	0.20
02 FL turf (TN met file, W13882)	0.286	0.0280	*0.36*	0.54	*0.13*	0.20
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.745	0.0757	**0.94**	**1.5**	*0.33*	0.53
06, 07 BSS residential, ROW [Residential lots]	0.126	0.00857	*0.16*	0.16	*0.06*	0.06
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	1.70	0.167	**2.2**	**3.2**	**0.77**	**1.17**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	1.04	0.101	**1.3**	**1.9**	*0.47*	0.71
15 OR nursery [Ornamentals]	0.126	0.0172	*0.16*	0.33	*0.06*	0.12
16 NJ nursery [Ornamentals]	1.60	0.127	**2.0**	**2.4**	**0.72**	0.89

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.79 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.052 ppb [for Bluegill sunfish, *Lepomis macrochirus*, based on an ACR].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Atlantic Silverside, *Menidia menidia*]. Chronic RQ = use-specific 60-day EEC / 0.143 ppb [for Atlantic Silverside, *Menidia menidia*].

For freshwater fish exposed to esfenvalerate, the turf and residential scenarios exceeded the acute listed species LOC (acute listed species LOC = 0.05). The commercial lots and the nursery scenarios exceeded the acute non-listed species LOC (LOC = 0.5), with RQs of 2.81 to 5.02. None of the scenarios exceeded the chronic non-listed species LOC (LOC = 1.0). The highest chronic RQ was for the NJ nursery scenario, with and RQ of 0.69.

For estuarine/marine fish exposed to esfenvalerate, all the acute RQs were ≤0.04 and did not exceed the listed and/or non-listed LOCs (LOC = 0.05 and 0.5, respectively). All the chronic RQs were ≤0.02 and did not exceed the LOC (LOC = 1.0).

Table 68. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0411	7.62×10^{-4}	*0.28*	0.04	<0.01	<0.01
02 FL turf (TN met file, W13882)	0.0355	0.00148	*0.25*	0.09	<0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00661	2.56×10^{-4}	*0.05*	0.02	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0201	5.67×10^{-4}	*0.14*	0.03	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0140	4.10×10^{-4}	*0.10*	0.02	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.713	0.00638	**5.02**	0.38	0.04	0.01
15 OR nursery [Ornamentals]	0.399	0.00531	**2.81**	0.31	<0.02	0.01
16 NJ nursery [Ornamentals]	0.427	0.0117	**3.01**	0.69	<0.02	0.02

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.142 ppb [for Bluegill, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.017 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 19.3 ppb [>19.3 ppb estimated from sheepshead minnow, *Cyprinodon variegatus*, TEP toxicity data, along with a rainbow trout adjustment factor for estimating TGAI toxicity from TEP data]. Chronic RQ = use-specific 60-day EEC / 0.63 ppb [for sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish and cypermethrin, all the scenarios exceeded the acute listed species LOC (LOC = 0.05). The commercial lots located in FL also exceeded the acute non-listed species LOC with an RQ of 11 (LOC = 0.5). None of the chronic RQs exceeded the non-listed species LOC (LOC = 1.0), although for the FL commercial lots, the RQ approached the LOC (RQ = 0.99).

For estuarine/marine fish exposed to cypermethrin, the acute RQ for the commercial lots using a FL weather file exceeded the acute listed and non-listed LOC with an acute RQ = 4.4 (acute listed and non-listed LOCs = 0.05 and 0.5, respectively). The remaining scenario RQs exceeded only the acute non-listed LOC. None of the chronic RQs exceeded the LOC (LOC = 1.0).

Table 69. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Cypermethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0942	0.00208	*0.24*	0.04	*0.09*	0.02
02 FL turf (TN met file, W13882)	0.0776	0.0037	*0.20*	0.07	*0.08*	0.03

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.0528	2.16×10^{-3}	*0.14*	0.04	*0.06*	0.02
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.126	4.29×10^{-3}	*0.32*	0.08	*0.13*	0.03
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.106	3.00×10^{-3}	*0.27*	0.06	*0.11*	0.02
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	4.18	0.0504	**11**	0.99	**4.4**	0.40
15 OR nursery [Ornamentals]	0.124	0.0019	*0.32*	0.04	*0.13*	0.02
16 NJ nursery [Ornamentals]	0.127	0.00376	*0.32*	0.07	*0.13*	0.03

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.39 ppb [for Rainbow Trout, *Oncorhynchus mykiss*, conducted with *beta*-cypermethrin]. Chronic RQ = use-specific 60-day EEC / 0.051 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.95 ppb [for sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.125 ppb [no valid chronic study, estimated using an ACR].

For freshwater fish exposed to cyfluthrin, both turf and two of three of the residential scenarios exceeded the acute listed species LOC (LOC = 0.05), while the remaining residential scenario (in CA) did not exceed the LOC. Both nursery scenarios, and the commercial lots using a FL weather file exceeded the acute non-listed species LOC (LOC = 0.5), with RQs of 1.7 to 5.7. None of the chronic RQs exceeded the non-listed species LOC (LOC = 1.0). The highest chronic RQ was 0.76 for the FL commercial lots scenario.

For estuarine/marine fish exposed to cyfluthrin, none of the acute or chronic RQs exceeded any of the LOCs (acute LOCs = 0.05 and 0.5, for listed and non-listed species, respectively; chronic LOC = 1.0). The only exception was the acute listed species LOC (LOC = 0.05) was exceeded for the FL commercial lots scenario, with an RQ of 0.10.

Table 70. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Cyfluthrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0212	3.05×10^{-4}	*0.31*	0.07	0.01	0.01
02 FL turf (TN met file, W13882)	0.0158	2.54×10^{-4}	*0.23*	0.06	<0.01	0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.07×10^{-3}	2.48×10^{-5}	0.02	0.01	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	7.33×10^{-3}	1.97×10^{-4}	*0.11*	0.05	<0.01	0.01

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	5.50×10^{-3}	9.00×10^{-5}	*0.08*	0.02	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.387	3.18×10^{-3}	**5.7**	0.76	*0.10*	0.13
15 OR nursery [Ornamentals]	0.115	0.00108	**1.7**	0.25	0.03	0.04
16 NJ nursery [Ornamentals]	0.115	0.00187	**1.7**	0.45	0.03	0.07

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.068 ppb [for Rainbow Trout, *Oncorhynchus mykiss*, conducted with *beta*-cyfluthrin]. Chronic RQ = use-specific 60-day EEC / 0.0042 ppb [NOAEC for Rainbow Trout, *Oncorhynchus mykiss*, conducted with *beta*-cyfluthrin].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 4.05 ppb [for sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.025 ppb [for sheepshead minnow, *Cyprinodon variegatus*].

For *lambda*-cyhalothrin and freshwater fish, one of the turf, one of three of the residential scenarios, the commercial lots using a FL weather file, and both nursery scenarios exceeded the acute listed and non-listed species LOCs (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5), while the remaining three scenarios only exceeded the listed species LOC. The range in acute RQs is 0.06 to 11. Only the nursery scenarios chronic RQs exceeded the non-listed species LOC (LOC = 1.0). The highest chronic RQ was 3.0 for the NJ nursery scenario.

For estuarine/marine fish exposed to *lambda*-cyhalothrin, the acute RQs did not exceed any of the LOCs for the turf, commercial and residential scenarios. Both nursery scenarios exceeded only the acute listed species LOC (acute listed species LOC = 0.05), with RQs of 0.34 to 0.39. All the chronic RQs were ≤0.37 and none exceeded the LOC (chronic LOC = 1.0).

Table 71. Acute and Chronic RQs for Freshwater Fish Exposed to *Lambda*-Cyhalothrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0153	0.00304	**0.53**	0.10	0.02	<0.01
02 FL turf (TN met file, W13882)	0.00672	0.00244	*0.23*	0.08	0.01	0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.88×10^{-3}	7.83×10^{-4}	*0.06*	0.03	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0256	6.36×10^{-3}	**0.88**	0.20	0.03	0.03
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0127	3.79×10^{-3}	*0.43*	0.12	0.02	0.02
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.0195	4.10×10^{-3}	**0.67**	0.13	0.02	0.02
15 OR nursery [Ornamentals]	0.276	0.0497	**9.5**	**1.6**	*0.34*	0.20

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
16 NJ nursery [Ornamentals]	0.317	0.0919	**11**	**3.0**	*0.39*	0.37

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.029 ppb [for Bluegill sunfish, *Lepomis macrochirus*, conducted with *gamma*-cyhalothrin]. Chronic RQ = use-specific 60-day EEC / 0.031 ppb [for Fathead Minnow, *Pimephales promelas*, conducted with *lambda*-cyhalothrin].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.807 ppb [for sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.25 ppb [for sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to fenpropathrin there were multiple exceedances of acute and chronic LOCs. On an acute basis of the nursery scenarios, assuming 24 applications per year, all the scenario RQs exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). When assuming three applications per year, the OR and TX scenarios exceeded only the acute listed species LOC. When assuming a single application per year, all the scenarios exceeded only the acute listed species LOC, but not the non-listed species LOC. For the commercial lots using a FL weather file, for a single application the RQ did not exceed any of the LOCs; for three and 24 applications, the scenario exceeded only the listed species LOC.

On a chronic basis for fenpropathrin and freshwater fish, the RQs exceeded the LOC (1.0) for all but eight of the scenarios. Assuming 24 applications per year to the nursery scenarios, all the scenarios exceeded the chronic LOC (LOC = 1.0). When assuming three applications per year, all the scenario RQs exceeded the LOC except for the OR and TX nursery. When assuming a single application per year, only the NJ, MI and TN scenarios were marginally equaling the LOC (RQs = 1.0 in all three instances). For the commercial lots using a FL weather file, for a single application or for three applications per year, the RQ did not exceed the chronic LOC, while for 24 applications per year, the scenario exceeded the chronic LOC (RQ = 1.1).

For estuarine/marine fish exposed to fenpropathrin there were multiple exceedances of the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), and four chronic RQs exceeded the chronic LOC (1.0). For the nursery scenarios assuming a single application per year, the acute RQs exceeded only the listed species LOC for all the scenarios, except for the OR nursery (no exceedances). For three applications per year, four out of the eight scenarios exceeded both the listed species LOC and the non-listed species LOC, while the remaining four scenarios exceeded only the listed species LOC. For 24 applications per year, all the scenarios exceeded both LOCs. For the commercial lots using a FL weather file, for a single application there were no exceedances of LOCs, and for three and 24 applications, only the listed species LOC was exceeded (but not the non-listed species LOC).

For estuarine/marine fish exposed to fenpropathrin, on a chronic basis, four of the eight nursery scenarios, treated 24 times per year exceeded the chronic LOC (1.0), with RQs in the range of 1.3 to 2.0. The remaining scenario combinations had RQs that did not exceed the chronic LOC.

Table 72. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Fenpropathrin

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
				Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	2.05	0.106	**0.93**	**1.8**	**0.66**	0.13
02 FLnurserySTD_V2/ ornamentals	0.3x3	1.51	0.147	**0.69**	**2.5**	*0.49*	0.18
03 MInurserySTD_V2/ ornamentals	0.3x3	1.20	0.182	**0.55**	**3.0**	*0.39*	0.22
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	2.04	0.182	**0.93**	**3.0**	**0.66**	0.22
06 ORnurserySTD_V2/ ornamentals	0.3x3	0.422	0.054	*0.19*	0.9	*0.14*	0.07
07 TNnurserySTD_V2/ ornamentals	0.3x3	1.66	0.18	**0.75**	**3.0**	**0.54**	0.22
08 NurseryBSS_V2/ ornamentals	0.3x3	0.695	0.058	*0.32*	0.97	*0.22*	0.07
09 CAnurserySTD_V2/ ornamentals	0.3x24	9.80	0.744	**4.5**	**12**	**3.2**	0.92
10 FLnurserySTD_V2/ ornamentals	0.3x24	10.3* (13.4)	1.09	**4.7**	**18**	**3.3**	**1.3**
11 MInurserySTD_V2/ ornamentals	0.3x24	7.56	1.38	**3.4**	**126**	**2.4**	**1.7**
12 NJnurserySTD_V2/ ornamentals	0.3x24	10.3* (19.1)	1.59	**4.7**	**172**	**3.3**	**2.0**
13 ORnurserySTD_V2/ ornamentals	0.3x24	2.53	0.384	**1.2**	**6.4**	**0.82**	0.47
14 TNnurserySTD_V2/ ornamentals	0.3x24	9.57	1.27	**4.4**	**21**	**3.1**	**1.6**
15 NurseryBSS_V2/ ornamentals	0.3x24	3.66	0.378	**1.7**	**6.3**	**1.2**	0.47
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	0.151	0.008	*0.07*	0.13	*0.05*	0.01
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	0.963	0.063	*0.44*	**1.1**	*0.31*	0.08
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	0.049	0.003	0.02	0.05	0.02	<0.01
19 CAnurserySTD_V2/ ornamentals	0.3x1	0.817	0.0421	*0.37*	0.70	*0.26*	0.05
20 FLnurserySTD_V2/ ornamentals	0.3x1	0.537	0.0493	*0.24*	0.82	*0.17*	0.06
21 MInurserySTD_V2/ ornamentals	0.3x1	0.388	0.0621	*0.18*	**1.0**	*0.13*	0.08
22 NJnurserySTD_V2/ ornamentals	0.3x1	0.669	0.061	*0.30*	**1.0**	*0.22*	0.08
23 ORnurserySTD_V2/ ornamentals	0.3x1	0.133	0.0178	*0.06*	0.30	0.04	0.02
24 TNnurserySTD_V2/ ornamentals	0.3x1	0.601	0.0594	*0.27*	**1.0**	*0.19*	0.07
25 NurseryBSS_V2/ ornamentals	0.3x1	0.235	0.0194	*0.11*	0.32	*0.08*	0.02

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 10.3 ppb because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.06 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 3.1 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.81 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

Besides the parent alone, for fenpropathrin additional runs were performed including the unextracted residues. For freshwater fish exposed to fenpropathrin plus the unextracted residues, there were also multiple exceedances of acute and chronic LOCs. On an acute basis of the nursery scenarios, assuming 24 applications per year, all the scenario RQs exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). When assuming three applications per year, the OR and TX scenarios exceeded only the acute listed species LOC. When assuming a single application per year, all the scenarios exceeded only the acute listed species LOC. For the commercial lots using a FL weather file, for a single application the RQ did not exceed any of the LOCs; for three applications, the scenario exceeded only the listed species LOC; and for 24 applications, the scenario exceeded the listed non-listed species LOC.

On a chronic basis for fenpropathrin plus the unextracted residues, the RQs exceeded the LOC (1.0) for all but six of the scenarios. Assuming three and 24 applications per year to the nursery scenarios, all the scenarios exceeded the chronic LOC. When assuming a single application per year, for the NJ, MI and TN scenario, the RQs exceeded the chronic LOCs, in the range of 1.2 to 1.5. For the commercial lots using a FL weather file, for a single application or for three applications per year, the RQ did not exceed the chronic LOC, while for 24 applications per year, the scenario exceeded the chronic LOC.

For estuarine/marine fish exposed to fenpropathrin plus the unextracted residues there were multiple exceedances of the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), and five chronic RQs exceeded the LOC (1.0). Assuming a single application per year, the acute RQs exceeded the listed species LOC for all the scenarios, including the OR nursery. For three applications per year, all but two out of the eight scenarios exceeded both the listed species LOC and the non-listed species LOC; the OR and TX nursery scenarios exceeded only the listed species LOC. For 24 applications per year, all the scenarios exceeded both LOCs. For the commercial lots using a FL weather file, for a single application there were no exceedances of LOCs, for three applications only the listed species LOC was exceeded, and for 24 applications the non-listed species LOCs were exceeded.

On a chronic basis, five of the eight nursery scenarios, treated 24 times per year exceeded the LOC (1.0), with RQs in the range of 1.1 to 2.5. The remaining scenario combinations had RQs that did not exceed the chronic LOC.

In general, for the parent alone, compared to the parent plus the unextracted residues, the overall risk pictures were similar.

Table 73. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Fenpropathrin plus Unextracted Residues

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
				Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	2.32	0.130	**1.1**	**2.2**	**0.75**	0.16
02 FLnurserySTD_V2/ ornamentals	0.3x3	2.00	0.175	**0.91**	**2.9**	**0.65**	0.22
03 MInurserySTD_V2/ ornamentals	0.3x3	1.59	0.260	**0.72**	**4.3**	**0.51**	0.32
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	2.54	0.222	**1.2**	**3.7**	**0.82**	0.27
06 ORnurserySTD_V2/ ornamentals	0.3x3	0.563	0.079	*0.25*	**1.3**	*0.18*	0.10
07 TNnurserySTD_V2/ ornamentals	0.3x3	1.99	0.222	**0.90**	**3.7**	**0.64**	0.27
08 NurseryBSS_V2/ ornamentals	0.3x3	0.959	0.085	*0.44*	**1.4**	*0.31*	0.10
09 CAnurserySTD_V2/ ornamentals	0.3x24	10.3* (12.5)	0.895	**4.7**	**15**	**3.3**	**1.1**
10 FLnurserySTD_V2/ ornamentals	0.3x24	10.3* (19.5)	1.31	**4.7**	**22**	**3.3**	**1.6**
11 MInurserySTD_V2/ ornamentals	0.3x24	10.3* (11.6)	2.00	**4.7**	**33**	**3.3**	**2.5**
12 NJnurserySTD_V2/ ornamentals	0.3x24	10.3* (22.9)	1.92	**4.7**	**32**	**3.3**	**2.4**
13 ORnurserySTD_V2/ ornamentals	0.3x24	3.91	0.584	**1.8**	**9.7**	**1.3**	0.72
14 TNnurserySTD_V2/ ornamentals	0.3x24	10.3* (13.0)	1.64	**4.7**	**27**	**3.3**	**2.0**
15 NurseryBSS_V2/ ornamentals	0.3x24	5.76	0.591	**2.6**	**9.9**	**1.9**	0.73
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	0.218	0.015	*0.10*	0.25	*0.07*	0.02
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	1.60	0.122	**0.73**	**2.0**	**0.52**	0.15
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	0.071	0.005	0.03	0.08	0.02	0.01
19 CAnurserySTD_V2/ ornamentals	0.3x1	0.939	0.051	*0.43*	0.85	*0.30*	0.06
20 FLnurserySTD_V2/ ornamentals	0.3x1	0.765	0.058	*0.35*	0.97	*0.25*	0.07
21 MInurserySTD_V2/ ornamentals	0.3x1	0.520	0.088	*0.24*	**1.5**	*0.17*	0.11
22 NJnurserySTD_V2/ ornamentals	0.3x1	0.831	0.074	*0.38*	**1.2**	*0.27*	0.09
23 ORnurserySTD_V2/ ornamentals	0.3x1	0.186	0.026	*0.08*	0.43	*0.06*	0.03
24 TNnurserySTD_V2/ ornamentals	0.3x1	0.700	0.073	*0.32*	**1.2**	*0.23*	0.09
25 NurseryBSS_V2/ ornamentals	0.3x1	0.319	0.029	*0.15*	0.48	*0.10*	0.04

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

* EECs marked with an asterisk were set to 10.3 ppb because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.06 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 3.1 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.81 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

7.1.2 Freshwater and Estuarine/Marine Invertebrates Risk Quotients

For freshwater invertebrates exposed to bifenthrin, all the acute RQs exceeded the listed and non-listed LOCs (acute LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 8.19 to 28.4. On a chronic basis, the RQs exceeded the LOC (chronic LOC = 1.0) for all the scenarios. The chronic RQs ranged from 9.1 to 280.

For estuarine/marine invertebrates exposed to bifenthrin, all the RQs exceeded the acute listed (LOC = 0.05) and non-listed (LOC = 0.5) species LOCs. The range of acute RQs was 1.0 to 3.5 (the highest RQ is at the limit of solubility of 0.0140 µg/L). On a chronic basis, only the residential scenario using a CA weather file did not exceed the LOC (LOC = 1.0). The highest chronic RQ was >23 for the NJ nursery scenario (at the limit of solubility).

Table 74. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Bifenthrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.014 (0.131)*	0.00921	**28.4**	**184**	**3.5**	**>15**
02 FL turf (TN met file, W13882	0.014 (0.0806)*	0.00952	**28.4**	**190**	**3.5**	**>16**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00404	4.57×10^{-4}	**8.19**	**9.1**	**1.0**	>0.76
06, 07 BSS residential, ROW [Residential lots]	0.014 (0.0652)*	0.00646	**28.4**	**129**	**3.5**	**>11**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.014 (0.0193)*	0.00215	**28.4**	**43**	**3.5**	**>3.6**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.014 (0.0203)*	0.00226	**28.4**	**45**	**3.5**	**>3.8**
15 OR nursery [Ornamentals]	0.014 (0.0498)*	0.00713	**28.4**	**143**	**3.5**	**>12**
16 NJ nursery [Ornamentals]	0.014 (0.593)*	0.014 (0.0597)*	**28.4**	**280**	**3.5**	**>23**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.000493 ppb [for amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.000050 ppb [for amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00397 ppb [for Mysid Shrimp,

Americamysis bahia]. Chronic RQ = use-specific 21-day EEC / 0.0006 ppb [<0.0006 ppb for Mysid Shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to deltamethrin, all the acute RQs exceeded the listed and non-listed LOCs (acute LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 3.3 for the residential lots using a CA weather file to 1000 for the commercial lots using a FL weather file. On a chronic basis, all of the RQs exceeded the LOC (chronic LOC = 1.0), with the exception of the residential lots in California. The chronic RQs ranged from 0.60 to 112.

For estuarine/marine invertebrates exposed to deltamethrin, only the following scenario's acute RQ exceeded the listed species LOC (LOC = 0.05): residential lots using a CA weather file (acute RQ = 0.18). All the remaining scenario's acute RQs exceeded the listed and non-listed (LOC = 0.5) species LOCs. The highest RQ was 54 for the commercial lots using a FL weather file. On a chronic basis, the RQs for the following two scenarios exceeded the chronic LOC (1.0): commercial lots (FL weather), and NJ nursery, with respective RQs of 18 and 6.2. Both turf scenarios (CA and FL) approached the LOC, but did not exceed it (RQs of 0.90 and 0.97).

Table 75. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0251	4.25×10^{-4}	**126**	**16**	**6.8**	0.90
02 FL turf (TN met file, W13882)	0.0251	4.57×10^{-4}	**126**	**18**	**6.8**	0.97
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.19×10^{-3}	2.07×10^{-5}	**6.0**	0.80	*0.32*	0.04
06, 07 BSS residential, ROW [Residential lots]	0.00904	3.75×10^{-4}	**45**	**14**	**2.4**	0.79
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.00448	1.23×10^{-4}	**22**	**4.7**	**1.2**	0.26
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.200 (0.622)*	0.00828	**1000**	**318**	**54**	**18**
15 OR nursery [Ornamentals]	0.00311	1.30×10^{-4}	**16**	**5.0**	**0.84**	0.28
16 NJ nursery [Ornamentals]	0.121	0.00292	**605**	**112**	**33**	**6.2**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0002 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0037 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00047 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to the pyrethrins, five of the scenario acute RQs exceeded only the listed species LOC (acute LOC = 0.05 for listed species). None exceeded the acute non-listed species LOC (acute LOC = 0.5 for non-listed species). Both turf and both nursery scenarios, and the commercial lots scenario using a FL weather file exceeded the listed species LOC. The highest acute RQ was 0.19 for the NJ nursery scenario. None of the RQs exceeded the chronic LOC (chronic LOC = 1.0), with the exception of the NJ nursery scenario. The highest chronic RQ was 1.3, for the NJ nursery scenario.

For estuarine/marine invertebrates exposed to the pyrethrins, there were exceedances of the acute listed species LOC (acute listed species LOC = 0.05) for the following scenarios: CA turf (MI weather file), FL turf (TN weather file), commercial lots (FL weather file), and both nursery scenarios (OR and NJ). The highest acute RQ was 0.11 for the NJ nursery scenario. None of the chronic RQs exceeded the LOC (LOC = 1.0). The highest chronic RQ was 0.22 (for the NJ nursery scenario).

Table 76. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.132	0.0342	*0.17*	0.86	*0.09*	0.14
02 FL turf (TN met file, W13882)	0.128	0.0271	*0.17*	0.68	*0.09*	0.11
03, 04, 05 CA residential, ROW, impervious [Residential lots]	2.14×10^{-4}	7.04×10^{-5}	<0.01	<0.01	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0131	0.00394	0.02	0.10	0.01	0.02
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.00408	8.92×10^{-4}	0.01	0.02	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.0904	0.0210	*0.12*	0.53	*0.06*	0.08
15 OR nursery [Ornamentals]	0.0895	0.0224	*0.12*	0.56	*0.06*	0.09
16 NJ nursery [Ornamentals]	0.148	0.0539	*0.19*	**1.3**	*0.11*	0.22

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.76 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.04 ppb [for midge, *Chironomus dilutus*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 1.4 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.25 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to permethrin the acute RQs exceeded the listed and non-listed species LOCs (acute LOCs = 0.05 and 0.5, respectively) for all the scenarios tested. The range of acute RQs was 19 to 258. On a chronic basis, all the scenario RQs also exceeded the LOC (chronic LOC = 1.0). The highest chronic RQ was 42 for the

residential lots, using the PA weather file.

For estuarine/marine invertebrates exposed to permethrin, all the RQs exceeded the acute and chronic listed and non-listed species LOCs (all acute RQs > 0.5; all chronic RQs > 1.0). The highest acute and chronic RQs were 94 and 73, respectively, for the residential lots using a PA weather file.

Table 77. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.378	0.0393	**57**	**9.4**	**21**	**16**
02 FL turf (TN met file, W13882)	0.286	0.0324	**43**	**7.7**	**16**	**14**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.745	0.0980	**113**	**23**	**41**	**41**
06, 07 BSS residential, ROW [Residential lots]	0.126	0.0124	**19**	**3.0**	**7.0**	**5.2**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	1.70	0.175	**258**	**42**	**94**	**73**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	1.04	0.127	**158**	**30**	**58**	**53**
15 OR nursery [Ornamentals]	0.126	0.0194	**19**	**4.6**	**7.0**	**8.1**
16 NJ nursery [Ornamentals]	1.60	0.157	**242**	**37**	**89**	**65**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0066 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0042 ppb [for the amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.018 ppb [for Stone crab, *Menippe mercenaria*]. Chronic RQ = use-specific 21-day EEC / 0.0024 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to esfenvalerate, all the acute RQs exceeded the listed and non-listed LOCs (LOCs = 0.05 and 0.5, respectively). Furthermore, all the chronic RQs also exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 7.79 to 848, while the chronic RQs ranged from 11.7 to 502.

For estuarine/marine invertebrates exposed to esfenvalerate, the acute RQs for all the scenarios exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively). The acute RQs ranged from 1.42 to 153. In addition, all the chronic RQs exceeded the LOC (LOC = 1.0). The chronic RQs ranged from 2.1 to 91.

Table 78. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0411	0.00111	**48.5**	**35.9**	**8.82**	**6.5**
02 FL turf (TN met file, W13882)	0.0355	0.00159	**41.9**	**51.5**	**7.62**	**9.4**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00661	3.61×10^{-4}	**7.79**	**11.7**	**1.42**	**2.1**
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0201	8.33×10^{-4}	**23.7**	**27.0**	**4.31**	**4.9**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0140	5.90×10^{-4}	**16.5**	**19.1**	**3.00**	**3.5**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.713	0.0131	**848**	**423**	**153**	**77**
15 OR nursery [Ornamentals]	0.399	0.00879	**471**	**284**	**85.6**	**52**
16 NJ nursery [Ornamentals]	0.427	0.0155	**504**	**502**	**91.6**	**91**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.000848 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0000309 ppb [for the amphipod, *Hyalella azteca* acute data and ACR of 27 from mysid studies].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00466 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00017 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to cypermethrin, all the acute RQs exceeded the listed and non-listed LOCs (LOCs = 0.05 and 0.5, respectively). Furthermore, all the chronic RQs also exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 94 to 7460, while the chronic RQs ranged from >68 to >2200.

For estuarine/marine invertebrates exposed to cypermethrin, all the acute and chronic RQs exceeded the listed and non-listed species LOCs (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5; chronic LOC = 1.0). The acute RQs ranged from 9.8 to 774. The chronic RQs ranged from 17 to 550.

For both freshwater and estuarine/marine invertebrates, the highest RQs were for the FL commercial lots scenario.

Table 79. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Cypermethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0942	0.00341	**168**	**>68**	**17**	**17**
02 FL turf (TN met file, W13882)	0.0776	0.00349	**139**	**>70**	**14**	**17**

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.0528	3.59×10^{-3}	**94**	**>72**	**9.8**	**18**
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.126	6.51×10^{-3}	**225**	**>130**	**23**	**33**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.106	5.58×10^{-3}	**189**	**>112**	**20**	**28**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	4.18	0.110	**7460**	**>2200**	**774**	**550**
15 OR nursery [Ornamentals]	0.124	0.00354	**221**	**>71**	**23**	**18**
16 NJ nursery [Ornamentals]	0.127	0.00553	**227**	**>111**	**24**	**28**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00056 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.00005 ppb [<0.00005 ppb, for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0054 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.0002 ppb [for amphipod, *Leptocheirus plumulosus*].

For freshwater invertebrates exposed to cyfluthrin, both turf, the commercial lots (FL weather), and both nursery scenario RQs exceeded the acute listed and non-listed species LOCs (acute LOCs = 0.05 and 0.5, respectively). The residential lots in PA and TX exceeded only the listed species LOC, while the residential lots in CA did not exceed any of the acute LOCs. On a chronic basis, all the scenario RQs, with the exception of the residential lots in CA exceeded the LOC (chronic LOC = 1.0).

For estuarine/marine invertebrates exposed to cyfluthrin, all the acute RQs exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively), for all the scenarios, except for the residential lots in CA (for this scenario, only the listed species LOC was exceeded, with an RQ = 0.49). On a chronic basis all the scenarios, with the exception of the residential lots in California exceeded the chronic LOC (LOC = 1.0). The highest chronic RQ was 115 for the FL commercial lots scenario.

Table 80. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Cyfluthrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0212	6.1×10^{-4}	**0.85**	**5.1**	**9.6**	**8.7**
02 FL turf (TN met file, W13882)	0.0158	4.71×10^{-4}	**0.63**	**3.9**	**7.2**	**6.7**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.07×10^{-3}	4.15×10^{-5}	0.04	0.35	*0.49*	0.59
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	7.33×10^{-3}	4.70×10^{-4}	*0.29*	**3.9**	**3.3**	**6.7**

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	5.50×10^{-3}	2.03×10^{-4}	*0.22*	**1.7**	**2.5**	**2.9**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.387	8.05×10^{-3}	**15**	**67**	**176**	**115**
15 OR nursery [Ornamentals]	0.115	0.00242	**4.6**	**20**	**52**	**35**
16 NJ nursery [Ornamentals]	0.115	0.00311	**4.6**	**26**	**52**	**44**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.025 ppb [for Water flea, *Daphnia magna*]. Chronic RQ = use-specific 21-day EEC / 0.00012 ppb [for amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0022 ppb [for Mysid shrimp, *Americamysis bahia*, conducted with *beta*-cyfluthrin]. Chronic pore water RQ = use-specific 21-day EEC/ 0.00007 ppb [estimated or calculated for mysid shrimp, *Mysidopsis bahia*, for *beta*-cyfluthrin based on cyfluthrin data].

For freshwater invertebrates exposed to *lambda*-cyhalothrin, all the acute RQs exceeded the listed and non-listed LOCs (LOCs = 0.05 and 0.5, respectively). Furthermore, all the chronic RQs also exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 23 to 3960, while the chronic RQs ranged from 3.6 to 435. The highest RQs were for the nursery scenarios.

For estuarine/marine invertebrates exposed to *lambda*-cyhalothrin, the acute RQs exceeded the listed species LOC (LOC = 0.05) for the residential lots in CA. For the remaining scenarios, the RQs also exceeded the non-listed species LOC (LOC = 0.5). The acute RQs ranged from 0.38 to 64.6. All the chronic RQs exceeded the LOC (LOC = 1.0), exhibiting a range of 4 to 479. The highest RQs were for the nursery scenarios.

Table 81. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to *Lambda*-Cyhalothrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.0153	0.00338	**191**	**15**	**3.11**	**17**
02 FL turf (TN met file, W13882)	0.00672	0.00253	**84**	**12**	**1.37**	**13**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.88×10^{-3}	7.86×10^{-4}	**24**	**3.6**	*0.38*	**4**
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0256	6.38×10^{-3}	**320**	**29**	**5.21**	**32**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0127	4.03×10^{-3}	**159**	**18**	**2.59**	**20**

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.0195	4.32×10^{-3}	**243**	**20**	**3.69**	**22**
15 OR nursery [Ornamentals]	0.276	0.055	**3,450**	**250**	**56.2**	**275**
16 NJ nursery [Ornamentals]	0.317	0.0958	**3,960**	**435**	**64.6**	**479**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00008 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.00022 ppb [for amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00491 ppb [for Mysid shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin]. Chronic RQ = use-specific 21-day EEC / 0.0002 ppb [for Mysid shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin].

For freshwater invertebrates exposed to fenpropathrin residues on an acute basis, the RQs exceeded the listed and non-listed species LOCs in all instances (acute LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 16.1 to 3,380. On a chronic basis, the RQs exceeded the LOC (chronic LOC = 1.0) in all cases as well. The chronic RQs ranged from >2 to >1130.

For estuarine/marine invertebrates exposed to fenpropathrin, for all the scenario combinations, the RQs exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). The range in acute RQs was 2.3 to as high as 490. Further, all the chronic RQs exceeded the LOC (chronic LOC = 1.0), with the exception of the commercial lots using a FL weather file and one or three applications per year. For 24 applications per year and the commercial lots using a FL weather file, the chronic LOC was exceeded (RQ = 6.0). The overall range of chronic RQs was 0.25 to 140.

Table 82. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Fenpropathrin

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
				Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	2.05	0.126	**672**	**>84**	**98**	**11**
02 FLnurserySTD_V2/ ornamentals	0.3x3	1.51	0.157	**495**	**>105**	**72**	**13**
03 MInurserySTD_V2/ ornamentals	0.3x3	1.20	0.190	**393**	**>127**	**57**	**16**
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	2.04	0.206	**669**	**>137**	**97**	**17**
06 ORnurserySTD_V2/ ornamentals	0.3x3	0.422	0.057	**138**	**>38**	**20**	**4.8**
07 TNnurserySTD_V2/ ornamentals	0.3x3	1.66	0.191	**544**	**>127**	**79**	**16**
08 NurseryBSS_V2/ ornamentals	0.3x3	0.695	0.063	**228**	**>39**	**33**	**5.3**
09 CAnurserySTD_V2/ ornamentals	0.3x24	9.80	0.805	**3,210**	**>537**	**470**	**67**
10 FLnurserySTD_V2/ ornamentals	0.3x24	10.3* (13.4)	1.19	**3,380**	**>793**	**490**	**99**

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
				Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
11 MInurserySTD_V2/ ornamentals	0.3x24	7.56	1.44	**2,480**	**>960**	**360**	**120**
12 NJnurserySTD_V2/ ornamentals	0.3x24	10.3* (19.1)	1.69	**3,380**	**>1130**	**490**	**140**
13 ORnurserySTD_V2/ ornamentals	0.3x24	2.53	0.400	**830**	**>267**	**120**	**33**
14 TNnurserySTD_V2/ ornamentals	0.3x24	9.57	1.36	**3,140**	**>907**	**460**	**110**
15 NurseryBSS_V2/ ornamentals	0.3x24	3.66	0.412	**1,200**	**>275**	**170**	**34**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	0.151	0.009	**49.5**	**>6**	**7.2**	0.75
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	0.963	0.072	**316**	**>48**	**46**	**6.0**
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	0.049	0.003	**16.1**	**>2**	**2.3**	0.25
19 CAnurserySTD_V2/ ornamentals	0.3x1	0.817	0.0529	**268**	**>35**	**39**	**4.4**
20 FLnurserySTD_V2/ ornamentals	0.3x1	0.537	0.0527	**176**	**>35**	**26**	**4.4**
21 MInurserySTD_V2/ ornamentals	0.3x1	0.388	0.0648	**127**	**>43**	**18**	**5.4**
22 NJnurserySTD_V2/ ornamentals	0.3x1	0.669	0.069	**219**	**>46**	**32**	**5.8**
23 ORnurserySTD_V2/ ornamentals	0.3x1	0.133	0.0189	**43.6**	**>13**	**6.3**	**1.6**
24 TNnurserySTD_V2/ ornamentals	0.3x1	0.601	0.0641	**197**	**>43**	**29**	**5.3**
25 NurseryBSS_V2/ ornamentals	0.3x1	0.235	0.0215	**77.0**	**>14**	**11**	**1.8**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

* EECs marked with an asterisk were set to 10.3 ppb because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0015 ppb [<0.0015 ppb, for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.012 [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to fenpropathrin plus the unextracted residues on an acute basis, the RQs exceeded the listed and non-listed species LOCs (acute LOCs = 0.05 and 0.5, respectively) in all instances. The acute RQs ranged from 23.3 to 3,380. On a chronic basis, all the RQs exceeded the LOC (chronic LOC = 1.0). The chronic RQs ranged from >4 to >1400.

For estuarine/marine invertebrates exposed to fenpropathrin plus unextracted residues, for all the scenario combinations, the RQs exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). The range in acute RQs was 3.4 to as high as 490 (the RQ = 490 was limited by the solubility of fenpropathrin). All the chronic RQs exceeded the LOC (1.0), with the exception of the commercial lots using a FL weather file and a single

application per year (RQ = 0.50). For three or 24 applications per year and the commercial lots using a FL weather file, the chronic LOCs were exceeded. The overall range of chronic RQs was 0.50 to 180.

Table 83. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Fenpropathrin plus Unextracted Residues

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
				Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	2.32	0.154	**761**	**>103**	**110**	**13**
02 FLnurserySTD_V2/ ornamentals	0.3x3	2.00	0.189	**656**	**>126**	**95**	**16**
03 MInurserySTD_V2/ ornamentals	0.3x3	1.59	0.271	**521**	**>181**	**76**	**23**
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	2.54	0.254	**833**	**>169**	**120**	**21**
06 ORnurserySTD_V2/ ornamentals	0.3x3	0.563	0.084	**185**	**>56**	**27**	**7.0**
07 TNnurserySTD_V2/ ornamentals	0.3x3	1.99	0.235	**652**	**>157**	**95**	**20**
08 NurseryBSS_V2/ ornamentals	0.3x3	0.959	0.092	**314**	**>6.1**	**46**	**7.7**
09 CAnurserySTD_V2/ ornamentals	0.3x24	10.3* (12.5)	0.961	**3,380**	**>641**	**490**	**80**
10 FLnurserySTD_V2/ ornamentals	0.3x24	10.3* (19.5)	1.45	**3,380**	**>967**	**490**	**120**
11 MInurserySTD_V2/ ornamentals	0.3x24	10.3* (11.6)	2.10	**3,380**	**>1400**	**490**	**180**
12 NJnurserySTD_V2/ ornamentals	0.3x24	10.3* (22.9)	2.07	**3,380**	**>1380**	**490**	**173**
13 ORnurserySTD_V2/ ornamentals	0.3x24	3.91	0.611	**1,280**	**>407**	**190**	**51**
14 TNnurserySTD_V2/ ornamentals	0.3x24	10.3* (13.0)	1.77	**3,380**	**>1180**	**490**	**150**
15 NurseryBSS_V2/ ornamentals	0.3x24	5.76	0.635	**1,890**	**>423**	**270**	**53**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	0.218	0.018	**71.5**	**>12**	**10**	**1.5**
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	1.60	0.140	**525**	**>93**	**76**	**12**
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	0.071	0.006	**23.3**	**>4**	**3.4**	0.50
19 CAnurserySTD_V2/ ornamentals	0.3x1	0.939	0.063	**308**	**>41**	**45**	**5.3**
20 FLnurserySTD_V2/ ornamentals	0.3x1	0.765	0.063	**251**	**>42**	**36**	**5.3**
21 MInurserySTD_V2/ ornamentals	0.3x1	0.520	0.091	**170**	**>61**	**25**	**7.6**
22 NJnurserySTD_V2/ ornamentals	0.3x1	0.831	0.085	**272**	**>57**	**40**	**7.1**
23 ORnurserySTD_V2/ ornamentals	0.3x1	0.186	0.028	**61.0**	**>19**	**8.9**	**2.3**
24 TNnurserySTD_V2/ ornamentals	0.3x1	0.700	0.079	**230**	**>53**	**33**	**3.8**
25 NurseryBSS_V2/ ornamentals	0.3x1	0.319	0.031	**105**	**>21**	**15**	**2.6**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

* EECs marked with an asterisk were set to 10.3 ppb because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and

italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0015 ppb [<0.0015 ppb, for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.012 [for Mysid shrimp, *Americamysis bahia*].

7.1.3 Freshwater Benthic Invertebrates Risk Quotients

For freshwater benthic organisms exposed to bifenthrin, there were multiple exceedances of LOCs (acute and chronic). On an acute basis, all scenario RQs exceeded the acute listed and non-listed species LOCs. The acute RQs ranged from 0.66 to 28. On a chronic basis (pore water based and sediment based), all scenario RQs exceeded the chronic LOC (1.0). The pore water-based chronic RQs ranged from 6.5 to 280. The sediment-based chronic RQs ranged from 4.0 to 552.

Table 84. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Bifenthrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.4x1	GR	0.00738	0.00743	22.9	22.9	**15**	**149**		**92**
02 FL turf (TN met file, W13882	0.22x1	G	0.00783	0.00771	24.4	23.9	**16**	**154**		**96**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.22x1	G	3.26×10^{-4}	3.25×10^{-4}	1.01	1.01	**0.66**	**6.5**		**4.0**
06, 07 BSS residential, ROW [Residential lots]	0.2, 0.4x1	GR	0.00430	0.00420	13.3	13.0	**8.7**	**84**		**52**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.22x1	G	0.00197	0.00195	6.12	6.04	**4.0**	**39**		**24**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.22x1	G	0.00157	0.00155	4.87	4.81	**3.2**	**31**		**19**
15 OR nursery [Ornamentals]	0.2x1	G	0.00598	0.00595	18.5	18.5	**12**	**119**		**74**
16 NJ nursery [Ornamentals]	0.2x1	G	0.014 (0.0449)*	0.014 (0.0444)*	139	138	**28**	**280**		**552**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.000493 ppb [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000050 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC dry weight / 0.25 µg/kg-dw [for amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to deltamethrin, there were multiple exceedances of LOCs (acute and chronic). On an acute basis, all scenario RQs exceeded the acute non-listed species LOC (LOC = 0.5), except for the residential scenarios using CA and PA weather files (these two scenario RQs exceeded only the listed species LOC =

0.05). On a chronic basis (pore water and sediment-based), all scenario RQs exceeded the chronic LOC except for the residential scenario using a CA weather file. All the chronic RQs were expressed as a greater than value, which means that the residential lots using a CA weather file has the potential to exceed the LOC. The highest acute and chronic RQs were for the NJ nursery scenario.

Table 85. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Deltamethrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.13x1	G	2.11×10^{-4}	2.03×10^{-4}	95.0	91.4	**1.1**	**7.8**		**7.6**
02 FL turf (TN met file, W13882)	0.13x1	G	2.35×10^{-4}	2.25×10^{-4}	106	101	**1.2**	**8.7**		**8.4**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.21x1	G	1.19×10^{-5}	1.16×10^{-5}	5.34	5.21	*0.06*	0.44		0.43
06, 07 BSS residential, ROW [Residential lots]	0.21x1	GR	1.65×10^{-4}	1.54×10^{-4}	74.0	69.3	**0.82**	**5.9**		**5.8**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.21x1	G	7.28×10^{-5}	6.99×10^{-5}	32.7	31.3	*0.36*	**2.7**		**2.6**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.21x1	G	0.00221	0.00211	992	947	**11**	**81**		**79**
15 OR nursery [Ornamentals]	0.13x1	GR	9.98×10^{-5}	9.61×10^{-5}	44.9	43.2	**0.50**	**3.7**		**3.6**
16 NJ nursery [Ornamentals]	0.13x1	GR	0.00172	0.00163	774	734	**8.6**	**63**		**61**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg$_{OC}$ [for *Hyalella azteca*].

For freshwater benthic organisms exposed to the pyrethrins, there were no exceedances of LOCs (acute listed and non-listed, or chronic). The highest acute RQ was for the NJ nursery scenario (RQ = 0.04; acute listed species LOC = 0.05). The highest chronic RQ was only 0.66 (chronic LOC = 1.0).

Table 86. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Pyrethrins

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.327x1	G	0.0105	0.0103	3.17	3.11	0.01	0.26		0.08
02 FL turf (TN met file, W13882)	0.327x1	G	0.00796	0.00772	2.40	2.33	0.01	0.19		0.06
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.0560, 0.087, 0.087x1	G	2.30×10^{-5}	2.26×10^{-5}	0.00693	0.00681	<0.01	<0.01		<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0560x1	G	0.00163	0.00157	0.491	0.473	<0.01	0.04		0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0560, 0.087, 0.087x1	G	3.33×10^{-4}	3.50×10^{-4}	0.100	0.106	<0.01	0.01		<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.327x1	G	0.00663	0.00646	2.00	1.95	0.01	0.16		0.05
15 OR nursery [Ornamentals]	0.327x1	G	0.00749	0.00727	2.26	2.19	0.01	0.18		0.05
16 NJ nursery [Ornamentals]	0.327x1	G	0.0273	0.0265	8.23	7.99	0.04	0.66		0.19

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.76 ppb [water column test for the Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.04 ppb [for Midge, *Chironomus dilutus*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 41 µg/kg$_{-dw}$ [for Midge, *Chironomus dilutus*].

For freshwater benthic organisms exposed to permethrin, all the scenarios exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), and the chronic LOC (1.0). The highest acute and chronic RQs were for the residential scenario using a PA weather file (acute RQ = 22; chronic RQ = 63).

Table 87. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Permethrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	1x1	G	0.0262	0.0257	83.5	81.9	**4.0**	**6.1**		**11**
02 FL turf (TN met file, W13882)	0.7894x1	G	0.0240	0.0233	76.5	74.2	**3.6**	**5.5**		**10**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	18, 17.2, 17.2x1	G	0.0663	0.0663	211	211	**10**	**16**		**29**

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
06, 07 BSS residential, ROW [Residential lots]	0.6533x1	GR	0.00704	0.00687	22.4	21.9	**1.1**	**1.6**		**3.0**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	18, 17.2, 17.2x1	G	0.148	0.146	472	465	**22**	**35**		**63**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	1, 18.2, 18.2x1	G	0.0792	0.0775	252	247	**12**	**18**		**33**
15 OR nursery [Ornamentals]	0.5015x1	G	0.0158	0.0156	50.4	49.7	**2.4**	**3.7**		**6.7**
16 NJ nursery [Ornamentals]	0.5015x1	G	0.111	0.109	354	347	**17**	**26**		**47**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0066 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0042 ppb [for the amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 7.4 µg/kg$_{-dw}$ [for the amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to esfenvalerate, the acute RQs exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively) for all the scenarios, except for the residential lots with the CA and PA weather files. The highest acute RQ is 12 for the NJ nursery scenario. The chronic RQs exceeded the non-listed species LOC (1.0) for all the scenarios, except for the three residential scenarios (CA, TX, and PA). The highest chronic RQ is 14 for the NJ nursery scenario.

Table 88. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Esfenvalerate

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.184x1	G	$7.2x10^{-4}$	$7.25x10^{-4}$	182	183	**0.85**	**1.0**		**1.04**
02 FL turf (TN met file, W13882)	0.184x1	G	0.00119	0.00112	300	283	**1.40**	**1.6**		**1.61**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.184x1	G	$1.92x10^{-4}$	$1.87x10^{-4}$	48.3	47.0	*0.23*	0.27		0.27
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.184x1	GR	$4.45x10^{-4}$	$4.15x10^{-4}$	112	104	**0.52**	0.59		0.59
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.184x1	G	$3.62x10^{-4}$	$3.64x10^{-4}$	91.1	91.6	*0.43*	0.52		0.52

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.184x1	G	0.00350	0.00336	881	846	**4.1**	**4.8**		**4.81**
15 OR nursery [Ornamentals]	0.096x1	G	0.0037	0.00361	931	909	**4.4**	**5.2**		**5.16**
16 NJ nursery [Ornamentals]	0.096x1	G	0.01	0.00954	2520	2400	**12**	**14**		**13.6**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.000848 [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00070 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 176 µg/kg$_{OC}$ [for amphipod, *Hyalella azteca*].

For freshwater benthic invertebrates exposed to cypermethrin, all the acute and chronic RQs exceeded the listed and non-listed species LOCs (acute LOCs 0.05 and 0.5; chronic LOC = 1.0). The highest RQs were for the commercial lots, using a FL weather file (acute RQ = 17; chronic RQ > 180).

Table 89. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Cypermethrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.36x1	G	0.00172	0.00159	244	225	**3.1**	**>32**		**>29**
02 FL turf (TN met file, W13882)	0.36x1	G	0.0032	0.00286	453	405	**5.7**	**>57**		**>53**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.36, 0.90, 0.90x1	G	$1.53x10^{-3}$	$1.49x10^{-3}$	217	211	**2.7**	**>30**		**>27**
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.36, 0.90, 0.90x1	G	$2.97x10^{-3}$	$2.78x10^{-3}$	421	394	**5.3**	**>56**		**>51**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.36, 0.90, 0.90x1	G	$2.08x10^{-3}$	$2.04x10^{-3}$	295	289	**3.7**	**>41**		**>38**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.36, 0.90, 0.90x1	G	0.0287	0.0264	4067	3741	**51**	**>528**		**>486**
15 OR nursery [Ornamentals]	0.048x1	G	0.0012	0.00115	170	163	**2.1**	**>23**		**>21**
16 NJ nursery [Ornamentals]	0.048x1	G	0.00312	0.00286	442	405	**5.6**	**>57**		**>53**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and

italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00056 ppb [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00005 ppb [<0.00005 ppb, for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 7.7 µg/kg$_{OC}$ [no valid chronic study, estimated].

For freshwater benthic organisms exposed to cyfluthrin, none of the acute RQs exceeded the listed or non-listed species LOCs (0.05 and 0.5, respectively), with the exception of the FL commercial lots scenario and NJ nursery scenario(exceeded only the listed species LOC). On a chronic basis, all the scenario RQs, except for the residential lots in CA and PA exceeded the LOC (chronic LOC = 1.0). The highest chronic RQ was 13 for the FL commercial lots scenario.

Table 90. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Cyfluthrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.19x1	G	$2.8x10^{-4}$	$2.15x10^{-4}$	51.8	39.7	0.01	**1.8**		**1.8**
02 FL turf (TN met file, W13882)	0.19x1	G	$2.23x10^{-4}$	$1.82x10^{-4}$	41.2	33.6	0.01	**1.5**		**1.5**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.192, 0.09, 0.09x1	G	$1.63x10^{-5}$	$1.51x10^{-5}$	3.01	2.79	<0.01	0.13		0.13
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.192, 0.09, 0.09x1	G	$2.02x10^{-4}$	$1.44x10^{-4}$	37.3	26.6	0.01	**1.2**		**1.2**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.192, 0.09, 0.09x1	G	$6.99x10^{-5}$	$5.54x10^{-5}$	12.9	10.2	<0.01	0.46		0.46
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.192, 0.09, 0.09x1	G	$2.08x10^{-3}$	$1.58x10^{-3}$	385	292	*0.08*	**13**		**13**
15 OR nursery [Ornamentals]	0.048x1	G	$6.55x10^{-4}$	$5.62x10^{-4}$	121	104	0.03	**4.7**		**4.7**
16 NJ nursery [Ornamentals]	0.048x1	G	0.00118	$8.91x10^{-4}$	218	165	*0.05*	**7.4**		**7.5**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.025 ppb [water column test for water flea, *Daphnia magna*, conducted on cyfluthrin]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00012 ppb [for amphipod, *Hyalella azteca*, conducted on cyflurthrin]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 22 µg/kg$_{OC}$ [for amphipod, *Hyalella azteca*, conducted on cyfluthrin].

For freshwater benthic organisms exposed to cyhalothrin, the acute RQs exceeded the listed and non-listed LOCs for all the scenarios (LOCs = 0.05 and 0.5, respectively).

Additionally, all the chronic RQs exceeded the LOC (LOC = 1.0). The acute RQs ranged from 10 to 1120, and the chronic RQs ranged from 6.5 to 774.

Table 91. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to *Lambda*-Cyhalothrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.24x1	GR	0.00294	0.00293	7.85	7.82	**37**	**13**		**25**
02 FL turf (TN met file, W13882)	0.24x1	GR	0.00237	0.00237	6.33	6.33	**30**	**11**		**20**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.24x1	G	7.77×10^{-4}	7.77×10^{-4}	2.09	2.09	**10**	**3.5**		**6.7**
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.24x1	G	6.28×10^{-3}	6.26×10^{-3}	16.9	16.8	**79**	**28**		**54**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.24x1	G	3.70×10^{-3}	3.70×10^{-3}	9.93	9.89	**46**	**17**		**32**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.24x1	G	3.86×10^{-3}	3.87×10^{-3}	10.3	10.3	**48**	**18**		**33**
15 OR nursery [Ornamentals]	0.078x1	GR	0.0473	0.0473	127	127	**591**	**215**		**410**
16 NJ nursery [Ornamentals]	0.078x1	GR	0.0896	0.0894	241	240	**1,120**	**406**		**774**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00008 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.00022 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC / 0.31 µg/kg$_{dw}$ [for amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to fenpropathrin, the acute RQs exceeded the listed and non-listed LOCs for all the scenarios (LOCs = 0.05 and 0.5, respectively). Additionally, all the chronic RQs exceeded the LOC (LOC = 1.0). The acute RQs ranged from 0.98 to 495, and the chronic RQs ranged from >2 to >1000.

Table 92. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Fenpropathrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.0979	0.0972	20300	20200	**32.1**	**>65**		**>65**
02 FLnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.139	0.137	28900	28400	**45.6**	**>91**		**>92**

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
03 MInurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.179	0.178	37200	36900	**58.7**	**>119**		**>119**
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.173	0.171	35900	35500	**56.7**	**>114**		**>115**
06 ORnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.0532	0.053	11040	11000	**17.4**	**>35**		**>35**
07 TNnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.179	0.179	37400	37400	**58.7**	**>119**		**>121**
08 NurseryBSS_V2/ ornamentals	0.3x3	Foliar, GR	0.0545	0.0539	11300	11200	**17.9**	**>36**		**>36**
09 CAnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.709	0.704	147000	146000	**232**	**>469**		**>471**
10 FLnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.05	1.04	218000	216000	**344**	**>693**		**>697**
11 MInurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.36	1.36	282000	282000	**446**	**>907**		**>910**
12 NJnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.51	1.5	313400	311400	**495**	**>1000**		**>1000**
13 ORnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.374	0.373	77600	77400	**122**	**>249**		**>250**
14 TNnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.098	0.097	20300	20100	**31.8**	**>65**		**>65**
15 NurseryBSS_V2/ ornamentals	0.3x24	Foliar, GR	0.139	0.137	28900	28400	**45.6**	**>91**		**>92**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	Foliar, H	0.008	0.008	1660	1660	**2.6**	**>5**		**>5**
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	Foliar, H	0.060	0.060	12500	12500	**19.7**	**>40**		**>40**
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	Foliar, H	0.003	0.003	623	623	**0.98**	**>2**		**>2**
19 CAnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0401	0.0398	8320	8260	**13.1**	**>26**		**>27**
20 FLnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0467	0.0462	9690	9590	**15.3**	**>31**		**>31**
21 MInurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0614	0.0613	12700	12700	**20.1**	**>41**		**>41**
22 NJnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0581	0.0577	12060	12980	**19.0**	**>38**		**>39**
23 ORnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0177	0.0176	3670	3650	**5.8**	**>12**		**>12**
24 TNnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0593	0.0592	12300	12300	**19.4**	**>39**		**>40**
25 NurseryBSS_V2/ ornamentals	0.3x1	Foliar, GR	0.0184	0.0182	3820	3780	**6.0**	**>12**		**>12**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0015 ppb [NOAEC <0.0015 ppb, for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 310 µg/kg$_{OC}$ [NOAEC <310 µg/kg$_{OC}$, for amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to fenpropathrin plus the unextracted residues, the acute RQs exceeded the listed and non-listed LOCs for all the scenarios (LOCs = 0.05 and 0.5, respectively). Additionally, all the chronic RQs exceeded the LOC (LOC = 1.0). The acute RQs ranged from 1.6 to 649, and the chronic RQs ranged from >3 to >1310.

Table 93. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Fenpropathrin plus Unextracted Residues

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.121	0.120	25100	24900	**39.7**	**>80**		**>80**
02 FLnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.166	0.164	34500	34040	**54.4**	**>109**		**>110**
03 MInurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.259	0.260	53800	53970	**84.9**	**>173**		**>174**
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.212	0.210	44000	43600	**69.5**	**>140**		**>141**
06 ORnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.077	0.077	16000	16000	**25.2**	**>51**		**>52**
07 TNnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.220	0.219	45700	45400	**72.1**	**>146**		**>146**
08 NurseryBSS_V2/ ornamentals	0.3x3	Foliar, GR	0.081	0.080	16800	16600	**26.6**	**>53**		**>54**
09 CAnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.851	0.845	176700	175400	**279**	**>563**		**>566**
10 FLnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.25	1.24	259500	257400	**410**	**>826**		**>830**
11 MInurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.98	1.97	411000	408900	**649**	**>1310**		**>1320**
12 NJnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.82	1.80	377800	373600	**597**	**>1200**		**>1210**
13 ORnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.569	0.568	118100	117900	**187**	**>379**		**>380**
14 TNnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.59	1.58	330100	328000	**521**	**>1050**		**>1060**
15 NurseryBSS_V2/ ornamentals	0.3x24	Foliar, GR	0.570	0.569	118300	118100	**187**	**>379**		**>381**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	Foliar, H	0.015	0.015	3110	3110	**4.92**	**>10**		**>10**

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	Foliar, H	0.117	0.117	24300	24300	**38.4**	**>78**		**>78**
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	Foliar, H	0.005	0.005	1040	1040	**1.6**	**>3**		**>3**
19 CAnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.048	0.048	9960	9960	**15.7**	**>32**		**>32**
20 FLnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.055	0.055	11400	11400	**18.0**	**>37**		**>37**
21 MInurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.088	0.088	18300	18300	**28.9**	**>59**		**>59**
22 NJnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.071	0.070	14700	14500	**23.3**	**>47**		**>47**
23 ORnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.026	0.026	5400	5400	**8.5**	**>17**		**>17**
24 TNnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.073	0.073	15200	15200	**23.9**	**>49**		**>49**
25 NurseryBSS_V2/ ornamentals	0.3x1	Foliar, GR	0.027	0.027	5600	5600	**8.9**	**>18**		**>18**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0015 ppb [NOAEC <0.0015 ppb, for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 310 µg/kg$_{OC}$ [NOAEC <310 µg/kg$_{OC}$, for amphipod, *Hyalella azteca*].

7.1.4 Estuarine/Marine Benthic Invertebrates Risk Quotients

For estuarine/marine benthic invertebrates exposed to bifenthrin, the residential lots using a CA weather file and the commercial lots with FL weather file exceeded the acute listed species LOC (0.05). All the remaining scenarios exceeded the listed and non-listed LOCs (0.5). The highest acute RQ was 3.5 for the NJ nursery scenario. The pore water and sediment-based RQs were similar (except for the pore water-based RQs that are limited by the solubility vs. the sediment-based RQs). The only scenario that did not exceed the chronic LOC (1.0) were the residential lots (CA weather file); however, the RQ was expressed as >0.54, as a result of a non-definitive endpoint. This means that these scenario has the potential to exceed the chronic LOC. The highest chronic RQ (sediment-based), was >26 for the NJ nursery scenario.

Table 94. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Bifenthrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.4x1	GR	0.00738	0.00743	22.9	22.9	**1.9**	**>12**		**>4.3**
02 FL turf (TN met file, W13882	0.22x1	G	0.00783	0.00771	24.4	23.9	**2.0**	**>13**		**>4.4**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.22x1	G	$3.26x10^{-4}$	$3.25x10^{-4}$	1.01	1.01	*0.08*	>0.54		>0.19
06, 07 BSS residential, ROW [Residential lots]	0.2, 0.4x1	GR	0.00430	0.00420	13.3	13.0	**1.08**	**>7.0**		**>2.4**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.22x1	G	0.00197	0.00195	6.12	6.04	**0.50**	**>3.3**		**>1.1**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.22x1	G	0.00157	0.00155	4.87	4.81	*0.40*	**>2.6**		>0.89
15 OR nursery [Ornamentals]	0.2x1	G	0.00598	0.00595	18.5	18.5	**1.5**	**>9.9**		**>3.4**
16 NJ nursery [Ornamentals]	0.2x1	G	0.014 (0.0449)*	0.014 (0.0444)*	139	138	**3.5**	**>23**		**>26**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00397 ppb [water column result for Mysid Shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / <0.0006 ppb [for amphipod, *Leptocheirus plumulosus*]. Chronic sediment RQ = use-specific sediment 21-day EEC dry weight / <5.4 µg/kg-dw [for the amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to deltamethrin, the following scenarios exceeded only the acute listed species LOC (0.05): CA turf (MI weather file), FL turf (TN weather file), commercial lots (FL weather file), and NJ nursery. The remaining scenarios did not exceed any acute LOC. The highest acute RQ was 0.46 for the NJ nursery scenario. The FL commercial and NJ nursery scenarios also exceeded the chronic LOC; however, the remaining scenarios did not exceed the chronic LOC (LOC = 1.0).

Table 95. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Deltamethrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.13x1	G	$2.11x10^{-4}$	$2.03x10^{-4}$	95.0	91.4	*0.06*	0.28

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#
02 FL turf (TN met file, W13882)	0.13x1	G	$2.35x10^{-4}$	$2.25x10^{-4}$	106	101	*0.06*	0.47
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.21x1	G	$1.19x10^{-5}$	$1.16x10^{-5}$	5.34	5.21	<0.01	0.02
06, 07 BSS residential, ROW [Residential lots]	0.21x1	GR	$1.65x10^{-4}$	$1.54x10^{-4}$	74.0	69.3	0.04	0.32
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.21x1	G	$7.28x10^{-5}$	$6.99x10^{-5}$	32.7	31.3	0.02	0.15
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.21x1	G	0.00221	0.00211	992	947	**0.60**	**4.5**
15 OR nursery [Ornamentals]	0.13x1	GR	$9.98x10^{-5}$	$9.61x10^{-5}$	44.9	43.2	0.03	0.20
16 NJ nursery [Ornamentals]	0.13x1	GR	0.00172	0.00163	774	734	*0.46*	**3.5**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0037 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00047 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic sediment-based RQ = N/A [no study was submitted].

For estuarine/marine benthic invertebrates exposed to pyrethrins, none of the acute or chronic RQs exceeded the listed and non-listed LOCs. The highest acute RQ was 0.02 for the NJ nursery scenario, and the highest chronic RQ was 0.11 for the same scenario.

Table 96. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Pyrethrins

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.327x1	G	0.0105	0.0103	3.17	3.11	0.01	0.04
02 FL turf (TN met file, W13882)	0.327x1	G	0.00796	0.00772	2.40	2.33	0.01	0.03
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.0560, 0.087, 0.087x1	G	$2.30x10^{-5}$	$2.26x10^{-5}$	0.00693	0.00681	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0560, 0.087, 0.087x1	G	0.00163	0.00157	0.491	0.473	<0.01	0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0560, 0.087, 0.087x1	G	$3.33x10^{-4}$	$3.50x10^{-4}$	0.100	0.106	<0.01	<0.01

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.327x1	G	0.00663	0.00646	2.00	1.95	<0.01	0.02
15 OR nursery [Ornamentals]	0.327x1	G	0.00749	0.00727	2.26	2.19	0.01	0.03
16 NJ nursery [Ornamentals]	0.327x1	G	0.0273	0.0265	8.23	7.99	0.02	0.11

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 1.4 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.25 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. No sediment toxicity study was submitted.

For estuarine/marine benthic invertebrates exposed to permethrin, the residential scenario (TX weather file) exceeded the acute listed species LOC (LOC = 0.05; RQ = 0.39), while all the remaining scenarios exceeded the acute listed and non-listed species LOCs (non-listed species LOC = 0.5). All the scenarios tested exceeded the chronic LOC (LOC = 1.0). The pore water-based chronic RQs were higher than the sediment-based RQs. The reason is that the water column test with mysid shrimp, *Americamysis bahia* yielded more sensitive endpoints than the sediment study, conducted with the amphipod, *Leptocheirus plumulosus*. The highest chronic RQs were for the residential lots, using the PA weather file (RQs = 61 and 12).

Table 97. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Permethrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	1x1	G	0.0262	0.0257	83.5	81.9	**1.5**	**11**		**2.2**
02 FL turf (TN met file, W13882)	0.7894x1	G	0.0240	0.0233	76.5	74.2	**1.3**	**9.7**		**2.0**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	18, 17.2, 17.2x1	G	0.0663	0.0663	211	211	**3.7**	**28**		**5.6**
06, 07 BSS residential, ROW [Residential lots]	0.6533x1	GR	0.00704	0.00687	22.4	21.9	*0.39*	**2.9**		0.58
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	18, 17.2, 17.2x1	G	0.148	0.146	472	465	**8.2**	**61**		**12**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	1, 18.2, 18.2x1	G	0.0792	0.0775	252	247	**4.4**	**32**		**6.5**
15 OR nursery [Ornamentals]	0.5015x1	G	0.0158	0.0156	50.4	49.7	**0.88**	**6.5**		**1.3**

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
16 NJ nursery [Ornamentals]	0.5015x1	G	0.111	0.109	354	347	**6.2**	**45**		**9.1**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.018 ppb [water column test for the Stone crab, *Menippe mercenaria*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0024 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 38 µg/kg$_{-dw}$ [for the amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to esfenvalerate, the acute RQ for the residential lots located in CA did not exceed any LOC (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5). Both turf scenarios, plus the remaining residential scenarios exceeded the listed species LOC. The acute RQs for both nursery scenarios and the FL commercial lots scenario exceeded the listed and non-listed species LOC (highest RQ for the NJ nursery scenario, with an acute RQ = 2.1). On a chronic basis, the RQs for both nursery scenarios and the FL commercial lots scenario exceeded the chronic LOC (LOC = 1.0). The highest chronic RQ is 3.2 for the NJ nursery scenario.

Table 98. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Esfenvalerate

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.184x1	G	$7.2x10^{-4}$	$7.25x10^{-4}$	182	183	*0.15*	0.24		0.22
02 FL turf (TN met file, W13882)	0.184x1	G	0.00119	0.00112	300	283	*0.26*	0.37		0.34
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.184x1	G	$1.92x10^{-4}$	$1.87x10^{-4}$	48.3	47.0	0.04	0.06		0.06
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.184x1	GR	$4.45x10^{-4}$	$4.15x10^{-4}$	112	104	*0.10*	0.14		0.13
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.184x1	G	$3.62x10^{-4}$	$3.64x10^{-4}$	91.1	91.6	*0.07*	0.12		0.11
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.184x1	G	0.00350	0.00336	881	846	**0.75**	**1.1**		**1.0**
15 OR nursery [Ornamentals]	0.096x1	G	0.0037	0.00361	931	909	**0.79**	**1.2**		**1.1**
16 NJ nursery [Ornamentals]	0.096x1	G	0.01	0.00954	2520	2400	**2.1**	**3.2**		**2.9**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00466 ppb [water column result for Mysid Shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / 0.003 ppb [for amphipod, *Leptocheirus plumulosus*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 830 µg/kg$_{OC}$ [for the amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to cypermethrin there were multiple exceedances of acute and chronic LOCs. For one of the turf scenarios (CA turf, MI weather file), residential lots in CA, residential lots in PA, and the OR nursery scenarios, the acute RQs exceeded the listed species LOC (LOC = 0.05), while all the remaining scenarios exceeded additionally the non-listed species LOC (LOC = 0.05). The highest acute RQ is 5.3 for the commercial lots, using a FL weather file. All the scenario RQs exceeded the chronic LOC (LOC = 1.0). The highest chronic RQ was 132 for the commercial lots, using a FL weather file.

Table 99. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Cypermethrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.36x1	G	0.00172	0.00159	244	225	*0.31*	**8.0**		**6.6**
02 FL turf (TN met file, W13882)	0.36x1	G	0.0032	0.00286	453	405	**0.59**	**14**		**11.9**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.36, 0.90, 0.90x1	G	1.53×10^{-3}	1.49×10^{-3}	217	211	*0.28*	**7.5**		**6.2**
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.36, 0.90, 0.90x1	G	2.97×10^{-3}	2.78×10^{-3}	421	394	**0.55**	**14**		**11.6**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.36, 0.90, 0.90x1	G	2.08×10^{-3}	2.04×10^{-3}	295	289	*0.38*	**10**		**8.5**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.36, 0.90, 0.90x1	G	0.0287	0.0264	4067	3741	**5.3**	**132**		**110**
15 OR nursery [Ornamentals]	0.048x1	G	0.0012	0.00115	170	163	*0.22*	**5.8**		**4.8**
16 NJ nursery [Ornamentals]	0.048x1	G	0.00312	0.00286	442	405	**0.58**	**14**		**11.9**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0054 ppb [water column result for mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / 0.0002 ppb [for amphipod, *Leptocheirus plumulosus*]. Chronic sediment RQ = use-specific 21-day EEC / 34 µg/kg$_{OC}$ [for amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to cyfluthrin, the acute RQs for the residential lots in CA and PA did not exceed any LOC (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5). The NJ nursery scenario and the FL commercial lots scenario exceeded the acute non-listed species LOC, with an RQ = 0.54-0.95. The remaining scenarios exceeded only the acute listed species LOC. On a chronic basis, the pore water based RQs were higher than the sediment based RQs. The reason is that there is a chronic water column test, conducted on the mysid shrimp, *Mysidopsis bahia*, that yielded a more sensitive endpoint than the sediment study. The chronic RQs for cyfluthrin exceeded the LOC (LOC = 1.0), for all the scenarios, except for the CA and PA residential lots. The highest chronic RQ was for the FL commercial lots scenario (RQ = 23). Considering the sediment chronic RQs, four out of eight of scenarios exceeded the chronic LOC, with a highest RQ > 8.6 for the FL commercial lots scenario.

Table 100. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Cyfluthrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.19x1	G	$2.8x10^{-4}$	$2.15x10^{-4}$	51.8	39.7	*0.13*	**3.1**		**>1.2**
02 FL turf (TN met file, W13882)	0.19x1	G	$2.23x10^{-4}$	$1.82x10^{-4}$	41.2	33.6	*0.10*	**2.6**		>0.99
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.192, 0.09, 0.09x1	G	$1.63x10^{-5}$	$1.51x10^{-5}$	3.01	2.79	0.01	0.22		>0.08
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.192, 0.09, 0.09x1	G	$2.02x10^{-4}$	$1.44x10^{-4}$	37.3	26.6	*0.09*	**2.1**		>0.78
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.192, 0.09, 0.09x1	G	$6.99x10^{-5}$	$5.54x10^{-5}$	12.9	10.2	0.03	0.79		>0.30
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.192, 0.09, 0.09x1	G	$2.08x10^{-3}$	$1.58x10^{-3}$	385	292	**0.95**	**23**		**>8.6**
15 OR nursery [Ornamentals]	0.048x1	G	$6.55x10^{-4}$	$5.62x10^{-4}$	121	104	*0.30*	**8.0**		**>3.1**
16 NJ nursery [Ornamentals]	0.048x1	G	0.00118	$8.91x10^{-4}$	218	165	**0.54**	**13**		**>4.9**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0022 ppb [water column result for mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / 0.00007 ppb [estimated for mysid shrimp, *Mysidopsis bahia*, for *beta*-cyfluthrin, based on data on cyfluthrin]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 34 µg/kg$_{OC}$ [<34 µg/kg$_{OC}$ for the amphipod, *Leptocheirus plumulosus*, for cyfluthrin].

For estuarine/marine benthic invertebrates exposed to *lambda*-cyhalothrin, the acute RQs for the FL turf scenario (TN weather file), and the residential lots in CA, exceeded the

listed species LOC (acute listed species LOC = 0.05; non-listed species LOC = 0.5). All the remaing scenario RQs exceeded the acute non-listed species LOC. The highest acute RQ was 18, for the NJ nursery scenario. On a chronic basis, the RQs based on pore water were higher than the ones based on sediment. The reason is that the chronic water column study yielded a more sensitive endpoint than the sediment study. The pore water-based RQs exceeded the chronic LOC (LOC = 1.0) for all the scenarios, showing a highest chronic RQ = 447. The sediment based RQs were lower, but as a result of a non-definitive endpoint, they were expressed as a greater than value. The lowest chronic RQ is >0.87 that did not exceed the chronic LOC, but has the potential to do so. The highest sediment based chronic RQ is >100 for the NJ nursery scenario.

Table 101. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to *Lambda*-Cyhalothrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CA turf (MI met file, W14840)	0.24x1	GR	0.00294	0.00293	7.85	7.82	**0.60**	**15**		**>3.26**
02 FL turf (TN met file, W13882)	0.24x1	GR	0.00237	0.00237	6.33	6.33	*0.48*	**12**		**>2.64**
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.24x1	G	7.77×10^{-4}	7.77×10^{-4}	2.09	2.09	*0.16*	**3.9**		>0.87
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.24x1	G	6.28×10^{-3}	6.26×10^{-3}	16.9	16.8	**1.28**	**31**		**>7.00**
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.24x1	G	3.70×10^{-3}	3.70×10^{-3}	9.93	9.89	**0.75**	**19**		**>4.12**
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.24x1	G	3.86×10^{-3}	3.87×10^{-3}	10.3	10.3	**0.79**	**19**		**>4.29**
15 OR nursery [Ornamentals]	0.078x1	GR	0.0473	0.0473	127	127	**9.6**	**237**		**>52.9**
16 NJ nursery [Ornamentals]	0.078x1	GR	0.0896	0.0894	241	240	**18**	**447**		**>100**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00491 ppb [water column result for Mysid Shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin]. Chronic pore water RQ = use-specific 21-day EEC / 0.0002 ppb [water column result for Mysid Shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin]. Chronic sediment RQ = use-specific 21-day EEC / 2.40 µg ai/kg-dw [<2.40 µg ai/kg-dw, for amphipod, *Leptocheirus plumulosus*].

For freshwater benthic invertebrates exposed to fenpropathrin, the acute RQs exceeded the listed and non-listed LOCs (0.05 and 0.5, respectively) for all the scenarios, with the exception of the commercial lots (FL meteorological file) with one and three applications per year. For the commercial lots (FL meteorological file) with one and three applications per year only the listed species LOC was exceeded.

The chronic RQs exceeded the LOC (LOC = 1.0) in all instances, with the exception of the commercial ornamentals, using one or three applications. When the same scenario was modeled with 24 applications, the RQ exceeded the LOC. The highest RQs were for the nursery ornamentals, with 24 applications. Even though the pore water based RQs were slightly higher than the sediment based RQs, the risk picture was the same in both cases. The slightly higher RQs for the pore water chronic RQs is due to the use of a more sensitive endpoint from a water column test, conducted with the mysid shrimp.

Table 102. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Fenpropathrin

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.0979	0.0972	20300	20200	**4.7**	**8.1**		**6.31**
02 FLnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.139	0.137	28900	28400	**6.6**	**11**		**8.88**
03 MInurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.179	0.178	37200	36900	**8.5**	**15**		**11.5**
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.173	0.171	35900	35500	**8.2**	**14**		**11.1**
06 ORnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.0532	0.053	11040	11000	**2.5**	**4.4**		**3.44**
07 TNnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.179	0.179	37400	37400	**8.5**	**15**		**11.7**
08 NurseryBSS_V2/ ornamentals	0.3x3	Foliar, GR	0.0545	0.0539	11300	11200	**2.6**	**4.5**		**3.50**
09 CAnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.709	0.704	147000	146000	**34**	**59**		**45.6**
10 FLnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.05	1.04	218000	216000	**50**	**87**		**67.5**
11 MInurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.36	1.36	282000	282000	**65**	**113**		**88.1**
12 NJnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.51	1.5	313400	311400	**72**	**125**		**97.3**
13 ORnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.374	0.373	77600	77400	**18**	**32**		**24.2**
14 TNnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.098	0.097	20300	20100	**4.7**	**8.1**		**6.28**
15 NurseryBSS_V2/ ornamentals	0.3x24	Foliar, GR	0.139	0.137	28900	28400	**6.6**	**11**		**8.89**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	Foliar, H	0.008	0.008	1660	1660	*0.38*	0.67		0.52
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	Foliar, H	0.060	0.060	12500	12500	**2.9**	**5.0**		**3.91**

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	Foliar, H	0.003	0.003	623	623	*0.14*	0.25		0.19
19 CAnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0401	0.0398	8320	8260	**1.9**	**3.3**		**2.58**
20 FLnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0467	0.0462	9690	9590	**2.2**	**3.8**		**3.00**
21 MInurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0614	0.0613	12700	12700	**2.9**	**5.1**		**3.97**
22 NJnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0581	0.0577	12100	11980	**2.8**	**4.8**		**3.74**
23 ORnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0177	0.0176	3670	3650	**0.84**	**1.5**		**1.14**
24 TNnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.0593	0.0592	12300	12300	**2.8**	**4.9**		**3.84**
25 NurseryBSS_V2/ ornamentals	0.3x1	Foliar, GR	0.0184	0.0182	3820	3780	**0.88**	**1.5**		**1.18**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For estuarine/marine benthic invertebrates, Acute pore water RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.012 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 3200 µg/kg$_{OC}$ [for Amphipod, *Leptocheirus plumulosus*].

For freshwater benthic invertebrates exposed to fenpropathrin plus the unextracted residues, the acute RQs exceeded the listed and non-listed LOCs (0.05 and 0.5, respectively) for all the scenarios, with the exception of the commercial lots (FL meteorological file) with one application per year. For the commercial lots (FL meteorological file) with one application per year only the listed species LOC was exceeded.

The chronic RQs (sediment based) exceeded the LOC (LOC = 1.0) in all instances, with the exception of the commercial ornamentals, using one or three applications. When the same scenario was modeled with 24 applications, the RQ exceeded the LOC. The highest RQs were for the nursery ornamentals, with 24 applications. The pore water based RQs were slightly higher than the sediment based RQs as a result of a more sensitive endpoint from a water column test with the mysid shrimp. As a result of slightly higher RQs, for the commercial ornamentals, and 3 applications, the pore water based RQ exceeded the LOC (RQ = 0.97 sediment based; RQ = 1.3 pore water based).

Table 103. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Fenpropathrin plus Unextracted Residues

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.121	0.120	25100	24900	**5.8**	**10**		**7.78**
02 FLnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.166	0.164	34500	34040	**7.9**	**14**		**10.6**
03 MInurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.259	0.260	53800	53970	**12**	**22**		**16.9**
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.212	0.210	44000	43600	**10**	**18**		**13.6**
06 ORnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.077	0.077	16000	16000	**3.7**	**6.4**		**5.0**
07 TNnurserySTD_V2/ ornamentals	0.3x3	Foliar, GR	0.220	0.219	45700	45400	**10**	**18**		**14.2**
08 NurseryBSS_V2/ ornamentals	0.3x3	Foliar, GR	0.081	0.080	16800	16600	**3.9**	**6.7**		**5.2**
09 CAnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.851	0.845	176700	175400	**41**	**70**		**54.8**
10 FLnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.25	1.24	259500	257400	**60**	**103**		**80.4**
11 MInurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.98	1.97	411000	408900	**94**	**164**		**128**
12 NJnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.82	1.80	377800	373600	**87**	**150**		**117**
13 ORnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	0.569	0.568	118100	117900	**27**	**47**		**36.8**
14 TNnurserySTD_V2/ ornamentals	0.3x24	Foliar, GR	1.59	1.58	330100	328000	**76**	**132**		**103**
15 NurseryBSS_V2/ ornamentals	0.3x24	Foliar, GR	0.570	0.569	118300	118100	**27**	**47**		**36.9**
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	Foliar, H	0.015	0.015	3110	3110	**0.71**	**1.3**		0.97
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	Foliar, H	0.117	0.117	24300	24300	**5.6**	**9.8**		**7.59**
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	Foliar, H	0.005	0.005	1040	1040	*0.24*	0.41		0.33
19 CAnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.048	0.048	9960	9960	**2.3**	**4.0**		**3.11**
20 FLnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.055	0.055	11400	11400	**2.6**	**4.6**		**3.56**
21 MInurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.088	0.088	18300	18300	**4.2**	**7.3**		**5.72**
22 NJnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.071	0.070	14700	14500	**3.4**	**5.8**		**4.53**

Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
23 ORnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.026	0.026	5400	5400	**1.2**	**2.2**		**1.69**
24 TNnurserySTD_V2/ ornamentals	0.3x1	Foliar, GR	0.073	0.073	15200	15200	**3.5**	**6.1**		**4.75**
25 NurseryBSS_V2/ ornamentals	0.3x1	Foliar, GR	0.027	0.027	5600	5600	**1.3**	**2.3**		**1.75**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For estuarine/marine benthic invertebrates, Acute pore water RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.012 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 3200 µg/kg$_{OC}$ [for Amphipod, *Leptocheirus plumulosus*].

7.1.5 Vascular and Non-Vascular Aquatic Plants Risk Quotients

For vascular plants exposed to bifenthrin there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). For vascular and non-vascular plants, the RQ values were very low in all instances (<0.01 for all the scenarios).

Table 104. Acute RQs for Vascular and Non-vascular Plants Exposed to Bifenthrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.014 (0.131)*	<0.01	<0.01	<0.01	<0.01
02 FL turf (TN met file, W13882	0.014 (0.0806)*	<0.01	<0.01	<0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00404	<0.01	<0.01	<0.01	<0.01
06, 07 BSS residential, ROW [Residential lots]	0.014 (0.0652)*	<0.01	<0.01	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.014 (0.0193)*	<0.01	<0.01	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.014 (0.0203)*	<0.01	<0.01	<0.01	<0.01
15 OR nursery [Ornamentals]	0.014 (0.0498)*	<0.01	<0.01	<0.01	<0.01
16 NJ nursery [Ornamentals]	0.014 (0.593)*	<0.01	<0.01	<0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 330 ppb [NOAEC = 330 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 330 ppb [IC_{50} of >330 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 290 ppb [NOAEC = 290 ppb for marine diatom, *Skeletonema costatum*]; the non-listed species acute RQ = use-specific peak EEC / 290 ppb [IC_{50} > 290 ppb, for marine diatom, *Skeletonema costatum*].

For vascular and non-vascular plants exposed to deltamethrin there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). All the RQs ranged from <0.01 to 0.06.

Table 105. Acute RQs for Vascular and Non-vascular Plants Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.0251	<0.01	<0.01	0.01	<0.01
02 FL turf (TN met file, W13882)	0.0251	<0.01	<0.01	0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00119	<0.01	<0.01	<0.01	<0.01
06, 07 BSS residential, ROW [Residential lots]	0.00904	<0.01	<0.01	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.00448	<0.01	<0.01	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.200 (0.622)*	<0.01	<0.01	0.06	<0.06
15 OR nursery [Ornamentals]	0.00311	<0.01	<0.01	<0.01	<0.01
16 NJ nursery [Ornamentals]	0.121	<0.01	<0.01	0.04	<0.04

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 779 ppb [NOAEC = 779 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 779 ppb [EC_{50} of >779 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 3.1 ppb [NOAEC = 3.1 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC / 3.1 ppb [EC_{50} >3.1 ppb for green algae, *Pseudo-kirchneriella subcapitata*].

For pyrethrins all the vascular and non-vascular plant listed and non-listed RQs were below the LOC (1.0) for all uses. The RQs ranged from <0.01 to 0.01.

Table 106. Acute RQs for Vascular and Non-vascular Plants Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.132	<0.01	<0.01	<0.01	<0.01
02 FL turf (TN met file, W13882)	0.128	<0.01	<0.01	<0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	2.14×10^{-4}	<0.01	<0.01	<0.01	<0.01
06, 07 BSS residential, ROW [Residential lots]	0.0131	<0.01	<0.01	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.00408	<0.01	<0.01	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.0904	<0.01	<0.01	<0.01	<0.01
15 OR nursery [Ornamentals]	0.0895	<0.01	<0.01	<0.01	<0.01
16 NJ nursery [Ornamentals]	0.148	<0.01	<0.01	0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 480 ppb [NOAEC = 480 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1230 ppb [EC_{50} of 1230 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 29 ppb [NOAEC = 29 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC/ 105 ppb [EC_{50} = 105 ppb, for green algae, *Pseudo-kirchneriella subcapitata*].

For permethrin the vascular plant listed and non-listed RQs were below the LOCs for all uses. The RQs ranged from <0.04 to 0.53. For listed non-vascular plants, the RQs exceeded the LOC for four out of eigth uses. The RQs were 0.19 to 2.6 overall for all uses. For non-listed non-vascular plants exposed to permethrin, the RQs did not exceed the LOC (1.0) for any of the scenarios. The range in RQs was 0.03 to 0.39.

Table 107. Acute RQs for Vascular and Non-vascular Plants Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.378	0.12	<0.12	0.58	<0.07
02 FL turf (TN met file, W13882)	0.286	0.09	<0.09	0.44	0.07
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.745	0.23	<0.23	**1.1**	0.17
06, 07 BSS residential, ROW [Residential lots]	0.126	0.04	<0.04	0.19	0.03
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	1.70	0.53	<0.53	**2.6**	0.39

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	1.04	0.33	<0.33	**1.6**	0.24
15 OR nursery [Ornamentals]	0.126	0.04	<0.04	0.19	0.03
16 NJ nursery [Ornamentals]	1.60	0.50	<0.50	**2.5**	0.36

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 3.2 ppb [NOAEC = 3.2 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 3.2 ppb [IC_{50} of >3.2 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 0.65 ppb [NOAEC = 0.65 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC / 4.4 ppb [IC_{50} > 4.4 ppb, for green algae, *Pseudo-kirchneriella subcapitata*].

For vascular plants exposed to esfenvalerate there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). The highest RQs were 0.08 and <0.08, respectively, for the FL commercial lots scenario.

For non-vascular plants exposed to esfenvalerate, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to 0.13.

Table 108. Acute RQs for Vascular and Non-vascular Plants Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.0411	<0.01	<0.01	0.01	<0.01
02 FL turf (TN met file, W13882)	0.0355	<0.01	<0.01	0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.00661	<0.01	<0.01	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0201	<0.01	<0.01	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0140	<0.01	<0.01	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.713	0.08	<0.08	0.13	<0.13
15 OR nursery [Ornamentals]	0.399	0.05	<0.05	0.07	<0.07
16 NJ nursery [Ornamentals]	0.427	0.05	<0.05	0.08	<0.08

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 8.6 ppb [NOAEC = 8.6 for Duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 8.6 ppb [EC_{50} of >8.6 for Duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 5.6 ppb [NOAEC = 5.6 ppb for freshwater algae, *Pseudokirchneriella subcapita*]; the non-listed species acute RQ = use-specific peak EEC / 5.6 ppb [EC_{50} >5.6 ppb for freshwater algae, *Pseudokirchneriella subcapita*].

For vascular plants exposed to cypermethrin, all the listed and non-listed RQs were below the LOC (LOC = 1.0), with the exception of the RQs for the FL commercial lots scenario. The RQ values were low in all instances: ≤0.08, except for the commercial lots in FL, with value of ≤2.6.

For non-vascular plants exposed to cypermethrin, all the listed and non-listed RQs were well below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to 0.02.

Table 109. Acute RQs for Vascular and Non-vascular Plants Exposed to Cypermethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.0942	0.06	<0.06	<0.01	<0.01
02 FL turf (TN met file, W13882)	0.0776	0.05	<0.05	<0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.0528	0.03	<0.03	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.126	0.08	<0.08	<0.01	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.106	0.07	<0.07	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	4.18	**2.6**	**<2.6**	<0.01	0.02
15 OR nursery [Ornamentals]	0.124	0.08	<0.08	<0.01	<0.01
16 NJ nursery [Ornamentals]	0.127	0.08	<0.08	<0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 1.62 ppb [NOAEC = 1.62 for Duckweed, *Lemna gibba*, conducted on *alpha*-cypermethrin]; the non-listed species acute RQ = use-specific peak EEC / 1.62 ppb [EC_{50} of >1.62 for Duckweed, *Lemna gibba*, conducted on *alpha*-cypermethrin].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 60 ppb [NOAEC = 60 ppb for freshwater algae, *Pseudokirchneriella subcapitata*, conducted on *alpha*-cypermethrin]; the non-listed species acute RQ = use-specific peak EEC / 25,000 ppb [EC_{50} of 25,000 ppb for freshwater algae, *Pseudokirchneriella subcapitata*, conducted on *alpha*-cypermethrin].

For the cyfluthrin there is no vascular plants data available. Therefore, no RQs could be calculated.

For non-vascular plants exposed to cyfluthrin, all non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to <0.19. There was no endpoint available to calculate the listed species RQ.

Table 110. Acute RQs for Non-Vascular Plants Exposed to Cyfluthrin

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	App Method+	Peak EEC (µg/L)	Listed Acute RQ+	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.19x1	G	0.0212	NC	<0.01
02 FL turf (TN met file, W13882)	0.19x1	G	0.0158	NC	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	0.192, 0.09, 0.09x1	G	1.07×10^{-3}	NC	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.192, 0.09, 0.09x1	G	7.33×10^{-3}	NC	<0.01
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.192, 0.09, 0.09x1	G	5.50×10^{-3}	NC	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.192, 0.09, 0.09x1	G	0.387	NC	<0.19
15 OR nursery [Ornamentals]	0.048x1	G	0.115	NC	<0.06
16 NJ nursery [Ornamentals]	0.048x1	G	0.115	NC	<0.06

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; NC=not calculated since there is no suitable endpoint.
= LOC for acute risk 1, and acute endangered species 1.
For non-vascular plants, the non-listed species acute RQ = use-specific peak EEC / 2 ppb [EC_{50} >2 for algae, *Scenedesmus subspicatus*, conducted with cyfluthrin].

For vascular plants exposed to *lambda*-cyhalothrin, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were ranged from <0.01 to 0.62.

For non-vascular plants exposed to *lambda*-cyhalothrin, all the listed and non-listed RQs were below the LOC (1.0). All the RQ values were ≤0.01 in all instances.

Table 111. Acute RQs for Vascular and Non-vascular Plants Exposed to *Lambda*-Cyhalothrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CA turf (MI met file, W14840)	0.0153	0.03	<0.03	≤0.01	<0.01
02 FL turf (TN met file, W13882)	0.00672	0.01	<0.01	≤0.01	<0.01
03, 04, 05 CA residential, ROW, impervious [Residential lots]	1.88×10^{-3}	<0.01	<0.01	≤0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [Residential lots]	0.0256	0.05	<0.05	≤0.01	<0.01

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
09, 10, 11 CA residential, ROW, impervious (PA met file, W14751) [Residential lots]	0.0127	0.03	<0.03	≤0.01	<0.01
12, 13, 14 CA residential, ROW, impervious (FL met file, W12839) [Commercial lots]	0.0195	0.04	<0.04	≤0.01	<0.01
15 OR nursery [Ornamentals]	0.276	0.54	<0.54	≤0.01	<0.01
16 NJ nursery [Ornamentals]	0.317	0.62	<0.62	≤0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 0.508 ppb [NOAEC = 0.508 for Duckweed, *Lemna gibba*, conducted with *lambda*-cyhalothrin]; the non-listed species acute RQ = use-specific peak EEC / 0.508 ppb [EC_{50} of >0.508 for Duckweed, *Lemna gibba*, conducted with *lambda*-cyhalothrin].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 310 ppb [NOAEC ≥310 ppb for green algae, *Selenastrum capricornutum*]; the non-listed species acute RQ = use-specific peak EEC / 310 ppb [EC_{50} >310 for green algae, *Selenastrum capricornutum*].

For vascular plants exposed to fenpropathrin, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to 0.01.

For non-vascular plants exposed to fenpropathrin, none of the listed species or non-listed species RQs exceeded the LOCs (LOC = 1.0) for any of the scenarios tested. Even for the two scenarios for which the EEC was capped at the limit of solubility of fenpropathrin, the RQs were only 0.43 and 0.16 for listed and non-listed species, respectively.

Table 112. Acute RQs for Vascular and Non-vascular Plants Exposed to Fenpropathrin

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	2.05	<0.01	<0.01	0.09	0.03
02 FLnurserySTD_V2/ ornamentals	0.3x3	1.51	<0.01	<0.01	0.06	0.02
03 MInurserySTD_V2/ ornamentals	0.3x3	1.20	<0.01	<0.01	0.05	0.02
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	2.04	<0.01	<0.01	0.09	0.03
06 ORnurserySTD_V2/ ornamentals	0.3x3	0.422	<0.01	<0.01	0.02	0.01

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
07 TNnurserySTD_V2/ ornamentals	0.3x3	1.66	<0.01	<0.01	0.07	0.03
08 NurseryBSS_V2/ ornamentals	0.3x3	0.695	<0.01	<0.01	0.03	0.01
09 CAnurserySTD_V2/ ornamentals	0.3x24	9.80	0.01	<0.01	0.41	0.16
10 FLnurserySTD_V2/ ornamentals	0.3x24	10.3* (13.4)	0.01	<0.01	0.43	0.16
11 MInurserySTD_V2/ ornamentals	0.3x24	7.56	0.01	<0.01	0.32	0.12
12 NJnurserySTD_V2/ ornamentals	0.3x24	10.3* (19.1)	0.01	<0.01	0.43	0.16
13 ORnurserySTD_V2/ ornamentals	0.3x24	2.53	<0.01	<0.01	0.11	0.04
14 TNnurserySTD_V2/ ornamentals	0.3x24	9.57	0.01	<0.01	0.40	0.15
15 NurseryBSS_V2/ ornamentals	0.3x24	3.66	<0.01	<0.01	0.15	0.06
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	0.151	<0.01	<0.01	0.01	<0.01
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	0.963	<0.01	<0.01	0.04	0.02
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	0.049	<0.01	<0.01	<0.01	<0.01
19 CAnurserySTD_V2/ ornamentals	0.3x1	0.817	<0.01	<0.01	0.03	0.01
20 FLnurserySTD_V2/ ornamentals	0.3x1	0.537	<0.01	<0.01	0.02	0.01
21 MInurserySTD_V2/ ornamentals	0.3x1	0.388	<0.01	<0.01	0.02	0.01
22 NJnurserySTD_V2/ ornamentals	0.3x1	0.669	<0.01	<0.01	0.03	0.01
23 ORnurserySTD_V2/ ornamentals	0.3x1	0.133	<0.01	<0.01	0.01	<0.01
24 TNnurserySTD_V2/ ornamentals	0.3x1	0.601	<0.01	<0.01	0.03	0.01
25 NurseryBSS_V2/ ornamentals	0.3x1	0.235	<0.01	<0.01	0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

= LOC for acute risk 1, and acute endangered species 1.

* EECs marked with an asterisk were set to 10.3 µg/L because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling (solubility from MRID 44370001). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 1000 ppb [NOAEC for Duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1000 ppb [EC_{50} >1000 µg/L for Duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 24 ppb [NOAEC for marine diatom, *Skeletonema costatum*]; the non-listed species acute RQ = use-specific peak EEC / 63 ppb [EC_{50} for marine diatom, *Skeletonema costatum*].

For vascular plants exposed to fenpropathrin plus unextracted residues similarly, there were no exceedances of listed or non-listed LOC (1.0). The RQ values were also very low in all instances, ranging from <0.01 to 0.01.

For non-vascular plants exposed to fenpropathrin plus unextracted residues, none of the RQs (listed species or non-listed species) exceeded the LOCs (LOC = 1.0) for any of the scenarios tested despite the fact that the EECs were higher than for fenpropathrin alone (without the unextracted residues). There were five nursery scenarios for which the EEC was capped at the limit of solubility of fenpropathrin; for these scenarios the RQs were only 0.43 and 0.16 for listed and non-listed species, respectively.

Table 113. Acute RQs for Vascular and Non-vascular Plants Exposed to Fenpropathrin plus Unextracted Residues

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
01 CAnurserySTD_V2/ ornamentals	0.3x3	2.32	<0.01	<0.01	0.10	0.04
02 FLnurserySTD_V2/ ornamentals	0.3x3	2.00	<0.01	<0.01	0.08	0.03
03 MInurserySTD_V2/ ornamentals	0.3x3	1.59	<0.01	<0.01	0.07	0.03
06, 07 NJnurserySTD_V2/ ornamentals	0.3x3	2.54	<0.01	<0.01	0.11	0.04
06 ORnurserySTD_V2/ ornamentals	0.3x3	0.563	<0.01	<0.01	0.02	0.01
07 TNnurserySTD_V2/ ornamentals	0.3x3	1.99	<0.01	<0.01	0.08	0.03
08 NurseryBSS_V2/ ornamentals	0.3x3	0.959	<0.01	<0.01	0.04	0.02
09 CAnurserySTD_V2/ ornamentals	0.3x24	10.3* (12.5)	<0.01	<0.01	0.43	0.16
10 FLnurserySTD_V2/ ornamentals	0.3x24	10.3* (19.5)	<0.01	<0.01	0.43	0.16
11 MInurserySTD_V2/ ornamentals	0.3x24	10.3* (11.6)	<0.01	<0.01	0.43	0.16
12 NJnurserySTD_V2/ ornamentals	0.3x24	10.3* (22.9)	<0.01	<0.01	0.43	0.16
13 ORnurserySTD_V2/ ornamentals	0.3x24	3.91	<0.01	<0.01	0.16	0.06
14 TNnurserySTD_V2/ ornamentals	0.3x24	10.3* (13.0)	<0.01	<0.01	0.43	0.16
15 NurseryBSS_V2/ ornamentals	0.3x24	5.76	0.01	<0.01	0.24	0.09
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals	0.02x3	0.218	<0.01	<0.01	0.01	<0.01
17 FLresidentialPYR (CAresidential with FL met file W12839)	0.02x24	1.60	<0.01	<0.01	0.07	0.03

Scenario/Uses	App Rate (lb a.i./A) x No. of Apps	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals	0.02x1	0.071	<0.01	<0.01	<0.01	<0.01
19 CAnurserySTD_V2/ ornamentals	0.3x1	0.939	<0.01	<0.01	0.04	0.01
20 FLnurserySTD_V2/ ornamentals	0.3x1	0.765	<0.01	<0.01	0.03	0.01
21 MInurserySTD_V2/ ornamentals	0.3x1	0.520	<0.01	<0.01	0.02	0.01
22 NJnurserySTD_V2/ ornamentals	0.3x1	0.831	<0.01	<0.01	0.03	0.01
23 ORnurserySTD_V2/ ornamentals	0.3x1	0.186	<0.01	<0.01	0.01	<0.01
24 TNnurserySTD_V2/ ornamentals	0.3x1	0.700	<0.01	<0.01	0.03	0.01
25 NurseryBSS_V2/ ornamentals	0.3x1	0.319	<0.01	<0.01	0.01	0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. G=ground; GR=granular; H=handheld or backpack sprayer.

= LOC for acute risk 1, and acute endangered species 1.

* EECs marked with an asterisk were set to 10.3 µg/L because they exceeded the limit of solubility of fenpropathrin in the aquatic modeling (solubility from MRID 44370001). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 1000 ppb [NOAEC for Duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1000 ppb [EC_{50} >1000 µg/L for Duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 24 ppb [NOAEC for marine diatom, *Skeletonema costatum*]; the non-listed species acute RQ = use-specific peak EEC / 63 ppb [EC_{50} for marine diatom, *Skeletonema costatum*].

7.2 Risk Description

7.2.1 Main Factors Affecting the Risk Quotients

One of the major factors that affect the risk quotients for the synthetic pyrethroids and pyrethrins is their toxicity to aquatic animals. As indicated earlier, previous assessments had shown the potential for concerns in residential and commercial, as well as other non-agricultural and/or urban settings.

Pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} <0.1 mg/L). **Table 59** shows the most sensitive LC_{50}s and NOAECs for freshwater and estuarine/marine fish; **Table 61** presents the most sensitive EC_{50}s and NOAECs for freshwater and estuarine/marine invertebrates; **Table 62** presents the most sensitive NOAECs for freshwater and estuarine/marine benthic invertebrates; finally **Table 63** shows the most sensitive EC_{50}s and NOAECs for vascular and non-vascular plants for the pyrethroids for which data are available. Freshwater fish are generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates are more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis. On a chronic basis, a trend is not clear for freshwater invertebrates, when compared to estuarine/marine invertebrates. Comparison of **Table 59** against **Table 61** shows clearly that freshwater and estuarine/ marine invertebrates are orders of magnitude more sensitive to pyrethroids and pyrethrins than freshwater and estuarine/marine fish. Vascular and non-vascular plants endpoints for the pyrethroids for which data are available indicate that these organisms are much less sensitive than aquatic animals.

The use information utilized in the risk assessment is another factor that could affect the risk quotients. One thing that should be stressed is that EFED modeled only a single application per year for all the pyrethroids and pyrethrins, with the exception of fenpropathrin. For some of the organisms and fenpropathrin, the risk picture (RQs) changed when comparing one, three, or 24 applications. It appears that the calculated RQs may not be conservative as when one assumes 3 or 24 applications; however, for all chemicals it is assumed that all the 58 lots in the 10 hectare watershed are treated at the same time with the same pyrethroid and in all locations of the lot at the same time. Similarly, for the turf and ornamentals, a single application was assumed, which again, may not appear to be conservative.

7.2.2 Summary of Risk Quotients

Tables 59 to **113** (above), provided detailed RQ tables including EECs and endpoints used (see footnotes in those tables). **Tables 114** to **123** provide overall summaries of all the risk quotients for freshwater and estuarine/marine animals for eight pyrethroids and pyrethrins, for the uses assessed. The summary tables below are presented to show trends for each chemical and across chemicals.

Acute and chronic risks quotients (RQs) for freshwater and estuarine/marine fish were generally orders of magnitude lower than for freshwater and estuarine/marine invertebrates. For freshwater fish, there were a fewer exceedances of the acute and chronic LOCs and further, for estuarine/marine fish there were even fewer exceedances of acute and chronic LOCs. For deltamethrin, fenpropathrin and bifenthrin, some of the peak EECs were limited by the solubility of each compound. Refer to the EEC or RQ tables for the particular runs for which this occurred. In these tables, when the EEC exceeded the limit of solubility, the EEC from the run was added in a (parenthesis) for informative purposes. The pyrethroids are highly hydrophobic, and should not be bioavailable above the limit of solubility.

For one chemical, fenpropathrin, besides a single application, multiple applications were modelled. Furthermore, inspection of the unextracted residues was performed. Inspection of the RQ results for fenpropathrin and fenpropathrin plus the unextracted residues, in **Tables 122** and **123**, respectively, shows the following trends:

- When several scenarios are run (*i.e.*, for fenpropathrin seven nursery scenarios were run), the overall risk picture does not vary substantially from scenario to scenario when the application rate and number of application is the same. For example, if one runs 24 applications for seven nursery scenarios, similar RQs across all the scenarios are obtained for a given taxa. It appears that there is no need to run all the scenario combinations and that the approach to use a reduced number of scenarios to represent the uses is appropriate.
- RQs increased with the application rates and with the number of applications per year, as expected.
- RQs for invertebrates (freshwater and estuarine/marine) are higher than for fish (fresh water and estuarine/marine). This is common across all the chemicals tested, for which invertebrates are more susceptible than fish to pyrethroid exposure.
- Benthic acute and chronic RQs are lower than water column RQs, which is expected, since the pore water EECs are lower than water column EECs.
- The overall risk picture for parent only and parent plus unextracted residues are similar. It appears that additional runs for the unextracted residues would not change the overall conclusions of the risk assessment for the other chemicals. In a number of the pyrethroid metabolism studies, relatively high levels of unextracted radioactivity were observed. Many of these studies were conducted prior to the issuance of the guidance on the evaluation of unextracted residues[9]. It is appropriate to use a variety of solvents with different dielectric constants, in order to make sure that all residues have been extracted.
- Fenpropathrin appeared to have higher RQs than the other pyrethroids and pyrethrins, which may be due to the fact that multiple applications were run (*i.e.*, one, three and 24 applications), while for the remaining pyrethroids and pyrethrins a single application was modelled.

[9] The guidance is available at (accessed June 24, 2016): https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-addressing-unextracted-pesticide-residues.

No RQ *summary tables* were presented for vascular and non-vascular plants, since for these species there were no exceedances of the listed and/or non-listed species LOC (LOC = 1.0) for most of the pyrethroids for which aquatic plant data were available (the only exceptions were permethrin and cypermethrin, for which there were a few exceedances). Based on the above information, the risks to aquatic plants is low.

Table 114. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	0.03	0.01	0.01	0.02	*0.17*	0.86	0.01	0.26	*0.09*	0.14	0.01	0.04
02 FL turf (TN weather)	0.03	0.01	0.01	0.02	*0.17*	0.68	0.01	0.19	*0.09*	0.11	0.01	0.03
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
06, 07, 08 BSS residential, ROW, impervious [TX weather; Residential lots]	<0.01	<0.01	<0.01	<0.01	0.02	0.10	<0.01	0.04	0.01	0.02	<0.01	0.01
09, 10, 11 CA residential, ROW, impervious [PA weather; Residential lots]	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	0.02	0.01	0.01	0.01	*0.12*	0.53	0.01	0.16	*0.06*	0.08	<0.01	0.02
15 OR nursery [Ornamentals]	0.02	0.01	0.01	0.02	*0.12*	0.56	0.01	0.18	*0.06*	0.09	0.01	0.03
16 NJ nursery [Ornamentals]	0.03	0.02	0.01	0.04	*0.19*	**1.3**	0.04	0.66	*0.11*	0.22	0.02	0.11

RQs with *italics* font and shaded light grey exceed only the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 115. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Bifenthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	*0.09*	**1.8**	<0.01	0.07	**28.4**	**184**	**15**	**149**	**3.5**	**>15**	**1.9**	**>12**
02 FL turf (TN weather)	*0.09*	**2.0**	<0.01	0.08	**28.4**	**190**	**16**	**154**	**3.5**	**>16**	**2.0**	**>13**
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	0.03	0.09	<0.01	<0.01	**8.19**	**9.1**	**0.66**	**6.5**	**1.0**	>0.76	*0.08*	>0.54
06, 07 BSS residential, ROW [TX weather; Residential lots]	*0.09*	**1.2**	<0.01	0.05	**28.4**	**129**	**8.7**	**84**	**3.5**	**>11**	**1.08**	**>7.0**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
09, 10, 11 CA residential, ROW, impervious [PA weather; Residential lots]	*0.09*	0.53	<0.01	0.02	**28.4**	**43**	**4.0**	**39**	**3.5**	**>3.6**	**0.50**	**>3.3**
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	*0.09*	0.46	<0.01	0.02	**28.4**	**45**	**3.2**	**31**	**3.5**	**>3.8**	*0.40*	**>2.6**
15 OR nursery [Ornamentals]	*0.09*	**1.6**	<0.01	0.06	**28.4**	**143**	**12**	**119**	**3.5**	**>12**	**1.5**	**>9.9**
16 NJ nursery [Ornamentals]	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28**	**280**	**3.5**	**>23**	**3.5**	**>23**

RQs with *italics* font and shaded light grey exceed only the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 116. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Deltamethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	*0.17*	0.01	0.04	0.01	**126**	**16**	**1.1**	**7.8**	**6.8**	0.90	*0.06*	0.28
02 FL turf (TN weather)	*0.17*	0.02	0.04	0.01	**126**	**18**	**1.2**	**8.7**	**6.8**	0.97	*0.06*	0.47
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	0.01	<0.01	<0.01	<0.01	**6.0**	0.80	*0.06*	0.44	*0.32*	0.04	<0.01	0.02
06, 07 BSS residential, ROW [TX weather; Residential lots]	*0.06*	0.01	0.02	0.01	**45**	**14**	**0.82**	**5.9**	**2.4**	0.79	0.04	0.32
09, 10, 11 CA residential, ROW, impervious [PA weather; Residential lots]	0.03	0.01	0.01	<0.01	**22**	**4.7**	*0.36*	**2.7**	**1.2**	0.26	0.02	0.15
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	**1.3**	0.24	*0.34*	0.16	**1000**	**318**	**11**	**81**	**54**	**18**	**0.60**	**4.5**
15 OR nursery [Ornamentals]	0.02	0.01	0.01	<0.01	**16**	**5.0**	**0.50**	**3.7**	**0.84**	0.28	0.03	0.20
16 NJ nursery [Ornamentals]	**0.81**	0.12	*0.21*	0.09	**605**	**112**	**8.6**	**63**	**33**	**6.2**	*0.46*	**3.5**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 117. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	*0.48*	0.54	*0.17*	0.20	**57**	**9.4**	**4.0**	**11**	**21**	**16**	**1.5**	**11**
02 FL turf (TN weather)	*0.36*	0.54	*0.13*	0.20	**43**	**7.7**	**3.6**	**10**	**16**	**14**	**1.3**	**9.7**
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	**0.94**	**1.5**	*0.33*	0.53	**113**	**23**	**10**	**29**	**41**	**41**	**3.7**	**28**
06, 07 BSS residential, ROW [TX weather; Residential lots]	*0.16*	0.16	*0.06*	0.06	**19**	**3.0**	**1.1**	**3.0**	**7.0**	**5.2**	*0.39*	**2.9**
09, 10, 11 CA residential, ROW, impervious [PA weather; Residential lots]	**2.2**	**3.2**	**0.77**	**1.17**	**258**	**42**	**22**	**63**	**94**	**73**	**8.2**	**61**
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	**1.3**	**1.9**	*0.47*	0.71	**158**	**30**	**12**	**33**	**58**	**53**	**4.4**	**32**
15 OR nursery [Ornamentals]	*0.16*	0.33	*0.06*	0.12	**19**	**4.6**	**2.4**	**6.7**	**7.0**	**8.1**	**0.88**	**6.5**
16 NJ nursery [Ornamentals]	**2.0**	**2.4**	**0.72**	0.89	**242**	**37**	**17**	**47**	**89**	**65**	**6.2**	**45**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 118. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Esfenvalerate for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	*0.28*	0.04	<0.01	<0.01	**48.5**	**35.9**	**0.85**	**1.0**	**8.82**	**6.5**	*0.15*	0.24
02 FL turf (TN weather)	*0.25*	0.09	<0.01	<0.01	**41.9**	**51.5**	**1.40**	**1.6**	**7.62**	**9.4**	*0.26*	0.37
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	*0.05*	0.02	<0.01	<0.01	**7.79**	**11.7**	*0.23*	0.27	**1.42**	**2.1**	0.04	0.06
06, 07, 08 BSS residential, ROW, impervious [TX weather; Residential lots]	*0.14*	0.03	<0.01	<0.01	**23.7**	**27.0**	**0.52**	0.59	**4.31**	**4.9**	*0.10*	0.14
09, 10, 11 CA residential, ROW, impervious (PA weather; Residential lots]	*0.10*	0.02	<0.01	<0.01	**16.5**	**19.1**	*0.43*	0.52	**3.00**	**3.5**	*0.07*	0.12
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	**5.02**	0.38	0.04	0.01	**848**	**423**	**4.1**	**4.8**	**153**	**77**	**0.75**	**1.1**
15 OR nursery [Ornamentals]	**2.81**	0.31	<0.02	0.01	**471**	**284**	**4.4**	**5.2**	**85.6**	**52**	**0.79**	**1.2**
16 NJ nursery [Ornamentals]	**3.01**	0.69	<0.02	0.02	**504**	**502**	**12**	**14**	**91.6**	**91**	**2.1**	**3.2**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 119. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of for Cypermethrin Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	*0.24*	0.04	*0.09*	0.02	**168**	**>68**	**3.1**	**>32**	**17**	**17**	*0.31*	**8.0**
02 FL turf (TN weather)	*0.20*	0.07	*0.08*	0.03	**139**	**>70**	**5.7**	**>57**	**14**	**17**	**0.59**	**14**
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	*0.14*	0.04	*0.06*	0.02	**94**	**>72**	**2.7**	**>30**	**9.8**	**18**	*0.28*	**7.5**
06, 07, 08 BSS residential, ROW, impervious [TX weather; Residential lots]	*0.32*	0.08	*0.13*	0.03	**225**	**>130**	**5.3**	**>56**	**23**	**33**	**0.55**	**14**
09, 10, 11 CA residential, ROW, impervious (PA weather; Residential lots]	*0.27*	0.06	*0.11*	0.02	**189**	**>112**	**3.7**	**>41**	**20**	**28**	*0.38*	**10**
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	**11**	0.99	**4.4**	0.40	**7460**	**>2200**	**51**	**>528**	**774**	**550**	**5.3**	**132**
15 OR nursery [Ornamentals]	*0.32*	0.04	*0.13*	0.02	**221**	**>71**	**2.1**	**>23**	**23**	**18**	*0.22*	**5.8**
16 NJ nursery [Ornamentals]	*0.32*	0.07	*0.13*	0.03	**227**	**>111**	**5.6**	**>57**	**24**	**28**	**0.58**	**14**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 120. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Cyfluthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	*0.31*	0.07	0.01	0.01	**0.85**	**5.1**	0.01	**1.8**	**9.6**	**8.7**	*0.13*	**3.1**
02 FL turf (TN weather)	*0.23*	0.06	<0.01	0.01	**0.63**	**3.9**	0.01	**1.5**	**7.2**	**6.7**	*0.10*	**2.6**
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	0.02	0.01	<0.01	<0.01	0.04	0.35	<0.01	0.13	*0.49*	0.59	0.01	0.22
06, 07, 08 BSS residential, ROW, impervious [TX weather; Residential lots]	*0.11*	0.05	<0.01	0.01	*0.29*	**3.9**	0.01	**1.2**	**3.3**	**6.7**	*0.09*	**2.1**
09, 10, 11 CA residential, ROW, impervious (PA weather; Residential lots]	*0.08*	0.02	<0.01	<0.01	*0.22*	**1.7**	<0.01	0.46	**2.5**	**2.9**	0.03	0.79

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	**5.7**	0.76	*0.10*	0.13	**15**	**67**	*0.08*	**13**	**176**	**115**	**0.95**	**23**
15 OR nursery [Ornamentals]	**1.7**	0.25	0.03	0.04	**4.6**	**20**	0.03	**4.7**	**52**	**35**	*0.30*	**8.0**
16 NJ nursery [Ornamentals]	**1.7**	0.45	0.03	0.07	**4.6**	**26**	0.05	**7.5**	**52**	**44**	**0.54**	**13**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 121. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of *Lambda*-Cyhalothrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
01 CA turf (MI weather)	**0.53**	0.10	0.02	<0.01	**191**	**15**	**37**	**25**	**3.11**	**17**	**0.60**	**15**
02 FL turf (TN weather)	*0.23*	0.08	0.01	0.01	**84**	**12**	**30**	**20**	**1.37**	**13**	*0.48*	**12**
03, 04, 05 CA residential, ROW, impervious [CA weather; Residential lots]	*0.06*	0.03	<0.01	<0.01	**24**	**3.6**	**10**	**6.7**	*0.38*	**4**	*0.16*	**3.9**
06, 07, 08 BSS residential, ROW, impervious [TX weather; Residential lots]	**0.88**	0.20	0.03	0.03	**320**	**29**	**79**	**54**	**5.21**	**32**	**1.28**	**31**
09, 10, 11 CA residential, ROW, impervious (PA weather; Residential lots]	*0.43*	0.12	0.02	0.02	**159**	**18**	**46**	**32**	**2.59**	**20**	**0.75**	**19**
12, 13, 14 CA residential, ROW, impervious [FL weather; Commercial lots]	**0.67**	0.13	0.02	0.02	**243**	**20**	**48**	**33**	**3.69**	**22**	**0.79**	**19**
15 OR nursery [Ornamentals]	**9.5**	**1.6**	*0.34*	0.20	**3,450**	**250**	**591**	**410**	**56.2**	**275**	**9.6**	**237**
16 NJ nursery [Ornamentals]	**11**	**3.0**	*0.39*	0.37	**3,960**	**435**	**1,120**	**774**	**64.6**	**479**	**18**	**447**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 122. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Fenpropathrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals (1 application/year)	0.02	0.05	0.02	<0.01	**16.1**	**>2**	**0.98**	**>2**	**2.3**	0.25	*0.14*	0.25
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals (3 applications/year)	*0.07*	0.13	*0.05*	0.01	**49.5**	**>6**	**2.6**	**>5**	**7.2**	0.75	*0.38*	0.67
17 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals (24 applications/year)	*0.44*	**1.1**	*0.31*	0.08	**316**	**>48**	**19.7**	**>40**	**46**	**6.0**	**2.9**	**5.0**
19 CAnurserySTD_V2/ ornamentals (1 application/ year)	*0.37*	0.70	*0.26*	0.05	**268**	**>35**	**13.1**	**>27**	**39**	**4.4**	**1.9**	**3.3**
20 FLnurserySTD_V2/ ornamentals (1 application/ year)	*0.24*	0.82	*0.17*	0.06	**176**	**>35**	**15.3**	**>31**	**26**	**4.4**	**2.2**	**3.8**
21 MInurserySTD_V2/ ornamentals (1 application/ year)	*0.18*	**1.0**	*0.13*	0.08	**127**	**>43**	**20.1**	**>41**	**18**	**5.4**	**2.9**	**5.1**
22 NJnurserySTD_V2/ ornamentals (1 application/ year)	*0.30*	**1.0**	*0.22*	0.08	**219**	**>46**	**19.0**	**>39**	**32**	**5.8**	**2.8**	**4.8**
23 ORnurserySTD_V2/ ornamentals (1 application/year)	*0.06*	0.30	0.04	0.02	**43.6**	**>13**	**5.8**	**>12**	**6.3**	**1.6**	**0.84**	**1.5**
24 TNnurserySTD_V2/ ornamentals (1 application/ year)	*0.27*	**1.0**	*0.19*	0.07	**197**	**>43**	**19.4**	**>40**	**29**	**5.3**	**2.8**	**4.9**
25 NurseryBSS_V2/ ornamentals (1 application/ year)	*0.11*	0.32	*0.08*	0.02	**77.0**	**>14**	**6.0**	**>12**	**11**	**1.8**	**0.88**	**1.5**
01 CAnurserySTD_V2/ ornamentals (3 applications/year)	**0.93**	**1.8**	**0.66**	0.13	**672**	**>84**	**32.1**	**>65**	**98**	**11**	**4.7**	**8.1**
02 FLnurserySTD_V2/ ornamentals (3 applications/year)	**0.69**	**2.5**	*0.49*	0.18	**495**	**>105**	**45.6**	**>92**	**72**	**13**	**6.6**	**11**
03 MInurserySTD_V2/ ornamentals (3 applications/year)	**0.55**	**3.0**	*0.39*	0.22	**393**	**>127**	**58.7**	**>119**	**57**	**16**	**8.5**	**15**
06, 07 NJnurserySTD_V2/ ornamentals (3 applications/year)	**0.93**	**3.0**	**0.66**	0.22	**669**	**>137**	**56.7**	**>115**	**97**	**17**	**8.2**	**14**
06 ORnurserySTD_V2/ ornamentals (3 applications/year)	*0.19*	0.9	*0.14*	0.07	**138**	**>38**	**17.4**	**>35**	**20**	**4.8**	**2.5**	**4.4**
07 TNnurserySTD_V2/ ornamentals (3 applications/year)	**0.75**	**3.0**	**0.54**	0.22	**544**	**>127**	**58.7**	**>121**	**79**	**16**	**8.5**	**15**
08 NurseryBSS_V2/ ornamentals (3 applications/ year)	*0.32*	0.97	*0.22*	0.07	**228**	**>39**	**17.9**	**>36**	**33**	**5.3**	**2.6**	**4.5**
09 CAnurserySTD_V2/ ornamentals (24 applications/year)	**4.5**	**12**	**3.2**	0.92	**3,210**	**>537**	**232**	**>471**	**470**	**67**	**34**	**59**
10 FLnurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**18**	**3.3**	**1.3**	**3,380**	**>793**	**344**	**>697**	**490**	**99**	**50**	**87**
11 MInurserySTD_V2/ ornamentals (24 applications/year)	**3.4**	**126**	**2.4**	**1.7**	**2,480**	**>960**	**446**	**>910**	**360**	**120**	**65**	**113**
12 NJnurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**172**	**3.3**	**2.0**	**3,380**	**>1130**	**495**	**>1000**	**490**	**140**	**72**	**125**
13 ORnurserySTD_V2/ ornamentals (24 applications/year)	**1.2**	**6.4**	**0.82**	0.47	**830**	**>267**	**122**	**>250**	**120**	**33**	**18**	**32**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
14 TNnurserySTD_V2/ ornamentals (24 applications/year)	**4.4**	**21**	**3.1**	**1.6**	**3,140**	**>907**	**31.8**	**>65**	**460**	**110**	**4.7**	**8.1**
15 NurseryBSS_V2/ ornamentals (24 applications/ year)	**1.7**	**6.3**	**1.2**	0.47	**1,200**	**>275**	**45.6**	**>92**	**170**	**34**	**6.6**	**11**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 123. Summary of Risk Quotients for Certain Non-agricultural and Urban Uses of Fenpropathrin plus Unextracted Residues for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
18 FLresidentialPYR (CAresidential with FL met file W12839)/ commercial ornamentals (1 application/year)	0.03	0.08	0.02	0.01	**23.3**	**>4**	**1.6**	**>3**	**3.4**	0.50	*0.24*	0.41
16 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals (3 applications/year)	*0.10*	0.25	*0.07*	0.02	**71.5**	**>12**	**4.9**	**>10**	**10**	**1.5**	**0.71**	**1.3**
17 FLresidentialPYR (CAresidential with FL met file W12839)/ Commercial ornamentals (24 applications/year)	**0.73**	**2.0**	**0.52**	0.15	**525**	**>93**	**38.4**	**>78**	**76**	**12**	**5.6**	**9.8**
19 CAnurserySTD_V2/ ornamentals (1 application/ year)	*0.43*	0.85	*0.30*	0.06	**308**	**>41**	**15.7**	**>32**	**45**	**5.3**	**2.3**	**4.0**
20 FLnurserySTD_V2/ ornamentals (1 application/ year)	*0.35*	0.97	*0.25*	0.07	**251**	**>42**	**18.0**	**>37**	**36**	**5.3**	**2.6**	**4.6**
21 MInurserySTD_V2/ ornamentals (1 application/ year)	*0.24*	**1.5**	*0.17*	0.11	**170**	**>61**	**28.9**	**>59**	**25**	**7.6**	**4.2**	**7.3**
22 NJnurserySTD_V2/ ornamentals (1 application/ year)	*0.38*	**1.2**	*0.27*	0.09	**272**	**>57**	**23.3**	**>47**	**40**	**7.1**	**3.4**	**5.8**
23 ORnurserySTD_V2/ ornamentals (1 application/year)	*0.08*	0.43	*0.06*	0.03	**61.0**	**>19**	**8.5**	**>17**	**8.9**	**2.3**	**1.2**	**2.2**
24 TNnurserySTD_V2/ ornamentals (1 application/ year)	*0.32*	**1.2**	*0.23*	0.09	**230**	**>53**	**23.9**	**>49**	**33**	**3.8**	**3.5**	**6.1**
25 NurseryBSS_V2/ ornamentals (1 application/ year)	*0.15*	0.48	*0.10*	0.04	**105**	**>21**	**8.9**	**>18**	**15**	**2.6**	**1.3**	**2.3**
01 CAnurserySTD_V2/ ornamentals (3 applications/year)	**1.1**	**2.2**	**0.75**	0.16	**761**	**>103**	**39.7**	**>80**	**110**	**13**	**5.8**	**10**
02 FLnurserySTD_V2/ ornamentals (3 applications/year)	**0.91**	**2.9**	**0.65**	0.22	**656**	**>126**	**54.4**	**>110**	**95**	**16**	**7.9**	**14**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
03 MInurserySTD_V2/ ornamentals (3 applications/year)	**0.72**	**4.3**	**0.51**	0.32	**521**	**>181**	**84.9**	**>174**	**76**	**23**	**12**	**22**
06, 07 NJnurserySTD_V2/ ornamentals (3 applications/year)	**1.2**	**3.7**	**0.82**	0.27	**833**	**>169**	**69.5**	**>141**	**120**	**21**	**10**	**18**
06 ORnurserySTD_V2/ ornamentals (3 applications/year)	*0.25*	**1.3**	*0.18*	0.10	**185**	**>56**	**25.2**	**>52**	**27**	**7.0**	**3.7**	**6.4**
07 TNnurserySTD_V2/ ornamentals (3 applications/year)	**0.90**	**3.7**	**0.64**	0.27	**652**	**>157**	**72.1**	**>146**	**95**	**20**	**10**	**18**
08 NurseryBSS_V2/ ornamentals (3 applications/ year)	*0.44*	**1.4**	*0.31*	0.10	**314**	**>6.1**	**26.6**	**>54**	**46**	**7.7**	**3.9**	**6.7**
09 CAnurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**15**	**3.3**	**1.1**	**3,380**	**>641**	**279**	**>566**	**490**	**80**	**41**	**70**
10 FLnurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**22**	**3.3**	**1.6**	**3,380**	**>967**	**410**	**>830**	**490**	**120**	**60**	**103**
11 MInurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**33**	**3.3**	**2.5**	**3,380**	**>1400**	**649**	**>1320**	**490**	**180**	**94**	**164**
12 NJnurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**32**	**3.3**	**2.4**	**3,380**	**>1380**	**597**	**>1210**	**490**	**173**	**87**	**150**
13 ORnurserySTD_V2/ ornamentals (24 applications/year)	**1.8**	**9.7**	**1.3**	0.72	**1,280**	**>407**	**187**	**>380**	**190**	**51**	**27**	**47**
14 TNnurserySTD_V2/ ornamentals (24 applications/year)	**4.7**	**27**	**3.3**	**2.0**	**3,380**	**>1180**	**521**	**>1060**	**490**	**150**	**76**	**132**
15 NurseryBSS_V2/ ornamentals (24 applications/ year)	**2.6**	**9.9**	**1.9**	0.73	**1,890**	**>423**	**187**	**>381**	**270**	**53**	**27**	**47**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

7.2.3 Comparison of Risk Quotients Based on Monitored Concentrations

Another line of evidence is from the monitoring of pyrethroids. Monitoring data from water and sediment in California and the rest of the U.S. corroborate the presence of synthetic pyrethroids in urban environments. Even though it is apparent that the pyrethroids are ubiquitous in urban waters, the vast majority of the water concentrations available are for whole (unfiltered) water, as opposed to filtered water. Whole water may contain suspended soil, sediment or particulate that could sorb pyrethroids, while the calculated EECs in the water column are freely dissolved pyrethroid concentrations.

Given that the sediment concentrations are organic carbon normalized, they appear to be suitable for comparison with modeled EECs, and to calculate risk quotients. The following table shows the chronic risk quotients, based on monitored and modeled sediment concentrations.

Table 124. Summary of Risk Quotients for Pyrethroids and Pyrethrins for Freshwater and Estuarine/Marine Invertebrates, Based on the Maximum Sediment Monitored Concentration in Urban Environments

Chemical	Maximum Sediment Monitored Conc.[1] (µg/kg$_{OC}$)	90th Percentile Sediment Monitored Conc.[1] (µg/kg$_{OC}$)	Maximum Sediment Modeled EEC[2] (µg/kg$_{OC}$)	Chronic Risk Quotient (based on Max. Conc.)[3]			
				FW Inverts		E/M Inverts	
				Monitored	Modeled	Monitored	Modeled
Bifenthrin	10,000	1,400	333	**1,600**	**53**	**>74**	**>2.5**
Cyfluthrin	7,000	350	126	**318**	**5.7**	**>205**	**>3.7**
L-Cyhalothrin	2,900	180	423	**374**	**55**	**>48**	**>7.1**
Cypermethrin	12,000	260	1,360	**>1,560**	**>177**	**353**	**40**
Deltamethrin	2,800	120	324	**233**	**27**	NA	
Esfenvalerate	1,900	20	300	**10.8**	**1.7**	**2.3**	0.4
Fenpropathrin	2,300	2	623-12,500[4]	**>7.41**	**>2.0->40**[4]	0.7	0.2-**3.9**[4]
Permethrin	196,000	1,100	11,800	**1,060**	**64**	**206**	**12**

NA = no available suitable chronic endpoint.

[1] Based on sediment samples from urban flowing water use sites, see **Table 51**.

[2] Maximum EEC for the urban uses of pyrethroids (residential and commercial). When the sediment EEC was expressed in µg/kg-dw, the OC normalized EEC was estimated by dividing by 0.04, which is the fraction of OC in the standard pond sediment.

[3] RQs for bifenthrin, permethrin and *lambda*-cyhalothrin: the estimated endpoint was calculated by dividing ug/kg-dw by 0.04, which is the fraction of OC in the standard pond sediment.

[4] A range is provided, since in this assessment 1-24 applications per year were modeled.

Comparison of RQs derived based on the maximum monitored concentration against the acute and chronic endpoints yields the following findings and are detailed in **Table 124**:

- All RQs based on monitoring, with the exception of fenpropathrin, were greater than the RQs based on modelling (see below).
- All RQ values based on maximum monitored concentration, with the exception of estuarine/marine benthic invertebrates exposed to fenpropathrin exceeded the chronic LOC (1.0). All the RQs based on maximum modelled concentration, with the exception of esfenvalerate and fenpropathrin at one application/year, exceeded the chronic LOC.
- For all the chemicals, except for fenpropathrin, the RQ based on monitoring was about one order of magnitude higher or greater than the RQ based on modelling.
- As established in **Section 5.6.5.2**, "[c]omparison of the modeled and the maximum monitored concentration shows that for all the chemicals, except for fenpropathrin the monitored concentrations were above the modeled concentrations. This could be due to the fact that in modeling all these pyrethroids a single application was assumed. Fenpropathrin, which was the exception, was modeled at single, three and up to 24 applications/year and the maximum modeled concentration was greater than the maximum monitored concentration."
- No "monitoring" RQs could be derived for pyrethrins, since there is no readily available monitoring data for this chemical.

7.2.4 Alternative K_{OC} Values, Use of $K_{OC_SPME_free}$

As part of the ongoing efforts done by PWG to address certain uncertainties related to the environmental fate studies for pyrethroids, two non-guideline studies were submitted to the Agency that provided alternative K_{OC} values (MRIDs 49410301 and 49544001, supplemental). Three types of K_{OC} values were available from the studies: liquid-liquid extraction (LLE), solid phase micro-extraction free (SPME free) and SPME total. LLE values were conventional batch equilibrium studies derived using liquid-liquid extractions. The water concentrations derived using this methodology are the total pyrethroid concentrations (*i.e.*, freely dissolved plus the amount of chemical associated with dissolved organic carbon or DOC). SPME free values were derived using solid phase micro-extractions, in which the obtained water concentration is the *freely dissolved* pyrethroid concentration. Finally, SPME_total, in which the concentrations of the pyrethroid and its deuterated analog internal standard (pyrethroid-d_6) are compared and the ratio is proportional to the total pyrethroid concentration. The $K_{OC\ SPME\ total}$ is equivalent to the $K_{OC\ LLE}$. The K_{OC} values obtained varied across pyrethroids, but it was noted that they were invariably higher than previously reported (*e.g.*, Laskowski, 2002). No desorption was studied in this experiment and only a single concentration was evaluated; therefore, no Freundlich coefficients were derived.

The focus of this section is on the $K_{OC\ SPME\ free}$, which is the sorption coefficient derived from the freely dissolved pyrethroid concentrations, and two example chemicals were analysed: deltamethrin and esfenvalerate. For deltamethrin, the standard or previously reported mean K_{OC} is 449,000 mL/g_{OC}; meanwhile, the mean $K_{OC\ SPME\ free}$ (from two sediments tested), is 3,661,709 mL/g_{OC}. Therefore the $K_{OC\ SPME\ free}$ for deltamethrin is 816% higher than the standard K_{OC}. For esfenvalerate, the previously reported K_{OC} value is 251,717 mL/g_{OC}, and the $K_{OC\ SPME\ free}$ is 5,810,619 mL/g_{OC}. The $K_{OC\ SPME\ free}$ for esfenvalerate is 2,310% higher than the standard K_{OC}.

As indicated in the previous paragraph, EFED conducted additional runs for selected scenarios for these two chemicals, using the $K_{OC\ SPME\ free}$ instead of the standard $K_{OC\ LLE}$. Results are summarized in the following tables.

Table 125. Water Column, Pore Water, and Sediment EECs for Deltamethrin, for Runs Using Standard K_{OC} and $K_{OC\ SPME\ free}$[1,2]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
01a CA turf (MI met file, W14840), ***Standard $K_{OC\ LLE}$***	G	0.13	01-06	1	N/A	0.0251	4.25×10^{-4}	2.53×10^{-4}	2.11×10^{-4}	2.03×10^{-4}	95.0	91.4
01b CA turf (MI met file, W14840), ***$K_{OC\ SPME\ free}$***	G	0.13	01-06	1	N/A	0.00537	5.23×10^{-5}	3.11×10^{-5}	2.60×10^{-5}	2.50×10^{-5}	94.9	91.2
02a FL turf (TN met file, W13882), ***Standard $K_{OC\ LLE}$***	G	0.13	01-06	1	N/A	0.0251	4.57×10^{-4}	2.79×10^{-4}	2.35×10^{-4}	2.25×10^{-4}	106	101
02b FL turf (TN met file, W13882), ***$K_{OC\ SPME\ free}$***	G	0.13	01-06	1	N/A	0.00538	5.64×10^{-5}	3.44×10^{-5}	2.91×10^{-5}	2.80×10^{-5}	106	102
15a OR nursery [Ornamentals], Standard ***K_{OC_LLE}***	GR	0.13	01-06	1	N/A	0.00311	1.30×10^{-4}	1.13×10^{-4}	9.98×10^{-5}	9.61×10^{-5}	44.9	43.2
15b OR nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	GR	0.13	01-06	1	N/A	6.42×10^{-4}	1.59×10^{-5}	1.38×10^{-5}	1.23×10^{-5}	1.18×10^{-5}	44.9	43.1
16a NJ nursery [Ornamentals], Standard ***K_{OC_LLE}***	GR	0.13	01-06	1	N/A	0.121	0.00292	0.00205	0.00172	0.00163	774	734
16b NJ nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	GR	0.13	01-06	1	N/A	0.0262	3.67×10^{-4}	2.58×10^{-4}	2.16×10^{-4}	2.05×10^{-4}	788	748

G=ground; GR=granular

[1] EECs were generally rounded to three significant figures.

[2] Standard $K_{OC\ LLE}$ = 449,000 mL/g$_{OC}$; $K_{OC\ SPME\ free}$ = 3,661,709 mL/g$_{OC}$.

Table 126. Water Column, Pore Water, and Sediment EECs for Esfenvalerate, for Runs Using Standard K_{OC} and $K_{OC\ SPME\ free}$[1,2]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
01a CA turf (MI met file, W14840), original batch run	G	0.184	01-06	1	N/A	0.0411	0.00111	7.62×10^{-4}	7.2×10^{-4}	7.25×10^{-4}	182	183
01b CA turf (MI met file, W14840), ***Standard $K_{OC\ LLE}$***	G	0.184	01-06	1	N/A	0.0410	0.00108	7.18×10^{-4}	6.83×10^{-4}	6.88×10^{-4}	172	174
01c CA turf (MI met file, W14840), ***$K_{OC\ SPME\ free}$***	G	0.184	01-06	1	N/A	0.00443	4.84×10^{-5}	3.35×10^{-5}	3.17×10^{-5}	3.19×10^{-5}	184	185
02a FL turf (TN met file, W13882), original batch run	G	0.184	01-06	1	N/A	0.0355	0.00159	0.00148	0.00119	0.00112	300	283
02b FL turf (TN met file, W13882), ***Standard $K_{OC\ LLE}$***	G	0.184	01-06	1	N/A	0.0355	0.00155	0.00146	0.00117	0.00110	295	278
02c FL turf (TN met file, W13882), ***$K_{OC\ SPME\ free}$***	G	0.184	01-06	1	N/A	0.00419	7.60×10^{-5}	6.90×10^{-5}	5.59×10^{-5}	5.26×10^{-5}	324	305
15a OR nursery [Ornamentals], original batch run	G	0.096	01-06	1	N/A	0.399	0.00879	0.00531	0.0037	0.00361	931	909
15b OR nursery [Ornamentals], ***Standard K_{OC_LLE}***	G	0.096	01-06	1	N/A	0.399	0.00860	0.00514	0.00357	0.00348	901	879
15c OR nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	G	0.096	01-06	1	N/A	0.0433	3.87×10^{-4}	2.34×10^{-4}	1.65×10^{-4}	1.60×10^{-4}	957	928
16a NJ nursery [Ornamentals], original batch run	G	0.096	01-06	1	N/A	0.427	0.0155	0.0117	0.01	0.00954	2520	2400
16b NJ nursery [Ornamentals], ***Standard K_{OC_LLE}***	G	0.096	01-06	1	N/A	0.427	0.0151	0.0113	0.00974	0.00926	2459	2338
16c NJ nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	G	0.096	01-06	1	N/A	0.0478	7.25×10^{-4}	5.44×10^{-4}	4.73×10^{-4}	4.48×10^{-4}	2743	2598

G=ground

[1] EECs were generally rounded to three significant figures.

[2] Standard $K_{OC\ LLE}$ = 251,717 mL/g_{OC}; $K_{OC\ SPME\ free}$ = 5,810,619 mL/g_{OC}.

Water column and pore water EECs using the $K_{OC\ SPME\ free}$ were invariably lower than using the standard $K_{OC\ LLE}$. However, the sediment concentrations were similar using both the standard K_{OC_LLE} and $K_{OC\ SPME\ free}$, with minor differences. Based on a higher K_{OC} value (*i.e.*, the $K_{OC\ SPME\ free}$), the chemical is likely redistributed in the standard pond and more pyrethroid may move towards the sediment than to the water (*i.e.*, equilibrium is established based on the set K_{OC} value).

The following tables summarize the freshwater benthic invertebrates RQs, which in general, appear to be the most sensitive species to the pyrethroids. It is noted that the *acute* RQs are lower using the $K_{OC\ SPME\ free}$, due to the use of the same endpoint based on a water column acute test. However, the *chronic* RQs are similar. The reason is that the chronic pore water endpoints were recalculated, using the non-standard $K_{OC_SPME_free}$ value instead of the standard K_{OC_LLE}, as shown in the footnotes. The recalculated chronic pore water endpoint decreases with an increased $K_{OC_SPME_free}$ value.

Tables 127 and 128 summarize the freshwater benthic invertebrates RQs, which in general, appear to be the most sensitive species to the pyrethroids. The *acute* RQs are lower using the $K_{OC_SPME_free}$, due to the use of the same endpoint based on a water column acute test; however, the risk conclusions are the same. ***In order to obtain applicable chronic RQs, the pore water endpoints were recalculated, based on the sediment endpoint and the corresponding K_{OC} (standard LLE or SPME free).*** For example, the pore water chronic endpoint for deltamethrin for the runs using the standard $K_{OC\ LLE}$ is 12 µg/kg$_{OC}$/449,000 L/kg$_{OC}$ = 0.000026 µg/L. Meanwhile, for the runs using the $K_{OC_SPME_free}$, the endpoint is 12 µg/kg$_{OC}$/3,661,709 L/kg$_{OC}$ = 3.19×10^{-6} µg/L. It turns out that ***the chronic RQs, calculated using the adjusted endpoints are similar using both K_{OC} values***.

Table 127. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Deltamethrin, Using an Alternative $K_{OC\ SPME\ free}$ value

Uses	App Rate (lb a.i./A) x No. of Apps	App Method +	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01a CA turf (MI met file, W14840), ***Standard K_{OC}***	0.13x1	G	2.11×10^{-4}	2.03×10^{-4}	95.0	91.4	**1.1**	**>7.8**		**>7.6**
01b CA turf (MI met file, W14840), ***$K_{OC\ SPME\ free}$***	0.13x1	G	2.60×10^{-5}	2.50×10^{-5}	94.9	91.2	*0.13*	**>7.8**		**>7.6**
02a FL turf (TN met file, W13882), ***Standard K_{OC}***	0.13x1	G	2.35×10^{-4}	2.25×10^{-4}	106	101	**1.2**	**>8.7**		**>8.4**
02b FL turf (TN met file, W13882), ***$K_{OC\ SPME\ free}$***	0.13x1	G	2.91×10^{-5}	2.80×10^{-5}	106	102	*0.14*	**>8.8**		**>8.5**
15a OR nursery [Ornamentals], ***Standard K_{OC}***	0.13x1	GR	9.98×10^{-5}	9.61×10^{-5}	44.9	43.2	**0.50**	**>3.7**		**>3.6**
15b OR nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	0.13x1	GR	1.23×10^{-5}	1.18×10^{-5}	44.9	43.1	*0.06*	**>3.7**		**>3.6**
16a NJ nursery [Ornamentals], ***Standard K_{OC}***	0.13x1	GR	0.00172	0.00163	774	734	**8.6**	**>63**		**>61**
16b NJ nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	0.13x1	GR	2.16×10^{-4}	2.05×10^{-4}	788	748	**1.1**	**>64**		**>62**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

Standard K_{OC} = 449,000 mL/g$_{OC}$; $K_{OC\ SPME\ free}$ = 3,661,709 mL/g$_{OC}$.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Using ***standard K_{OC}*** values, the acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000026 ppb [estimated for *Hyalella azteca* <0.000026 ppb]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg_{OC} [for *Hyalella azteca* <12 µg/kg_{OC}].

Using ***$K_{OC\ SPME\ free}$***, the acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00000319 ppb = 3.19×10^{-6} ppb [estimated for *Hyalella azteca* <0.00000319 ppb]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg_{OC} [for *Hyalella azteca* <12 µg/kg_{OC}].

Table 128. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Esfenvalerate, Using an Alternative $K_{OC\ SPME\ free}$ value

Uses	App Rate (lb a.i./A) x No. of Apps	App Method +	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg_{oc})	21-day EEC (µg/kg_{oc})	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
01a CA turf (MI met file, W14840), ***Standard K_{OC}***	0.184x1	G	7.2×10^{-4}	7.25×10^{-4}	182	183	**0.85**	**1.0**		**1.04**
01b CA turf (MI met file, W14840), ***$K_{OC\ SPME\ free}$***	0.184x1	G	3.17×10^{-5}	3.19×10^{-5}	184	185	0.04	**1.1**		**1.05**
02a FL turf (TN met file, W13882), ***Standard K_{OC}***	0.184x1	G	0.00119	0.00112	300	283	**1.40**	**1.6**		**1.61**
02b FL turf (TN met file, W13882), ***$K_{OC\ SPME\ free}$***	0.184x1	G	5.59×10^{-5}	5.26×10^{-5}	324	305	*0.07*	**1.7**		**1.73**
15a OR nursery [Ornamentals], ***Standard K_{OC}***	0.096x1	G	0.0037	0.00361	931	909	**4.4**	**5.2**		**5.16**
15b OR nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	0.096x1	G	1.65×10^{-4}	1.60×10^{-4}	957	928	*0.19*	**5.3**		**5.27**
16a NJ nursery [Ornamentals], ***Standard K_{OC}***	0.096x1	G	0.01	0.00954	2520	2400	**12**	**14**		**13.6**
16b NJ nursery [Ornamentals], ***$K_{OC\ SPME\ free}$***	0.096x1	G	4.73×10^{-4}	4.48×10^{-4}	2743	2598	**0.56**	**15**		**14.8**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground.

Standard K_{OC} = 251,717 mL/g_{OC}; $K_{OC\ SPME\ free}$ = 5,810,619 mL/g_{OC}.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Using ***standard K_{OC}*** values, the acute pore water RQ = use-specific pore water peak EEC / 0.000848 [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00070 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 176 µg/kg_{OC} [for amphipod, *Hyalella azteca*].

Using ***$K_{OC\ SPME\ free}$***, the acute pore water RQ = use-specific pore water peak EEC / 0.000848 [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0000303 ppb = 3.03×10^{-5} ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 176 µg/kg_{OC} [for amphipod, *Hyalella azteca*].

7.2.5 Use of K_d instead of K_{OC} in the PWC

Four of the chemicals in this assessment were modeled using the K_d instead of the K_{OC} as the representative input for the mobility of the compounds: permethrin, pyrethrins, bifenthrin and *lambda*-cyhalothrin. The reason is that, per the current input parameter guidance, one or the other is selected according to the coefficient of variation (CV) for each parameter. For example, for bifenthrin, the CV for K_d is 22%, while for K_{OC} it is 84%. This implies that the K_d model is better to represent the mobility than the K_{OC} model for this compound. EFED further investigated this parameter. As another line of evidence, a plot of the percent organic carbon content *vs.* K_d might show whether the K_d is correlated with organic carbon. For bifenthrin, the plot is presented in **Figure 15**. The correlation coefficient was 0.0342, and the p-value was 0.726, indicating a low correlation between K_d and percent organic carbon. However, the range in organic carbon was *relatively* narrow (about 0.5-4%).

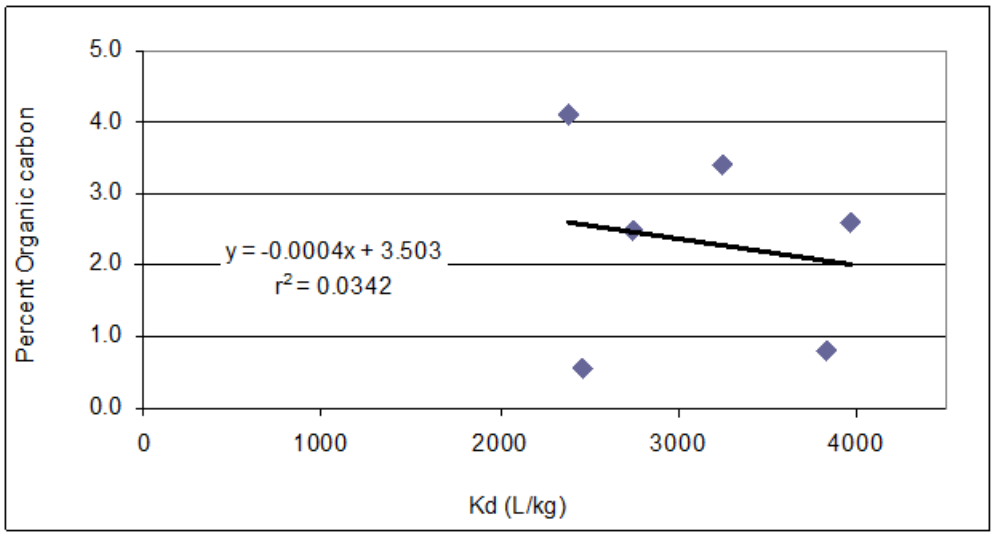


Figure 15. Plot of Percent Organic Carbon vs. K_d for Bifenthrin

For another example chemical, permethrin, two studies were available (MRIDs 45170102 & 49624901), one of which was recently submitted, and a previous supplemental study that used four soils of the same texture (a third study had been deemed unacceptable and was not used in this comparison). A comparison of the coefficients of variation is presented in **Table 127**.

Table 129. Coefficients of variation for K_d and K_{OC} for two permethrin batch equilibrium studies

Parameter	45170102 & 49624901 Combined	49624901 New Study Only
K_d	68 %	67 %
K_{OC}	75 %	86 %

The coefficient of variation are lower for K_d in both cases (*i.e.*, taking two studies combined or only the newly submitted study). For the new study, the range in percent organic carbon was wider than for bifenthrin (about 0.5 to 7%), plus the range of K_ds was relatively wide in relative terms as well (from <1000 to about 7500). In the plot of percent organic carbon *vs.* K_d, the

coefficient of correlation was low at 0.0137, and the p-value was 0.8511, indicating low correlation of K_d with organic carbon content (**Figure 16**).

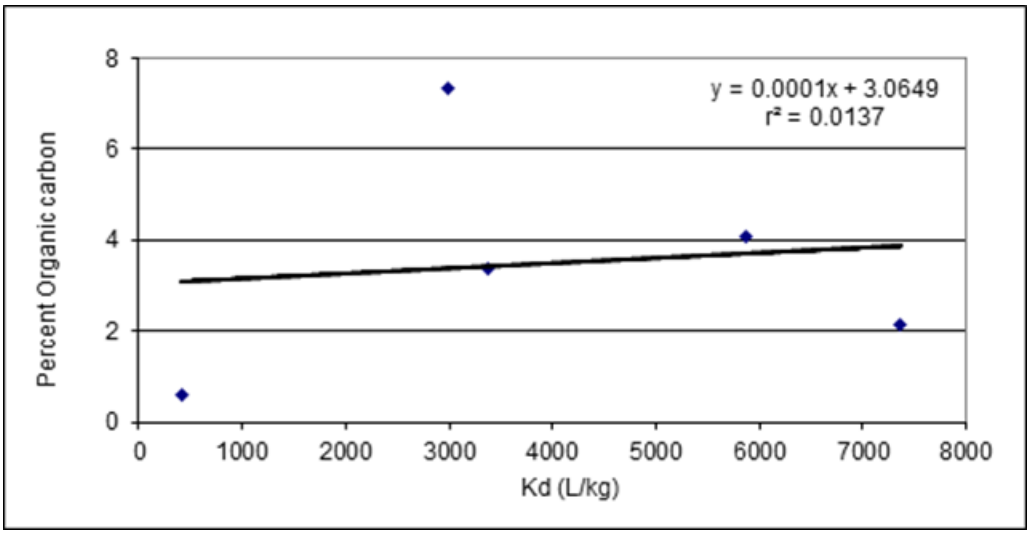


Figure 16. Plot of Percent Organic Carbon *vs.* K_d for Permethrin's New Study

Based on these example chemicals (bifenthrin and permethrin), it appears that the K_d model is more suitable for modelling these two pyrethroids than the K_{OC} model. However, to calculate the pore water concentrations associated with each endpoint in the sediment toxicity studies, the K_{OC} was used as it has been the use and practice in EFED and widely in the open literature.

7.2.6 Alternative Exposure Model (CDPR's SWPP Model)

The California Department of Pesticides Regulation (CDPR) has developed their own conceptual model for the non-agricultural urban uses of pesticides and incorporated it into the shell named Surface Water Protention Program (SWPP). It is customized to a California-specific situation. This model, which is based on PRZM/EXAMS, is briefly discussed in this section and compared with EPA's conceptual model using the PWC. Discussion in this section, is based in part on the CDPR report.

- According to the report, EFED's national based conceptual model may not be suitable to represent urban areas in California. A possible reason why EPA's estimates are low may be that the residential lot scenario, does not represent California-specific pesticide use and transport.
- In California, according to the report, urban areas are associated with smaller lots, higher impervious surfaces (in particular, impervious areas next to buildings), and more highly compacted soil.
- Further, the EPA model does not consider other processes, such as dry weather runoff from impervious surfaces, which is a major component of urban runoff in the California southwest region. It is also stated that averaging the EECs from the pervious and impervious surfaces may not represent appropriately the watershed EECs.

According to the report, the SWPP model tries to address the above concerns. There are four

areas in CDPR's model, according to the amount of water they receive and potential for runoff:

- Areas subject to dry weather runoff: includes pervious and impervious surfaces; and
- Areas not subject to dry weather runoff: includes pervious and impervious surfaces.

Areas not subject to dry weather runoff receive only precipitation, while the areas subject to dry weather runoff receive precipitation plus scheduled irrigation. Only a portion of each area is treated, as shown in the **Figure 17**. An example of a pervious area subject to dry weather runoff could be lawn, while an example of an impervious area subject to dry weather runoff is paved area adjacent to lawn.

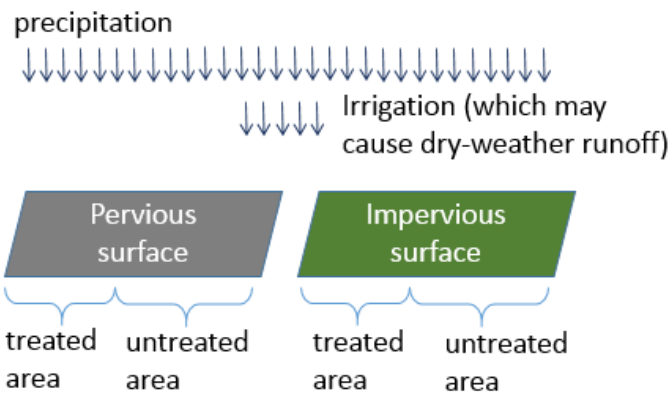


Figure 17. Conceptual Model Showing the Water Sources for Runoff and Urban Surfaces Used in CDPR's SWPP Model (Source: CDPR Report)

EPA used three types of surfaces, none is subject to dry weather runoff, meaning that the field is subject only to precipitation, although sprinkler irrigation occurs to residential scenario when the soil moisture is lower than 50% of soil capacity at a rate of 0.1 cm/hr. There are two types of pervious surfaces: Residential and ROW; plus the Impervious surface.

The conceptual model developed by CDPR has twelve lots per acre and ~202 lots in 10 hectare watershed. The footprint is 1500 ft^2 and 83% of the surface is impervious. In contrast, EPA's conceptual model has a lower house density (4 lots per acre) or ~58 lots in 10 hectares. The footprint is 1000 ft^2 and 50% of the surface is impervious. According to the CDPR report, the residential scenario is modified to reflect a more compacted soil and automatic irrigation is disabled. The new scenario is named "SWPP lawn". In EPA's model, separate runs for impervious, ROW, and residential are performed and daily output files are post-processed by means of a spreadsheet, while in CDPR's model, "PRZM is conducted for each modeled surface, and combined results for the watershed are routed into the EXAMS simulation" (Table 1 of CDPR report). It is also apparent that in the CDPR model, treatment on impervious surfaces located adjacent to impervious horizontal surfaces may be performed (*e.g.*, a wall adjacent to an impervious sidewalk may be treated). In contrast, EFED's conceptual model assumes that the area that surrounds the dwelling is right-of-way (ROW), and as a consequence, the chemical leaching from the wall surface will reach the ROW surface.

Tables 131 and 132 show the results of EPA's conceptual model for the California-specific scenario and the SWPP results, for the example chemicals deltamethrin and esfenvalerate. Row

(1) in each table gives the results for each pyrethroid, using the California Residential, ROW and Impervious scenario and the EPA's conceptual model used in this assessment. They were found to be lower than the SWPP results (*i.e.*, rows ***(3)*** and ***(4)*** in each table)[10]. After conversations with CDPR (Dr. Yuzhuo Luo), two main factors appeared to be affecting the results: 1) EFED used a chemical application method (CAM) of 2 (meaning linear foliar based on crop canopy, or above crop), with no incorporation, while CDPR used CAM = 4 (meaning soil applied, user defined incorporation depth, uniform with depth), with a depth of incorporation (DEPI) of 0.1 cm; and 2) it was apparent that the amount of impervious surface treated in CDPR's model was higher.

Regarding the CAM = 4, EFED confirmed with Dr. Dirk Young, EFED PWC model developer, that this CAM, suggested by the scenario metadata file was appropriate for impervious surfaces. For that reason, all residential and commercial runs, along with the associated RQs were recalculated with a CAM = 4. A DEPI = 0.1 cm, which is the minimum allowed by the model, is considered an acceptable depth for impervious surfaces.

Secondly, besides the results in row ***(1)***, EFED calculated another set of results as shown in row ***(2)*** in each table. This additional set involved applications of the two example pyrethroids with treatment to walls adjacent to impervious floors instead of adjacent to pervious rights-of-way surface. As a result, in the new runs, the impervious surface percent is higher, **Table 130**. As shown in the table, the *peak* results for both chemicals were similar to the SWPP outdoor residential treatment results in row ***(4)*** of each table. It is apparent that the CDPR conceptual model has a higher amount of impervious treated surface than the EPA conceptual model and that the results can be harmonized by using treated impervious surfaces over impervious floors in the EPA conceptual model.

Table 130. Comparison of adjusted percent area treated of the watershed for each of available scenarios, for the Residential lots, assuming 58 quarter acre lots in the 10-ha watershed, using EPA's conceptual model, and with modification to allow treatment to walls adjacent to impervious floors

ID \ PRZM Scenario	Residential	Rights-of-Way	Impervious
(1) Adjusted Percent Area Treated Assuming 58 Lots in the Watershed (Residential lots, *EPA's conceptual model*)	6.45%	18.6%	0.00674%
(2) Adjusted Percent Area Treated Assuming 58 Lots in the Watershed (Residential lots, *EPA's conceptual model with adjustment for treatment to walls adjacent to impervious floors*)	6.45%	8.67%	1.81%

[10] SWPP example results were kindly calculated and provided, using EFED-supplied set of fate input parameters, by Dr. Yuzhuo Luo, of CDPR.

Table 131. Comparison of Water Column and Pore Water EECs for Deltamethrin, Using the EPA Conceptual Model and the PWC, against CDPR's SWPP Model[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
EPA Results												
***(1)* CA residential, ROW, impervious** (Residential lots, *EPA's conceptual moded*)	Ground	0.21	01-06	1	N/A	0.00119	2.07×10^{-5}	1.40×10^{-5}	1.19×10^{-5}	1.16×10^{-5}	5.34	5.21
***(2)* CA residential, ROW, impervious** (Residential lots, *with treatment to walls adjacent to impervious floors*)	Ground	0.21	01-06	1	N/A	0.200* (0.265)	0.00345	0.00177	9.90×10^{-4}	9.60×10^{-4}	NC	NC
CDPR Results												
***(3)* Residential Lawn** treatment (*with overspray to impervious surface*)	Ground	0.21	01-06	1	N/A	0.0795	0.00141	7.53×10^{-4}	4.71×10^{-4}	4.58×10^{-4}	NC	NC
***(4)* Outdoor residential treatment** (*2-ft on wall; 1-in (pin stream) on garage door; and spot, crack-and-crevice, or pin stream on horizontal impervious surfaces*)	Ground	0.21	01-06	1	N/A	0.200* (0.295)	0.00736	0.00398	0.00242	0.00235	NC	NC

NC = Not calculated.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

Table 132. Comparison of Water Column and Pore Water EECs for Esfenvalerate, Using the EPA Conceptual Model and the PWC, against CDPR's SWPP Model[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
EPA Results												
***(1)* CA residential, ROW, impervious** (Residential lots, *EPA's conceptual moded*)	Ground	0.184	01-06	1	N/A	0.00661	3.61×10^{-4}	2.56×10^{-4}	1.92×10^{-4}	1.87×10^{-4}	48.3	47.0
***(2)* CA residential, ROW, impervious** (Residential lots, *with treatment to walls adjacent to impervious floors*)	Ground	0.184	01-06	1	N/A	0.336	0.00641	0.00343	0.00202	0.00196	NC	NC
CDPR Results												
***(3)* Residential Lawn** treatment (*with overspray to impervious surface*)	Ground	0.184	01-06	1	N/A	0.0904	0.00219	0.00115	7.35×10^{-4}	7.18×10^{-4}	NC	NC
***(4)* Outdoor residential treatment** (*2-ft on wall; 1-in (pin stream) on garage door; and spot, crack-and-crevice, or pin stream on horizontal impervious surfaces*)	Ground	0.184	01-06	1	N/A	0.337	0.0117	0.00628	0.00387	0.00375	NC	NC

NC = Not Calculated.

[1] EECs were rounded to three significant figures.

7.2.7 EPA's Experimental PWC v.1.53, Incorporating Calculated PRBEN

PWG has provided comments on the PRBEN function of the PWC, which represents the initial distribution of eroded phase pesticide between the sediment (benthic zone) and the water column. The PWG had argued that setting a value of 0.5 for all chemicals was not appropriate, especially for the pyrethroids, which have high K_{OC} values and are transported preferentially by soil erosion rather than by runoff. In such cases, the PWG reasoned that the pyrethroids would be quickly transported to the benthic zone in proportions greater than suggested by the default PRBEN value of 0.5 and acute water column concentrations should be lower. Following up on these PWG concerns, EFED issued an experimental version of the PWC (v. 1.53, dated 03/17/2016). This version of the model incorporates an alternative to the fixed PRBEN function. For this new version, during a runoff-erosion event, incoming pesticide (whether entering by runoff, erosion, or drift) equilibrates instantaneously with the water column which includes any eroded solids that may have entered during the event. After equilibrations calculations are performed, any pesticide that remains sorbed to the suspended solids is distributed to the benthic zone instantaneously and does not contribute to peak water column concentrations. Any pesticide that remains in the aqueous phase remains in the water column and does contribute to peak concentrations. This conceptualization is more in line with the equilibrium concept upon which the PWC components are built, is not overly mechanistic nor overly parameterized like sedimentation models, and was endorsed by the Scientific Advisory Panel (SAP) in 2008.

EFED selected a number of scenarios for two chemicals (deltamethrin and esfenvalerate) and both turf scenarios, and both nursery scenarios were run both ways (set PRBEN or calculated PRBEN). When comparing the EECs using the current default PRBEN, it was found that the results were consistent with those previously reported, using the official version 1.50, as expected. Additionally, comparing the sediment and pore water EECs, they were the same for the default PRBEN vs. the alternative calculation of PRBEN for deltamethrin.

Table 133. Comparison of Water Column, Pore Water, and Sediment EECs for Deltamethrin, for Runs Using PRBEN = 0.5 and the PWC against Variable/ Calculated PRBEN and the Experimental PWC v.1.53[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
01a CA turf (MI met file, W14840), ***PRBEN = 0.5***	G	0.13	01-06	1	N/A	0.0251	4.25×10^{-4}	2.53×10^{-4}	2.11×10^{-4}	2.03×10^{-4}	95.0	91.4
01b CA turf (MI met file, W14840), ***variable PRBEN***	G	0.13	01-06	1	N/A	0.0251	4.38×10^{-4}	2.66×10^{-4}	2.11×10^{-4}	2.03×10^{-4}	95.0	91.4
02a FL turf (TN met file, W13882), ***PRBEN = 0.5***	G	0.13	01-06	1	N/A	0.0251	4.57×10^{-4}	2.79×10^{-4}	2.35×10^{-4}	2.25×10^{-4}	106	101
02b FL turf (TN met file, W13882), ***variable PRBEN***	G	0.13	01-06	1	N/A	0.0251	4.57×10^{-4}	2.79×10^{-4}	2.35×10^{-4}	2.25×10^{-4}	106	101
15a OR nursery [Ornamentals], ***PRBEN = 0.5***	GR	0.13	01-06	1	N/A	0.00311	1.30×10^{-4}	1.13×10^{-4}	9.98×10^{-5}	9.61×10^{-5}	44.9	43.2
15b OR nursery [Ornamentals], ***variable PRBEN***	GR	0.13	01-06	1	N/A	0.00429	1.42×10^{-4}	1.24×10^{-4}	9.98×10^{-5}	9.61×10^{-5}	44.9	43.2
16a NJ nursery [Ornamentals], ***PRBEN = 0.5***	GR	0.13	01-06	1	N/A	0.121	0.00292	0.00205	0.00172	0.00163	774	734
16b NJ nursery [Ornamentals], ***variable PRBEN***	GR	0.13	01-06	1	N/A	0.0234	0.00186	0.00166	0.00172	0.00163	774	734

G=ground; GR=granular

[1] EECs were generally rounded to three significant figures.

Table 134. Comparison of Water Column, Pore Water, and Sediment EECs for Esfenvalerate, for Runs Using PRBEN = 0.5 and the PWC against Variable/ Calculated PRBEN and the Experimental PWC v.1.53[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
01a CA turf (MI met file, W14840), original batch run	G	0.184	01-06	1	N/A	0.0411	0.00111	7.62×10^{-4}	7.2×10^{-4}	7.25×10^{-4}	182	183
01b CA turf (MI met file, W14840), ***PRBEN = 0.5***	G	0.184	01-06	1	N/A	0.0410	0.00108	7.18×10^{-4}	6.83×10^{-4}	6.88×10^{-4}	172	174
01c CA turf (MI met file, W14840), ***variable PRBEN***	G	0.184	01-06	1	N/A	0.0610	0.00141	8.24×10^{-4}	6.80×10^{-4}	6.85×10^{-4}	172	173
02a FL turf (TN met file, W13882), original batch run	G	0.184	01-06	1	N/A	0.0355	0.00159	0.00148	0.00119	0.00112	300	283
02b FL turf (TN met file, W13882), ***PRBEN = 0.5***	G	0.184	01-06	1	N/A	0.0355	0.00155	0.00146	0.00117	0.00110	295	278
02c FL turf (TN met file, W13882), ***variable PRBEN***	G	0.184	01-06	1	N/A	0.0517	0.00157	0.00159	0.00117	0.00110	295	278
15a OR nursery [Ornamentals], original batch run	G	0.096	01-06	1	N/A	0.399	0.00879	0.00531	0.0037	0.00361	931	909
15b OR nursery [Ornamentals], ***PRBEN = 0.5***	G	0.096	01-06	1	N/A	0.399	0.00860	0.00514	0.00357	0.00348	901	879
15c OR nursery [Ornamentals], ***variable PRBEN***	G	0.096	01-06	1	N/A	0.400	0.00867	0.00520	0.00357	0.00348	901	879
16a NJ nursery [Ornamentals], original batch run	G	0.096	01-06	1	N/A	0.427	0.0155	0.0117	0.01	0.00954	2520	2400
16b NJ nursery [Ornamentals], ***PRBEN = 0.5***	G	0.096	01-06	1	N/A	0.427	0.0151	0.0113	0.00974	0.00926	2459	2338
16c NJ nursery [Ornamentals], ***variable PRBEN***	G	0.096	01-06	1	N/A	0.401	0.0128	0.00996	0.00980	0.00930	2475	2348

G=ground

[1] EECs were generally rounded to three significant figures.

For deltamethrin and esfenvalerate, results were mixed. For deltamethrin, the pore water and sediment EECs were essentially the same in all instances. The water column EECs were higher using the variable PRBEN function in two cases (CA turf with MI weather and OR nursery), lower in one case (NJ nursery), and the same in the other (FL turf with PA weather). For esfenvalerate, the water column EECs were higher using the variable PRBEN function in three out of four cases (CA turf with MI weather, FL turf with PA weather, and OR nursery), and lower in another case (NJ nursery).

Consultation with the model developer (Dr. Dirk Young) provided the additional insight that these results are reasonable. For these scenarios, the actual eroded material (*i.e.*, soil) appears to be low so that it does not radically affect the suspended solids concentration. In these instances, the actual effective (calculated) PRBEN may actually be lower than the standard default value of 0.5. Hence the concentrations are higher for those scenarios with low amounts of eroded material (*i.e.*, turf, nursery, and probably residential). Additionally, spray drift is a significant contributor to the EEC values and inputs from spray drift occur independently of erosion events and thus will tend to temper differences in the results of the two PRBEN methods.

Since the new PRBEN function appears to be scenario dependent, EFED decided that in the **Part III** of the Pyrethroids and Pyrethrins PRA (Agricultural Use Patterns), this exercise will be repeated, in order to find out whether for the agricultural scenarios, which are likely more prone to soil erosion, there is a substantial difference in the modelling results.

7.2.8 Uncertainties

7.2.8.1 Environmental Fate Database and Uncertainties

For the eight pyrethroids evaluated in this assessment, the environmental fate database was complete or nearly complete. These pyrethroids have been the subject of intense scrutiny over the past several years, and the Pyrethroid Working Group (PWG) has developed many studies to satisfy the Agency's and the California Department of Pesticide Regulation's (CDPR) requirements. For the pyrethrins, the absence of multiple anaerobic aquatic metabolism studies caused the use of a 3x uncertainty factor, which may have caused an overestimation of the EECs, and consequently, the RQs. Similarly, for cypermethrin, there was only one aerobic soil, anaerobic aquatic and anaerobic aquatic metabolism values and an uncertainty factor was used.

7.2.8.2 Exposure Issues

Meteorological data and scenario profiles, as well as best professional judgment, were used to establish an application date for modeling; however, the selected date may not represent the intended or actual application dates. The application date used for model runs can significantly alter the EECs; thus, EECs reported could over or under predict actual exposure. The dates of application used in this risk assessment were selected for the

majority of the runs to be June 1st, since applications during the summer months appear more likely than in the winter. It is unclear how much this application date differs from the typical timing of application, which is based on pest pressure.

According to the labels, all pyrethroids share a common mode of action, to which target pests can develop resistance if the chemicals are applied consecutively or repeatedly in the same field and/or in consecutive years with other chemicals belonging to the same group of insecticides. For that reason, it is recommended to avoid consecutive use of the pyrethroid insecticides and to base pyrethroid's use on a comprehensive Integrated Pest Management program. For fenpropathrin multiple applications were modeled. Thus, even though the initial EECs for fenpropathrin were based on maximum application rates and minimum intervals between applications, it appears unlikely that users will apply this chemical under these circumstances (up to 24 times per year), and on a yearly basis for 30 consecutive years, as assumed in the modeling performed in this preliminary ecological risk assessment. The frequency at which actual uses approach this maximum use scenario may be dependent on pest resistance, timing of applications, cultural practices, and market forces.

For fenpropathrin, it was found that the EECs increased with the number of applications per year (this is expected). In this assessment, for all chemicals except fenpropathrin, the modelling assumed a single application per year. This allowed the comparison across chemicals; however, the results may not be conservative. For many of the pyrethroids the maximum number of urban applications per year is high, or not specified. As indicated earlier, however, the typical service interval in California and in multiple regions across the U.S. is monthly or every other month (CA) and around four applications per year (U.S.) (**Tables 12 and 13**). It should be pointed out that it is highly unlikely that all 58 lots in a 10 hectare watershed, and all the types of surfaces, be treated once on the same day of the year and at the maximum application rate. Further, according to the use surveys from PWG, the likelihood of a consumer use of a lawn care operator (LCO) services is only 14% and pest control operator is 26%. Therefore, the higher rates applied by LCOs and PCOs would not be used in 100% of the lots in a watershed.

Issues with unextracted radioactivity were identified in a number of the laboratory-based metabolism studies. Although these levels were not considered for all the pyrethroids, and to help clear this uncertainty, modelling of total toxic residues comprising parent plus unextracted radioactivity was performed for fenpropathrin. It was found that the overall risk picture for fenpropathrin, when compared to fenpropathrin plus the unextracted residues were very similar, which indicated that additional modelling with the unextracted residues would not change the risk assessment results substantially.

In this assessment a limited number of runs was performed to represent regions across the U.S. as follows:

- Turf (Michigan and Tennessee weather files)
- Residential lots (California, Texas and Pennsylvania weather files)
- Commercial lots (Florida weather file)
- Nursery (Oregon and New Jersey weather files)

The weather files uses are the same ones from the standard nursery scenarios, except for the California and Texas residential lots (which used the native weather file for each of the scenarios). Additionally, for fenpropathrin all the nursery scenarios were run to represent the uses on ornamentals in a variety of scenarios. When a comparison of the results was conducted, it was found that running several scenarios across the U.S. did not change the overall risk picture from nursery scenarios for fenpropathrin, when comparing runs with the same number of applications per year. Note that the EECs were not the same, but they were similar enough to indicate that the results of two representative scenarios were appropriate.

A washoff/runoff from impervious surfaces study (MRID 48072902) indicated high variability in the potential levels of washoff, which ranged from <0.01 to 16.8% of the applied, depending on the impervious surface involved, and the formulation. The degree of washoff from the Impervious scenario should approach this range in order to be representative of the actual use conditions, although the range is very wide. Additionally, runoff losses from turfgrass were also variable in a study conducted with two pyrethroids (MRID 47647801), in a range of 0.052 to 0.58% of the applied in irrigated crops (*i.e.*, irrigation producing excess runoff). They depend on the specific chemical involved, and the formulation (granular or liquid). Similarly, runoff from the Residential scenario should be within this range in order to be representative of actual use conditions.

7.2.8.3 Use Information

For certain pyrethroids, such as permethrin, and for pyrethrins, EFED did not have Use Summary Tables (USTs) provided by the registrant(s). For permethrin, the latest LUIS report, issued by the Biological and Economic Analysis Division (BEAD) was used, plus the RED table. For the pyrethrins, the Table A from the RED, which summarizes all the uses of the chemical (agricultural and non-agricultural) was relied upon. Uncertainties may arise as a result of the use of these reports. The USTs are tables provided by the registrant that summarize the uses, maximum application rates, minimum interval between applications, and maximum number of applications that the registrant is willing to support. These tables were revised by BEAD prior to use by EFED.

7.2.8.4 Conceptual Model for the Residential and Commercial Lots

The conceptual models used in this assessment are uncertain. They rely on a number of assumptions regarding the typical lot size (one quarter acre, or 10,890 ft^2), number of lots in the watershed (58 lots), size of the residence or commercial facility (1000 ft^2), the areas to be treated in the quarter acre lots, *etc.* For the residential conceptual model, the house lot size is likely a good surrogate value on a national basis; however, to the degree that the house density is higher or lower in different parts of the country, the EECs will also be higher or lower than the ones calculated.

The CDPR has constructed their own conceptual models for the residential and commercial uses of pesticides. They were based initially on previous endangered species

assessments conducted by OPP, and they were adapted to California-specific circumstances. For example, in their residential model there are 12 dwelling units per acre (3630 ft^2), instead of 4; futhermore, the size of the footprint used by CDPR is 1500 ft^2, instead of 1000 ft^2. There are 201 lots in a 10-ha watershed in the CDPR model, compared to 58 in the conceptual model used in this assessment. In addition, the commercial conceptual model used by CDPR is substantially different than the one used in this assessment. The commercial unit is larger than 10x the 1000 ft^2 utilized in this assessment, and 9 units per 10-ha watershed instead of 58 used in this assessment.

Uncertainties associated with each of these individual components add to the overall uncertainty of the modeled concentrations.

7.2.8.5 Ecological Effects Database and Uncertainties

Although the aquatic toxicity dataset was fairly robust for this group of chemicals, some data gaps were present. For bifenthrin, chronic fish toxicity data were not available and so an estimated endpoint was used in risk calculations. For bifenthrin, cypermethrin, permethrin and pyrethrins, some or all of the vascular and non-vascular aquatic plant toxicity data were missing. This is an uncertainty and risk could not be estimated nor precluded. Based on the RQs calculated for the remaining pyrethroids, it appears that aquatic plants are not susceptible to pyrethroid exposure and that risk is low.

Several of the toxicity studies also had non-definitive endpoints. For esfenvalerate, the estuarine/marine fish acute endpoint was a non-definitive, greater than (>), value due to low toxicity. For cyfluthrin, *lambda*-cyhalothrin, deltamethrin, esfenvalerate and fenpropathrin, many of the vascular and non-vascular aquatic plant endpoints were also non-definitive, greater-than (>), values. However, in all cases, information was sufficient to bound the risk estimate resulting in clear evidence that the RQs were below LOCs. Therefore, data were sufficient for risk estimations.

For freshwater and estuarine/marine fish, the acute endpoints exceed the limit of solubility of some of the pyrethroids. This is the case for bifenthrin (both freshwater and estuarine/marine fish acute endpoints), cyfluthrin (estuarine/marine fish), deltamethrin (both freshwater and estuarine/marine fish), and esfenvalerate (estuarine/marine fish). Endpoints derived at above the limit of solubility may be uncertain.

Since sediment toxicity is heavily dependent on the amount and type of organic matter present to bind the pyrethrins/pyrethroids, the actual bioavailability in the environment can vary widely. As a result, conservative assumptions are used leaving some uncertainty as to real world effects.

An additional uncertainty is the unknown potential for synergists, such as piperonyl butoxide (PBO) that is co-applied (*i.e.*, tank mixed or co-formulated). Although information is available to estimate potential toxicity enhancement, the actual amount or ratio of synergist to insecticide that is applied can vary.

In summary, the toxicity data gaps and resulting uncertainties affecting the risk conclusions were:

- chronic risk to fish from bifenthrin use due to missing toxicity data, although the approach taken appears to be conservative;
- risk to aquatic plants from bifenthrin, cypermethrin, permethrin and pyrethrins use due to missing toxicity data;
- toxicity to sediment-dwelling organisms due to variability of organic content in natural sediments;
- potential for toxicity enhancement from synergists due to range of co-applied synergist amount and ratio; and,
- endpoints derived at above the limit of solubility, which is typically very low for all the pyrethroids.

Acclimation/Adaptation

The risk characterization for aquatic organisms is based on standard toxicity studies using laboratory-reared cultures. Recently, two studies have been published which document much greater tolerance of field-collected freshwater amphipods (*Hyalella azteca*) from urban and agriculturally-impacted streams in California with a known history of pyrethroid contamination (Weston *et al.*, 2013; Clark *et al.*, 2015). Compared to laboratory populations, Weston *et al.* report that field-collected *H. azteca* from urban impacted sites were up to 550 times less sensitive on an acute exposure basis to two common pyrethroids (cyfluthrin, bifenthrin). Using multiple lines of evidence, Weston *et al.* report that the resistant populations of field-collected *H. azteca* originate from genetically-distinct clads[11] and that the increased tolerance to pyrethroids likely pertains to genetic mutations associated with voltage-gated sodium channel membrane proteins, which are the target receptors of pyrethroid insecticides. Similarly, Clark *et al.* report field collected aquatic *H. azteca* to be less sensitive on an acute exposure basis to bifenthrin and cypermethrin by up to two orders of magnitude. Interestingly, Clark *et al.* report a substantial reduction in pyrethroid resistance of field collected *H. azteca* when reared in the laboratory over three generations, although the F3 generation populations were still about an order of magnitude less sensitive compared to populations that originated in the laboratory. These authors also report a strong seasonal variation in sensitivity of field-collected amphipods to these pyrethroids, which may be related to temporal variation in pyrethroid exposure history and subsequent activation of compensatory mechanisms associated with pesticide resistance (*e.g.*, enzyme activation).

Considering the well-documented occurrence of insect resistance to pyrethroids and other insecticides, these examples of pyrethroid resistance with aquatic arthropods are not surprising. However, they do have implications for this ecological risk assessment, particularly since *H. azteca* is consistently among the most sensitive aquatic invertebrate species to pyrethroids. One implication is that acute risks to pyrethroid-impacted populations of aquatic invertebrates may be much lower (by up to two orders of magnitude)

[11] *H. azteca* is currently considered a "species complex" consisting of multiple genetically distinct populations across geographic regions.

than predicted from this ecological risk assessment. However, it is important to caveat this interpretation because there is evidence that suggest *H. azteca* may experience periods of more or less tolerance depending on the prior history of pesticide exposure.

Another implication is that pyrethroids are already altering the genetic and/or epigenetic composition of aquatic crustaceans (amphipods), which could have deleterious consequences for overall organism and population fitness. For example, populations that become genetically tolerant to pyrethroids due to repeated exposures over generations may be genetically less diverse compared to less impacted populations. This loss of genetic diversity may have deleterious consequences when organisms are challenged by other anthropogenic or natural stressors, thereby compromising population health and fitness (*e.g.*, Reed and Frankham, 2003). Currently, the evolutionary consequence of genetic tolerance to chemical stressors is not well understood. Furthermore, there is uncertainty when extrapolating results from *H. azteca* to other species, which may have a lower or greater capacity for acclimating or adapting to pyrethroid perturbations.

7.2.8.6 Aquatic Modeling with the PWC

The standard ecological water body scenario (VVWM standard pond) used to calculate potential aquatic exposure to pesticides such as the pyrethroids is intended to represent conservative water concentration estimates, and to avoid underestimating most actual exposures. The standard scenario assumes pesticide application to a 10-hectare field bordering a 1-hectare, 2-meter deep (20,000 m^3) pond with no outlet. Exposure estimates generated using the VVWM pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and lower order streams. As a group, there are factors that may make such water bodies either more or less vulnerable than the VVWM pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher potential peak EECs than the VVWM pond. These water bodies may be either smaller in size or have larger drainage areas. Smaller water bodies have less dilution volume, may have less ability to store excess inflow, and thus may periodically overflow and export pesticide in the discharge; whereas, the VVWM pond has no discharge. As watershed size increases beyond 10-hectares, it presumably becomes increasingly less likely that the entire watershed is treated simultaneously with the pesticide. Headwater streams can also exhibit peak concentrations higher than those in the VVWM pond, but that persist for shorter periods of time as they are then carried and dissipated (advected) downstream.

In general, the linked PRZM/VVWM model (through the PWC GUI) produces EECs that are expected to be exceeded once within a ten-year period. PRZM is a process or "simulation" model that calculates runoff of a pesticide from a treated field on a daily temporal resolution, over a period of decades. It considers factors such as rainfall and plant transpiration of water, as well as how and when the pesticide is applied. It has two major components: hydrology and chemical transport. Water movement is simulated by the use of generalized soil parameters, including field capacity, wilting point, and saturation water content. The chemical transport component can simulate pesticide application on the soil

or on the plant foliage, if applicable. Dissolved, adsorbed, and vapor-phase concentrations in the soil are estimated by simultaneously considering the processes of pesticide uptake by plants when applicable, surface runoff, erosion, decay, volatilization, foliar wash-off, sorption and leaching.

Individual component uncertainties also add to the overall uncertainty of the modeled estimated environmental concentrations. Model inputs from the environmental fate degradation studies are chosen to reflect the upper 90 percent upper confidence limits on mean half-lives. Mobility input values (soil sorption coefficients) are chosen to represent average sorption in the environment. The natural variation in soils adds to the uncertainty of modeled values. Factors such as application date, crop emergence date (when applicable), and canopy cover can also affect estimated concentrations, adding to the uncertainty of modeled values. Factors within the ambient environment such as soil temperatures, sunlight intensity, antecedent soil moisture, and surface water temperatures can cause actual aquatic concentrations to differ for the modeled values.

7.2.8.7 Uncertainties Regarding Dilution and Chemical Transformations in Estuaries

The PWC-modeled EECs are intended to represent exposure of aquatic organisms in relatively small ponds, low-order streams, and other vulnerable water bodies. It is likely that EECs generated from the PWC model over-estimate (especially on an acute basis) potential concentrations in larger receiving water bodies including estuaries, embayments, and coastal marine areas because chemicals in runoff water (or spray drift, *etc.*) is diluted by larger volumes of water. In addition, as chemical constituents in water draining from freshwater streams encounter brackish or other near-marine-associated conditions, there is potential for new chemical transformations to occur. Many chemical compounds can undergo changes in mobility, toxicity, or persistence when changes in pH, E_h (redox potential), salinity, dissolved oxygen (DO) content, or temperature are encountered. For example, desorption and re-mobilization of some chemicals from sediments can occur with changes in salinity (Jordan *et al.*, 2008; Means, 1995; Swarzenski *et al.*, 2003), changes in pH (*e.g.*, Wood and Baptista 1993), E_h changes (Velde and Church, 1999; Wood and Baptista, 1993), and other factors. Thus, although chemicals in discharging rivers may be diluted by large volumes of water within receiving estuaries and embayments, the hydrochemistry of the marine-influenced water may negate some of the attenuating impact of the greater water volume; for example, the effect of dilution may be confounded by changes in chemical mobility (and/or bioavailability) in brackish water. In addition, freshwater contributions from discharging streams and rivers do not instantaneously mix with more saline water bodies. In estuarine settings, water is often vertically stratified, with fresh water lying atop denser, higher salinity water – meaning that exposure to concentrations found all in discharging stream water may propagate some distance beyond the point of the confluence with higher salinity water (especially near the water surface) without substantial dilution occurring. Therefore, it is not assumed that discharging water will be rapidly diluted by the entire water volume within an estuary, embayment, or other coastal aquatic environment. PWC model results should be considered consistent with concentrations that might be found near the head of an estuary unless there is specific

information – such as monitoring data – to indicate otherwise. Conditions nearer to the mouth of a bay or estuary, however, may be closer to a marine-type system, and thus more subject to the notable buffering, mixing, and diluting capacities of an open marine environment. Conversely, tidal effects (pressure waves) can propagate much further upstream than the actual estuarine water, so discharging river water may become temporarily partially impounded near the mouth (discharge point) of a channel, and resistant to mixing until tidal forces are reversed.

The Agency does not currently have sufficient information regarding the hydrology and hydrochemistry of estuarine aquatic habitats to develop alternate scenarios for assessed species that inhabit these types of ecosystems. The Agency acknowledges that there are unique brackish and estuarine habitats that may not be accurately captured by PWC modeling results, and may therefore, under- or over-estimate exposure, depending on the aforementioned variables.

8 Conclusions

For the non-agricultural uses of pyrethroids, the risk hypothesis of this part of the PRA stated that (**Section 3.5.1**):

> *Pyrethroids and Pyrethrins, when used outdoors in accordance with registered labels in urban environments, will likely lead to off-site movement of the compound via urban runoff, spray drift, and eroded soil, leading to exposure of nontarget aquatic animals and plants. Based on information on the environmental fate, mode of action, direct toxicity and potential indirect effects, EFED assumes that registered uses of pyrethroids and pyrethrins have the potential to cause reduced survival, growth, and reproduction to non-target aquatic animals, but not to non-target aquatic plants.*

Based on an analysis, this assessment concludes that the agricultural use patterns of synthetic pyrethroids and pyrethrins result in multiple exceedances of acute and chronic LOCs for freshwater and estuarine/marine fish, and especially for freshwater and estuarine/marine invertebrates, resulting in a potential reduction in survival, growth and reproduction to non-target aquatic animals. In general, the RQs for aquatic plants were below the LOCs and are considered at less risk. Generally the freshwater aquatic invertebrate RQs were higher than the estuarine/marine invertebrates RQs (an example of an exception is cyfluthrin). For freshwater invertebrates in the water column, the acute/chronic maximum RQs were 0.19/1.3 for pyrethrins, 28/280 for bifenthrin, 1000/318 for deltamethrin, 242/37 for permethrin, 848/502 for esfenvalerate, 7460/>2200 for cypermethrin, 15/67 for cyfluthrin, 3960/435 for *lambda*-cyhalothrin, and 3380/>1400 for fenpropathrin. Organisms that depend on aquatic invertebrates for food may indirectly be at risk as well. For the pyrethrins, the LOC exceedances were generally fewer than for any of the other chemicals. As additional line of evidence, RQs were calculated based on the maximum monitored sediment concentrations, and they also exceeded the chronic LOCs, suggesting potential for effects to non-target aquatic invertebrates.

As an additional line of evidence, a review of the OPP Incident Data System which now incorporates the Ecological Incident Information System (EIIS) database was conducted (refer to the **Attachment VI**). The IDS and EIIS databases contained 7 incidents for bifenthrin, 29 incidents for permethrin, 17 incidents for cypermethrin, 10 incidents for cyhalothrin (*lambda*- and *gamma*-), 11 incidents for esfenvalerate, 6 for cyfluthrin, 2 for deltamethrin, 2 for pyrethrins and only one for fenpropathrin (note that this is the total number of incidents, including those in agricultural and non-agricultural settings). The total for all pyrethroid actives searched was 84 aquatic incidents. Thirty-two of the reported incidents were determined to be from legally registered uses of the pesticides. The number of reports listed in the EIIS database is believed to be only a small fraction of the total incidents involving non-target organism mortality and damage caused by pesticides. These incidents appear to confirm the findings of the PRA.

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Appendix A. Risk Quotient Method

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of this integration is called the quotient method. Risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are used by OPP to analyze potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) acute risks - regulatory action may be warranted in addition to restricted use classification, (2) acute restricted use - the potential for acute risk is high, but may be mitigated through restricted use classification, (3) acute endangered species - endangered species may be adversely affected, and (4) chronic risk - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, or chronic risk from granular/bait formulations to birds or mammals.

The ecotoxicity test values (measurement endpoints) used in the acute and chronic risk quotients are derived from required studies. Examples of ecotoxicity values derived from short-term laboratory studies that assess acute effects are: (1) LC_{50} (fish and birds), (2) LD_{50} (birds and mammals), (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOAEL or LOAEC (birds, fish, and aquatic invertebrates) and (2) NOAEL or NOAEC (birds, fish and aquatic invertebrates). For birds, mammals, fish and aquatic invertebrates the NOAEL or NOAEC generally is used as the ecotoxicity test value in assessing chronic effects, although other values may be used when justified. Risk presumptions and the corresponding RQs and LOCs, are tabulated below.

Table A-1. Summary of the levels of concern used for the risk quotient method.

Risk Presumption	RQ	LOC
Birds and mammals		
Acute Risk	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.5
Acute Restricted Use	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50} (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.1
Chronic Risk	Diet or dose-based EEC/NOAEC	1
Aquatic Animals		
Acute Risk	EEC/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/NOAEC	1
Terrestrial and Semi-Aquatic Plants, and Aquatic Plants		
Acute Risk	EEC/EC_{25}	1
Acute Endangered Species	EEC/EC_{05} or NOAEC	1
Terrestrial Invertebrates		
Acute risk to bees	EEC/LD_{50}	0.4
Chronic risk to bees	EEC/NOAEC	1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins

Part III. Assessing Agricultural Uses of Pyrethroids

Chemical Names	PC Code
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

Date: September 30, 2016 **DP Barcode:** D433338

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Part III. Assessing Agricultural Uses of Pyrethroids and Pyrethrins

1. Executive Summary

1.1. Purpose

This preliminary risk assessment (PRA) examines the potential ecological risks associated with labeled uses of selected pyrethroid insecticides, based on the best available scientific and commercial information on the use, environmental fate and transport, and effects of the chemical on non-target organisms. The U.S. Environmental Protection Agency (USEPA, EPA, or the Agency) has developed a pyrethroid registration review risk assessment strategy that will assess the pyrethroids as a class with regard to ecological risks rather than conducting assessments by individual chemical. The high toxicity of pyrethroids to aquatic animals and their subsequent exposure is well established. Therefore, the assessment focuses mainly on the risks to aquatic animals, although aquatic plants are included. The assessment also focuses on the pyrethroids for which the Pyrethroid Working Group (PWG), a consortium of registrants, has conducted multiple studies and for which there is ample monitoring data. These include the synthetic pyrethroids bifenthrin, cypermethrin (cypermethrin, *zeta*-cypermethrin, *alpha*-cypermethrin), cyfluthrins (cyfluthrin, *beta*-cyfluthrin), deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins (*lambda*-cyhalothrin, *gamma*-cyhalothrin), and permethrin, with the addition of the pyrethrins. This document is **Part III** of the comparative assessment and deals with agricultural uses.[1]

1.2. Risk Conclusions

This comparative PRA examines the potential ecological risks associated with labeled uses of the insecticides bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins, permethrin, and the pyrethrins, based on the best available scientific and commercial information on the use, environmental fate and transport, and ecological effects of these chemicals on non-target aquatic animals. This section of the PRA deals solely with the potential exposure from conventional agricultural uses of pyrethrins and pyrethroids, to freshwater and estuarine/marine bodies of water.

Environmental Fate and Transport

The pyrethrins and synthetic pyrethroids are highly hydrophobic compounds, showing relatively low to very low solubility in water (from 0.014 ppb for bifenthrin to 10.3 for fenpropathrin, and 200-9000 ppb for pyrethrin 1 and pyrethrin 2, respectively). Their octanol/water partition coefficients (K_{OW}'s) for the pyrethroids are high (for solubility and

[1] Portions of this PRA are based on/or are citations from Shamim, *et al.* 2014.

K_{OW} values, see Laskowski, 2002). Based on these properties, there would be a potential to bioconcentrate in fish tissue. However, the fish bioconcentration factors (BCFs) for many of these compounds are lower than would be predicted based on K_{OW} alone, which is consistent with the understanding that they undergo extensive metabolism in fish tissue and, with exceptions, relatively rapid depuration. The pyrethroids and pyrethrins show a high tendency to sorb with organic carbon in soil, water and sediments and dissolved organic carbon, or particulate matter in the water environment, as suggested by their high K_{OW}s and/or their high organic carbon partition coefficients (K_{OC}s). Pyrethroids are relatively persistent in the environment and slow to biodegrade and hydrolyze. The eight pyrethroids involved in this assessment are generally more stable to sunlight than other synthetic pyrethroids, such as allethrin and resmethrin. They usually have other stable moieties attached to their backbone structure that cause them to persist longer. The major routes of dissipation of pyrethroids are generally metabolism in soil and water, and soil binding. Most pyrethroids are persistent to hydrolysis, aqueous and soil photolysis. Pyrethroids are usually more persistent in anaerobic than aerobic environments. It should be noted that the pyrethrins are less persistent in the environment than the eight synthetic pyrethroids involved in this assessment. For further discussion see **Section 5.2** (*Environmental Fate of Synthetic Pyrethroids and Pyrethrins*).

EFED currently obtains estimated environmental exposure concentrations (EECs) for agricultural use patterns by modeling selected agricultural scenarios in the Pesticide in Water Calculator (PWC). For agricultural uses, exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models Pesticide Root Zone Model (PRZM) and Varying Volume Water Body Model (VVWM). A graphical user interface PWC v.1.52 was used to facilitate inputting chemical and use specific parameters into the appropriate input files and chemical files. The PWC estimates pesticide concentrations in water bodies that result from pesticide applications to land. EECs were determined using the standard pond scenario which describes a vulnerable surface water scenario for the VVWM component of the modeling exercise.

The Pesticide in Flooded Application Model (PFAM) was used to model the rice uses of cypermethrins, cyhalothrins and pyrethrins. PFAM is used by the Agency to estimate pesticide concentrations in surface water from the use of pesticides in flooded fields, such as rice paddies.

The USEPA considers the modeling approaches described above and resultant EECs as conservative ("high end") estimates of exposure that consider many factors that affect pesticide concentrations in aquatic systems (*e.g.*, application rates, timing, frequency, weather pattern, soil characteristics, chemical fate properties). However, as they are intended for use in national level assessment, they do not address all relevant factors which may be important in affecting pesticide concentrations on a site-specific basis. For further information about the models, refer to **Section 5.3**.

Comparisons of water modeled and monitored concentrations involve a high degree of uncertainty (*e.g.*, uncertainties in the model, and in missing the peak concentration when sampling). Further, majority of samples are whole (unfiltered) water, which are not

directly comparable to EECs (which represent freely dissolved test substance). There is a general expectation that EFED's modeled concentrations should be greater than monitored concentrations. Assuming low and median dissolved organic carbon (DOC) and particulate organic carbon (POC), most of the modeling results are within one order of magnitude difference, which indicates that EFED's modeling is not beyond the realm of environmental realism.

The conservative or "high end" estimates of exposure produced by modeling are supported by comparison of the modeled and the maximum monitored sediment concentrations which show that for six out of eight of the chemicals, the modeled concentration exceeded the monitored concentrations by a factor of 10 for 6 of the 8 pyrethroids modeled. However, it is noted that as with most monitoring data, uncertainties exist with respect to the ability of monitoring studies to target "high-end" exposure conditions.

Ecological Effects

Synthetic pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish on an acute basis (*i.e.*, LC_{50} or EC_{50} are <0.1 mg/L). Freshwater fish appear to be generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates appeared to be more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis (cyfluthrin is an example of an exception). Meanwhile, on a chronic basis, there is no clear trend in the comparison of freshwater and estuarine/marine invertebrates. Aquatic invertebrates (freshwater and estuarine/marine) are usually orders of magnitude more sensitive to pyrethroids and pyrethrins than fish (freshwater and estuarine/marine), with acute LC_{50} or EC_{50} approximating 1 ng a.i./L or lower. Benthic or sediment-dwelling invertebrates tend to be especially sensitive to pyrethrins and synthetic pyrethroids with freshwater species being generally more sensitive; however, bioavailability seems to vary widely with the type and amount of organic carbon present in natural sediments.

Risk Determinations

Risk determinations for the major agricultural uses of pyrethroid and pyrethrins are summarized in **Table 1** to **Table 10**. In general, this assessment concludes that the use of bifenthrin, cypermethrin, cyfluthrins, deltamethrin, esfenvalerate, cyhalothrins, fenpropathrin and permethrin, plus the pyrethrins, in accordance with registered labels, results in exceedances of acute and/or chronic risk Levels of Concern (LOCs) for freshwater and estuarine/marine invertebrates by up to three orders of magnitude. Additionally, the modeled agricultural uses results in a number of acute and/or chronic risk quotient LOC exceedances for freshwater and/or estuarine/marine fish for the chemicals analyzed. It was noted that the number of exceedances for the pyrethrins were fewer than for the pyrethroids. For the pyrethrins there were no non-listed species LOC exceedances for freshwater and estuarine/marine fish, with the exception of the rice use. The uses on

rice were modeled for three chemicals (*i.e.*, pyrethrins, cyhalothrins and cypermethrins), and the EECs and RQs for this use were higher than for any other agricultural uses.

For all these chemicals, the maximum application rate, number of applications and minimum interval between applications were modeled. For fenpropathrin, runs representing the total potentially toxic residues (*i.e.*, the parent compound plus the unextracted residues), were performed. Inspection of the summary tables and the RQ tables for the pyrethroid fenpropathrin reveals that the overall risk picture for parent only and parent plus unextracted residues were similar, although as expected, for the parent plus unextracted residues the RQs were somewhat higher. It appears that additional runs for the unextracted residues for all the pyrethroids will not change the overall conclusions of the risk assessment. Since pyrethroids show high K_d and K_{OC} values, a degree of irreversible binding is expected. It is believed that for the pyrethroids the unextracted residues are not an issue (see **Tables 9 and 10**, and **Tables 127 and 128**).

The reader is directed to the risk characterization section for further details about risk estimation (*i.e.*, risk quotients) and risk description (**Sections 7.1** and **7.2**, respectively).

Table 1. Summary of Risk Determinations for Agricultural Uses of Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
MN alfalfa/ Alfalfa	*X*				**X**	**X**	*X*	**X**	*X*	**X**	*X*	
NY grapes/ Blueberries	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL citrus/ Citrus	*X*				**X**	**X**	*X*	**X**	*X*		*X*	
IL corn/ Corn	*X*		*X*		**X**	**X**	*X*	**X**	*X*	**X**	*X*	**X**
FL sweet corn/ Sweet Corn	*X*				**X**	**X**	*X*	**X**	*X*	**X**	*X*	
NC cotton/ Cotton	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
MS soybean/ Soybean	*X*		*X*		**X**	**X**	*X*	**X**	*X*	**X**	*X*	
ND wheat/ Sunflower	*X*				**X**	**X**	*X*	**X**	*X*	**X**	*X*	
ND wheat/ Wheat	*X*				**X**	**X**	*X*	**X**	*X*	**X**	*X*	
FL tomato/ Fruiting Vegetables	*X*		*X*		**X**	**X**	*X*	**X**	*X*	**X**	*X*	
CA rice/ Rice	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 2. Summary of Risk Determinations for Agricultural Uses of Bifenthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
FL cucumber/ Cucurbit Vegetables	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NY grapes/ Blueberries (and other Bushberries)	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL citrus/ Citrus	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
IL corn/ Corn	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybean	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
GA pecan/ Tree Nuts	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
CA cole crops/ Brassica Vegetables	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
CA lettuce/ Lettuce	*X*	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 3. Summary of Risk Determinations for Agricultural Uses of Deltamethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
GA onion/ Bulb Vegetables	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
WA potato/ Tuberous and Corm Vegetables	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
GA pecan/ Tree Nuts	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
IA corn/ Corn	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybean	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
ND wheat/ Sunflowers					**X**	**X**	**X**	**X**	**X**	**X**	*X*	
FL cucumbers/ Cucurbit Vegetables	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL tomatoes/ Fruiting Vegetables	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 4. Summary of Risk Determinations for Agricultural Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NY grapes/ Blueberries	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
GA pecans/ Tree Nuts (based on pistachios)	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
IL corn/ Corn	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
CA lettuce/ Leafy Greens (based on the rate for lettuce)	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybean	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 5. Summary of Risk Determinations for Agricultural Uses of Esfenvalerate for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA cole crops/ Brassica (head & stem) Vegetables	**X**	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
NY grapes/ Blueberries (*except CA*)	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
GA pecan/ Tree Nuts (based on rate on almonds)	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
IL corn/ Corn	**X**	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NC cotton/ Cotton	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybeans	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
ND wheat/ Sunflowers	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL cucumber/ Cucurbit Vegetables	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 6. Summary of Risk Determinations for Agricultural Uses of Cypermethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NY grapes/ Blueberries:	**X**		**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL citrus/ Citrus:	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
IL corn/ Corn	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	**X**		**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybean	**X**		**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
ND wheat/ Sunflower	*X*				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
ND wheat/ Wheat	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA rice/ Rice	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 7. Summary of Risk Determinations for Agricultural Uses of Cyfluthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	**X**				**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
NY grapes/ Grapes	**X**	**X**	*X*		**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
FL citrus/ Citrus	**X**	**X**	*X*		**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
IL corn/ Corn	**X**	**X**	*X*		**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	**X**	**X**			**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	**X**	**X**	*X*		**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybeans	**X**	**X**			**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**
ND wheat/ Sunflowers	**X**				**X**	**X**		**X**	**X**	**X**	*X*	**X**
ND wheat/ Wheat	**X**				**X**	**X**		**X**	**X**	**X**	*X*	**X**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	**X**	**X**	*X*		**X**	**X**	*X*	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 8. Summary of Risk Determinations for Agricultural Uses of *Lambda*-Cyhalothrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL cucumber/ Cucurbit Vegetables	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL citrus/ Citrus	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
IL corn/ Corn	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL sweet corn/ Sweet Corn	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS soybean/ Soybeans	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
ND wheat/ Sunflowers	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
ND wheat/ Wheat	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
CA cole crops/ Brassica (head and stem) & Fruiting Vegetables	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
CA rice/ Rice	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 9. Summary of Risk Determinations for Agricultural Uses of Fenpropathrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA cole crops/ Brassica (head and stem) Vegetables	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NY grapes/ Bushberries and caneberries	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL citrus/ Citrus	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL cucumber/ Cucurbit Vegetables	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
PA apple/ Pome Fruits	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
MI cherries/ Stone Fruits	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
GA pecan/ Tree Nuts	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NC peanuts/ Peanuts	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL tomato/ Fruiting Vegetables	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 10. Summary of Risk Determinations for Agricultural Uses of Fenpropathrin plus the Unextracted Residues for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA cole crops/ Brassica (head and stem) Vegetables	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NY grapes/ Bushberries and caneberries	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL citrus/ Citrus	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL cucumber/ Cucurbit Vegetables	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
PA apple/ Pome Fruits	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MS cotton/ Cotton	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
MI cherries/ Stone Fruits	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
GA pecan/ Tree Nuts	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
NC peanuts/ Peanuts	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL tomato/ Fruiting Vegetables	**X**	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

1.3. Data Gaps and Uncertainties

In this section, the uncertainties are only divided according to the following six major categories. For details about the uncertainties in this assessment, refer to **Section 7.2.7** in the Risk Description:

i. Uncertainties in the use information utilized in the assessment. In this assessment the *maximum number of applications* and the *minimum interval between applications*, according to the label were modeled for each specified crop and chemical. For fenpropathrin, runs for the parent plus the unextracted residues were performed.
ii. Environmental fate database/data gaps and their uncertainties.
iii. Ecological effects data gaps and uncertainties.
iv. Uncertainties related to the Pesticide in Water Calculator (PWC v.1.52) model and other exposure assessment issues.
v. Uncertainties related to the Pesticide in Flooded Applications Model (PFAM) and related exposure assessment issues.
vi. Uncertainties related to dilution and chemical transformations in estuarine environments.

2. Introduction

This part of the comparative Pyrethroid and Pyrethrins Ecological Risk Assessment is focused solely on the agricultural uses of pyrethroids leading to exposure to surface water bodies, and only on risk to aquatic organisms, which have been found to be the most sensitive receptors in previous pyrethroid ecological risk assessments. Subsequent to this risk assessment and incorporation of pertinent risk mitigation measures for aquatic animals, risks to other taxa will be considered. The agricultural uses are major use patterns for pyrethrins and pyrethroids. The combined agricultural uses of pesticides can result in significant exposure to water bodies through drift, runoff and erosion.

Many types of documentation, information and data are used by USEPA in conducting pesticide ecological risk assessments. In a regulatory setting, labels are considered first in determining pesticide exposure in various compartments of the environment, as the label is the legal document governing the permitted pesticide use patterns. Labels specify pesticide contents of active(s)/inert material(s), formulation type, target pests/areas, and detailed use instructions (application rate, number of applications permitted, frequency, timing and type of applications. In addition to label use information, pesticide usage data are also important as they indicate quantity, seasonality, historical and geographic usage extent of currently registered pesticides. Monitoring data are also important and could be the only reliable exposure data available for use in a risk assessment due to limitations associated with the current modeling approaches. Important aspects of exposure modeling for agricultural crops include the maximum number of applications, the interval between those applications, and the timing of applications. Further, possible sources of pesticide contamination (*i.e.*, drift, contaminated airborne particles and others, as applicable), may be considered.

BEAD provided input on the usage of the eight pyrethroids and pyrethrins, and determined that there were certain crops that constituted the vast majority of the usage for these chemicals (mainly field crops). All these major crops were modelled. Additionally, one vegetable crop, a specialty crop (*e.g.*, blueberries), and a tree crop treated using airblast methods of application (*e.g.*, citrus or tree nuts), were modeled.

In **Part III** of the comparative ecological risk assessment, a summary of the currently available information regarding pyrethroid and pyrethrins pesticide releases to agricultural environments in the U.S. and approaches considered for evaluating these exposure pathways in OPP's "*Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins*" is presented. Additionally, a summary of available monitoring data which have been generated specifically to characterize pyrethroid exposure to agricultural waters is presented. Aquatic toxicological endpoints for the pyrethroids and pyrethrins assessed are provided and discussed (in first tier assessments, the most sensitive species is used). In the risk estimation section of the risk characterization, the risk quotient method is used to characterize the risk of pyrethroids reaching adjacent surface bodies of water. This is followed by the risk description, where data available about monitoring, and other lines-of-evidence are integrated with modeling results and resulting risk quotients are placed in proper context.

3. Problem Formulation

The Problem Formulation provides a strategic framework for the risk assessment. It sets the objectives for the risk assessment and provides a plan for analyzing the data and characterizing the risk (USEPA 1998). By identifying the important components of the risk assessment process, it focuses the assessment on the most relevant ecological receptors (species), chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA 2004).

3.1. Pesticide Class, Type and Mode of Action

Pyrethrins and synthetic pyrethroids are neurotoxic insecticides acting through direct contact and ingestion. The insecticidal effect of pyrethroids is characterized by a rapid "knock down," or paralysis, of insects. All pyrethroids act as axonic poisons, affecting both the peripheral and central nervous systems, and share similar modes of action. The primary biological effects of pyrethroids on insects and vertebrates reflect an inhibition of the correct firing of neurotransmitter delivery signals from one cell to another via nerve membrane inhibition of the voltage-gated Ca^{2+} (calcium ion) channels coupled with a stimulatory effect on the voltage-gated Na^{+} (sodium ion) channels. Type I pyrethroids do not have a cyano group substitution in the *alpha*-position of the alcohol moiety of the ester

structure; in contrast, Type II pyrethroids have the *alpha*-cyano group. For additional discussion on pesticide class, type and mode of action, refer to **Section 3.1** of **Part I** of the PRA.

3.2. Conclusions from Previous Assessments

Ten of the pyrethrins, pyrethroids, and synergists were registered before November 1, 1984, and therefore were subject to reregistration. In 2008, EPA completed Reregistration Eligibility Decisions (REDs) for these 10 individual pesticides: pyrethrins, allethrins, cypermethrin, *tau*-fluvalinate, permethrin, resmethrin (which is now cancelled), *d*-phenothrin (commonly known as Sumithrin®), and tetramethrin. The remaining pyrethroids, registered later, were not subject to reregistration. Additionally, California Red Legged Frog (CRLF) and other threatened or endangered species in the San Francisco Bay (SFB) region endangered species assessments (ESAs), were issued for a number of pyrethroids. More information about pyrethrins and individual pyrethroid assessments (including ESAs) can be found in the EPA Pesticide Chemical Search site (URL: https://iaspub.epa.gov/apex/pesticides/f?p=chemicalsearch:1).

Previous assessments have generally concluded that pyrethroids can be relatively persistent in the environment and slow to biodegrade and hydrolyze. The major routes of dissipation of pyrethroids are generally aerobic soil and aquatic metabolism, and soil binding, and for some of the pyrethroids, aqueous photolysis in clear shallow water. For pyrethroids, hydrolysis is pH dependent, and they are more prone to hydrolyze at higher pH values (*i.e.*, pH = 9). Pyrethroids usually are more persistent in anaerobic than aerobic environments. It should be noted that the pyrethrins are less persistent in most environments than the eight synthetic pyrethroids involved in this assessment. Additionally, some of the pyrethroids not covered in this comparative assessment are less persistent to certain routes of dissipation than for the pyrethroids covered; however, the focus of this summary is on the eight pyrethroids and pyrethrins.

Pyrethroids are highly toxic to aquatic animals. As a result, generally risk quotients (RQs) approached or exceeded the levels of concern (LOCs) for fish and invertebrates (freshwater and estuarine/marine); however, RQs were usually higher for invertebrates. Because the pyrethroids can accumulate in sediments, risk to sediment-dwelling organisms was considered an area of particular concern. Previous risk assessments have been largely unable to adequately estimate risk to this group of organisms due to data gaps. Additionally, bioavailability has been difficult to ascertain due to strong influences from varied types and amounts of organic carbon in natural sediments.

RQs for water column aquatic organisms described in previous risk assessments are presented in **Table 11** below. This information was compiled by PRD from EFED documents. Most of the previous assessments focused on agricultural use patterns, although some of the Endangered Species Assessments may have included certain non-agricultural use patterns as well.

Table 11. Summary of RQs from Previous Assessments for Freshwater and Estuarine/Marine Fish and Invertebrates for the Pyrethroids and Pyrethrins

Active Ingredient	Freshwater Fish RQ's	Estuarine/ Marine Fish RQ's	Freshwater Invertebrate RQ's	Estuarine/ Marine Invertebrate RQ's
Bifenthrin	Acute: 0.58-0.67 Chronic: 0.425-2.5 (2007) Acute: <0.01 – 0.09 Chronic: 0.01 – 3.50 (2012 ESA)	Acute: 0.00 Chronic: not calculated (2007) Acute: <0.01 Chronic: 0.01- 3.50 (2012 ESA)	Acute: 0.063 Chronic: 15.4-77 (2007) Acute: 0.07-7.37 Chronic: 0.22- 82.35 (2012 ESA)	Acute: 25 Chronic: not calculated (2007) Acute: 0.03-3.53 Chronic: 0.19-70.00 (2012 ESA)
Cyfluthrins	Acute: 1.5-39 Chronic:0.45-30 (2004) Acute: 0.37-33.8 Chronic: 1.7 -547.6 (2013 ESA)	Acute: <0.01-0.70 Chronic:0.10-12 (2004) Acute: 0.01 – 1.35 Chronic: 0.64-209.1 (2013 ESA)	Acute: 1.7- 107 Chronic: 1.3 - 61 (2004) Acute: 0.08 – 7.93 Chronic: 3-766.7 (2013 ESA)	Acute: 48- 1214 Chronic: 45-2130 (2004) Acute: 11.4-1045.5 Chronic: 128.6-32,857.1 (2013 ESA)
Cyhalothrins (*lambda*-)	Acute: 0.50-1.07 Chronic: 0.26-0.97 (2002) Acute: 0.12 – 1.97 Chronic: 0.10- 2.87 (2006)	Acute: 0.13- 0.28 Chronic: 0.3-0.12 (2002) Acute:0.03- 0.51 Chronic: 0.01- 0.36 (2006)	Acute: 15.0-32.0 Chronic: 6.5- 19.5 (2002) Acute: 3.57-59.14 Chronic:2.0- 85.0 (2006)	Acute: 21.0-44.8 Chronic: 65-195 (2002) Acute: 5.0-82.8 Chronic: 20-850 (2006)
Cypermethrin	Acute: 0.5-5.2 Chronic: 0.1-0.7 (2006)	Acute: 0.2-2.1 Chronic:0.1 -0.03 (2006)	Acute: 49.4-558.3 Chronic: 57.6-325.4 (2006)	Acute: 37-423 Chronic:44-246 (2006)
Cypermethrin (*alpha*-)	Acute:0.02-0.28 Chronic: 0.03-0.21 (2012)	Acute: 0.04-0.65 Chronic:0.07-0.33 (2012)	Acute:11.11-172.22 Chronic:16.95-101.69 (2012)	Acute:8.42-130.53 Chronic: 12.80-76.82 (2012)
Cypermethrin (*zeta*-)	Acute: 0.10-3.73 Chronic: 0.02-0.46 (2006)	Acute: 0.04-1.53 Chronic: <0.01-0.19 (2006)	Acute: 11.25-404.44 Chronic: 6.83-206.78 (2006)	Acute: 8.53-306.53 Chronic: 5.16-156.21 (2006)
Deltamethrin	Acute: 0.01-0.06 Chronic: 0.01-0.11 (2014) Acute: <0.01 – 0.34 Chronic: <0.01 – 11.8 (2013 ESA)	Acute: 0.01-0.06 Chronic: <0.01-0.08 (2014) Acute: <0.01 – 0.34 Chronic: <0.01 – 8.33 (2013 ESA)	Acute: 1.8-9.3 Chronic: >7.4- >87.7 (2014) Acute: 0.11 – 50.0 Chronic: >4.73 - >7690 (2013 ESA)	Acute: 2.0-10.0 Chronic:0.26-3.1 (2014) Acute: 0.11-54.1 Chronic: 0.07- 274 (2013 ESA)
Esfenvalerate	Acute: 0.49-92.33 Chronic: 0.02-18.54 (2008 ESA)	Not calculated (2008 ESA)	Acute:0.34- 129.26 Chronic: 2.12 – 33.41 (2008 ESA)	Not calculated (2008 ESA)
Fenpropathrin	Acute: 0.06-1.4 Chronic: 0.6-11.6 (2008)	Acute: 0.07-1.0 Chronic: no data (2008)	Acute: 0.3-5.9 Chronic: 0.9-17.6 (2008)	Acute: 2.7-150 Chronic:4.7-94 (2008)
Permethrin	Acute: 0.68-6.73 Chronic: 0.3-3.4 (2009) Acute: 0.06-6.96 Chronic: 0.14-61.17 (2008 ESA)	Acute: 0.25-2.42 Chronic: 0.1-1.23 (2009) Acute: 0.02-2.50 Chronic: 0.05-21.97 (2008 ESA)	Acute: 5.4-53.2 Chronic: 4.1-33.9 (2009) Acute: 2.11-59.43 Chronic:6.66 -3271.43 (2008 ESA)	Acute: 29.0-280.0 Chronic: 9.1-120 (2009) Acute: 2.48-305.56 Chronic: 7.77-3816.67 (2008 ESA)

Active Ingredient	Freshwater Fish RQ's	Estuarine/ Marine Fish RQ's	Freshwater Invertebrate RQ's	Estuarine/ Marine Invertebrate RQ's
Pyrethrins	Agricultural uses: Acute:0.07-0.54 Chronic:0.04-0.19 Mosquito uses: Acute: <0.00-0.04 Down the Drain: Acute: <0.00 (2006)	Agricultural uses: Acute:0.02-0.17 Chronic:0.01-0.06 Mosquito uses: Acute: <0.00-0.04 Down the Drain: Acute: <0.00 (2006)	Agricultural uses: Acute:0.03-0.24 Chronic:0.17-0.7 Mosquito uses: Acute: <0.00-0.02 Down the Drain Acute: <0.00 (2006)	Agricultural uses: Acute: 0.25-1.98 Chronic: 1.5-6.0 Mosquito uses: Acute: 0.02-0.95 Down the Drain: Acute: 0.02 (2006)

ESA = endangered species assessment

Additionally, water quality, and sediment monitoring efforts in California and other states have identified pyrethroids in sediments of water bodies adjacent to agricultural and residential/urban areas. These monitoring data, coupled with additional pyrethroid-specific data submitted to EPA, highlight existing concerns regarding agricultural and residential uses of pyrethroid pesticide products and movement into non-target areas through runoff or spray drift that may occur during applications.

Risk conclusions from previous assessments regarding taxa, other than aquatic, are considered separately from this part of the PRA, which as indicated earlier, is focused on risk to aquatic organisms. To reduce exposure to water bodies from non-agricultural and agricultural uses of pyrethroids, EPA deployed a number of labeling initiatives, as shown briefly in the next **Section 3.3**, and in **Section 5.1.1**.

3.3. Overview of Pesticide Uses

Type I and Type II synthetic pyrethroids are currently registered for numerous diverse uses. Pyrethroids are broad spectrum insecticides that target adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying invertebrates. Formulation types registered for pyrethroids include, among others, wettable powders, dispersible granules, emulsifiable concentrates, liquids, ready to use products, granulars, seed treatments, and dusts. Application methods in agricultural settings include: broadcast ground spray, seed treatments, hand spray, airblast, soil band spray, surface spray, soil incorporation, aerial, and granular. Potential pyrethroid uses include a wide variety of field crops, fruits, nuts, vegetables (including fruiting, cucurbit and root crops, etc., fire ant control. Pyrethroids may be applied year-round, depending on crop and pest pressure, especially in the southern states.

In the reregistration process for permethrin and cypermethrin, it was determined that the existing spray drift language for pyrethroid agricultural products needed to be updated to comply with FIFRA. Because of similarities in use patterns and concern for exposure to aquatic resources, the same changes were considered appropriate for all pyrethroid products used on agricultural crops. In a letter to the registrants from the Agency dated February 21, 2008, all pyrethroid registrants with affected agricultural-use products were instructed to incorporate the revised spray drift language onto their agricultural labels, and

submit the amended labels to the Agency.

For more detail about the agricultural label requirements, refer to **Section 5.1** (*Use and Usage Information: Agricultural Uses and Considerations*). The maximum application rates and minimum interval between applications for the different crops assessed are provided in the tables of **Section 5.3.1** (*Description of Model Inputs*).

3.4. Overview of Environmental Fate

A brief discussion about relevant environmental fate properties of the pyrethroids was provided in the *Risk Conclusions* (**Section 1.2**). For more detailed fate information see the *Environmental Fate of Synthetic Pyrethroids and Pyrethrins* (**Section 5.2** of **Part II** of the "*Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins*").

3.5. Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a plausible route of exposure. The conceptual model is intended to provide a written description and visual representation of predicted relationships between pyrethroids or pyrethrins, potential routes of exposure, and the effects related to the Agency assessment endpoints. The conceptual model consists of two major components: the risk hypotheses and a conceptual diagram (USEPA 1998).

3.5.1. Risk Hypothesis

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA 1998). For this assessment, the risk is stressor-initiated, where the stressor is the release of pyrethrins and pyrethroids into the environment. The following risk hypothesis is presumed for this assessment:

> *Pyrethroids and Pyrethrins, when used outdoors in agricultural environments in accordance with registered labels, will likely lead to off-site movement of the compound via agricultural runoff, spray drift, and eroded soil, leading to exposure of nontarget aquatic animals and plants. Based on information on the environmental fate, mode of action, direct toxicity and potential indirect effects, EFED assumes that registered uses of pyrethroids and pyrethrins have the potential to cause reduced survival, growth, and reproduction to non-target aquatic animals, but not to non-target aquatic plants.*

This risk assessment will evaluate the aforementioned risk hypothesis and determine if it is supported by the risk conclusions.

3.5.2. Conceptual Diagram

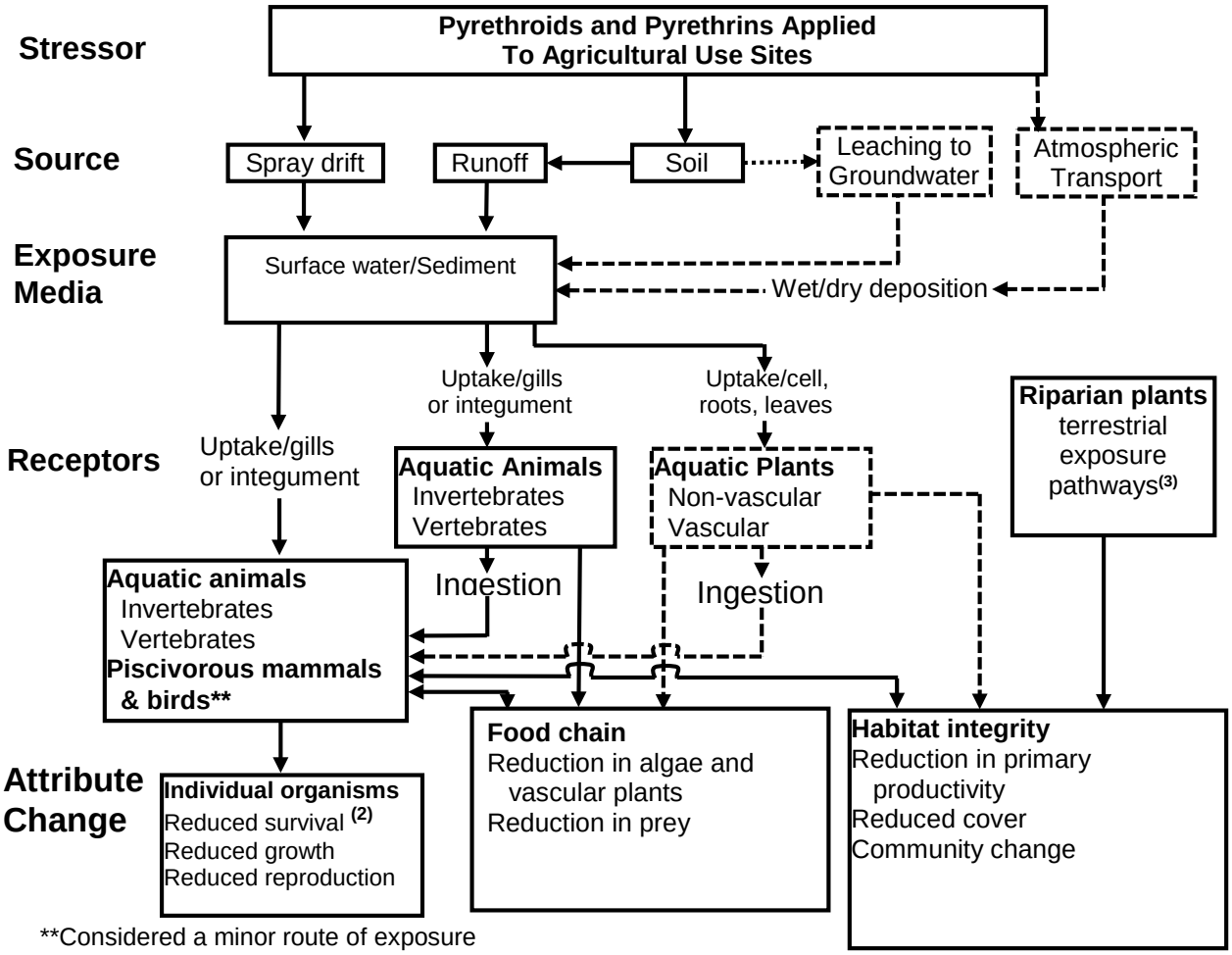
The conceptual model for potential risks of pyrethroids and pyrethrins to aquatic organisms for the agricultural uses of the chemical that could potentially end up in adjacent bodies of water is depicted in **Figure 1**.

Based on an examination of the physicochemical properties of pyrethroids and pyrethrins, the fate and disposition in the environment, and mode of application, a conceptual model (**Figure 1**) was developed that represents the possible relationships between the stressors, ecological receptors, and the assessment endpoints.

Under the possible uses of pyrethroids and pyrethrins, the sources and mechanisms of release of the compounds are from ground and aerial applications. Surface runoff from the areas of application is assumed to depend on factors such as topography, irrigation, and rainfall events. Spray drift results in contaminated adjacent areas, including bodies of water.

For aquatic receptors, the major point of exposure is through direct contact with the water column, suspended particulate, sediment, and pore water (gill/integument) contaminated with spray drift (from spray application) and/or runoff from treated areas. Indirect effects to aquatic organisms (both fish and aquatic invertebrates) can also occur through impact to various food chains for some of the chemicals. The representative aquatic receptors are certain freshwater and estuarine/marine fish, invertebrates, and aquatic plants. It should be noted, that these species do not cover all the possible species in the animal and plant kingdoms; certain taxa are considered as surrogates for other taxa. For example, freshwater fish are considered surrogates for aquatic phase amphibians.

Pyrethroids and pyrethrins show low solubility values, high K_{OW}'s and high sorption coefficients. These properties suggest that the chemicals partition with the sediments and particulate suspended in bodies of water. Pyrethroids and pyrethrins are likely to concentrate in the sediments, especially after repeated exposures (applications), where they could persist. Such sediments could serve as repositories of the chemical for extended periods of time and could potentially be toxic to sediment dwelling organisms, affecting the food chain. Aquatic plants show much lower sensitivity to pyrethroids and pyrethrins than aquatic animals; it appears that the pyrethroids and pyrethrins risk to non-target plants is low.



Dashed lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

[1] Includes flow across vegetation and vegetated drainage systems (*e.g.*, swales) and flow across impervious surfaces and through impervious (piped) storm drains.

[2] Immobilization is considered equivalent to mortality in toxicity tests for aquatic invertebrates.

[3] Riparian plants are not considered in this part of the PRA.

Figure 1. Conceptual diagram for potential risks of pyrethroids and pyrethrins to aquatic organisms for conventional agricultural uses of the chemicals that could potentially end up in surface water or sediment

For risk to aquatic organisms, exposure is evaluated in the rice paddy for organisms that may move onto the field by comparing toxicity endpoints to estimated exposure in the rice paddy. As exposure is estimated in the rice paddy for ecological risk assessment, releases of water after an application could reduce estimated exposure in the paddy, leading one to potentially erroneously conclude that risk could be reduced by early paddy releases. The risk however would move with the residues in the water after they left the paddy and it is uncertain to what extent residues in the water would be diluted after the water left the rice paddy as some receiving canals that water will flow into may not have much water in them or the water may be coming from releases from rice paddies upstream. Therefore, to follow the residues in the water and to provide a protective bound for risk for ecological organisms, water should be held on the rice paddy after the application and until harvest.

While it is acknowledged that typically risk to aquatic plants would be assessed off the rice paddy for aquatic and terrestrial plants, exposure to aquatic plants in waters adjacent to the rice paddy may be similar to exposure in the rice paddy and estimates of the degree of dilution are not available. Risk to aquatic plants could be characterized using the estimated pesticide concentrations in the rice paddy and in the water that would be released from the rice paddy after the specified minimum holding period, as recommended for other aquatic organisms.

4. Analysis Plan

The primary method used to assess risk in this assessment is the risk quotient (RQ) and follows closely methods outlined in the EPA Overview Document (USEPA, 2004). The RQ is the risk value for the assessment and is the result of comparing measures of exposure to measures of effect. Risk presumptions, along with the corresponding RQs, equations, and LOCs are summarized in **Section 7** and **Appendix A** of this assessment.

4.1. Measures of Exposure

In order to estimate risks of pyrethrins and pyrethroids exposures in aquatic environments, all exposure modeling and resulting risk conclusions are made based on maximum application rates for the current use patterns, maximum number of applications, and minimum retreatment interval. Available monitoring data are also considered when describing potential environmental exposure to non-target organisms. Measures of exposure are based on aquatic models, such as the Pesticides in Water Calculator (PWC), that predicts estimated environmental exposure concentrations of pyrethrins and pyrethroids using maximum labeled application rates and methods, as well as any mitigation measures specifically indicated on the label.

The Pesticide in Flooded Application Model (PFAM v.1.99906, dated February 18, 2016) is used to model the rice uses of cypermethrins, cyhalothrins and pyrethrins. PFAM is used by the Agency to estimate pesticide concentrations in surface water from the use of pesticides in flooded fields, such as rice paddies. PFAM simulates water and pest management practices, pesticide degradation in soil and aquatic environments, as well as discharge of paddy waters to lotic or lentic user defined waterbodies. **Figure 2** shows the general conceptual model for the applications of a pesticide to a rice paddy (Young, 2012 & 2013).

More information on aquatic pesticide exposure models can be found at http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment (accessed June 29, 2016), and in **Section 5.3**.

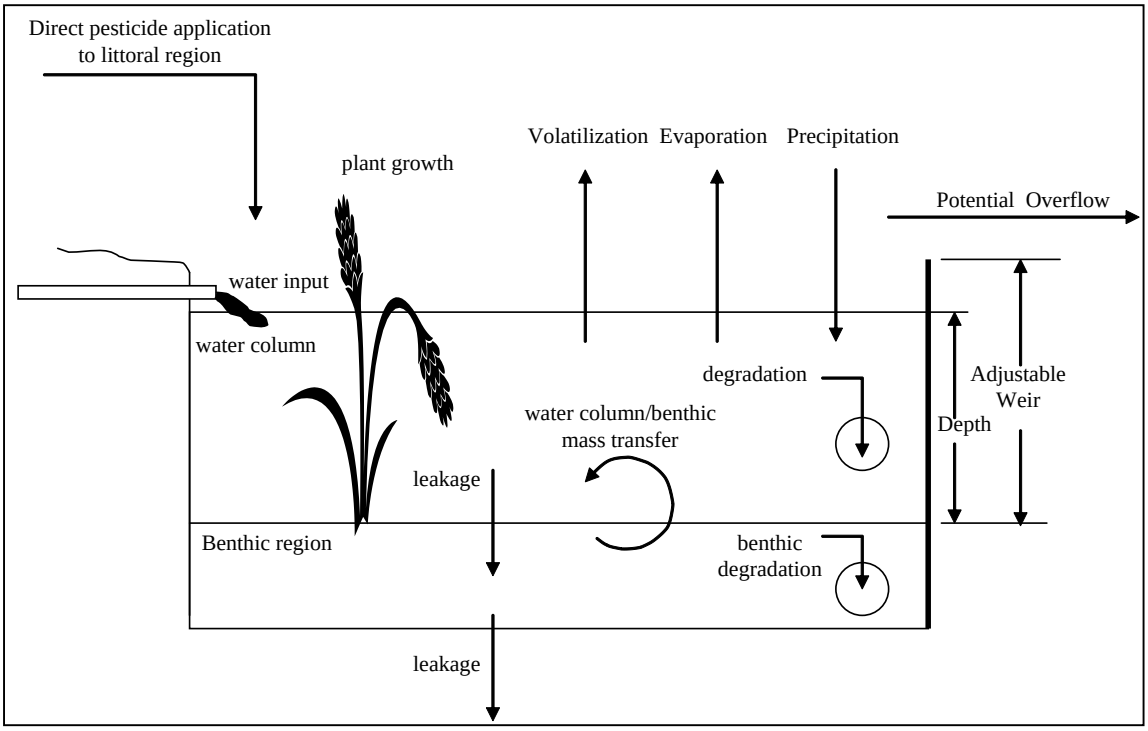


Figure 2. The conceptual model for applications of pyrethroids and pyrethrins in a flooded field, showing hydrological and chemical processes that occur in a rice paddy

4.2. Measures of Effects

Measures of ecological effects are obtained from a suite of registrant-submitted guideline studies conducted with a limited number of surrogate species. The test species are not intended to be representative of the most sensitive species but rather were selected based on their ability to thrive under laboratory conditions. Measures of effect are based on deleterious changes in an organism as a result of chemical exposure. Functionally, measures of effect typically used in risk assessments include changes in survival, reproduction, or growth as determined from standard laboratory toxicity tests. The focus on these effects for quantitative risk assessment is due to their clear relationship to higher-order ecological systems such as populations, communities, and ecosystems, and especially their ability to be readily reduced to population sustainability. The measures of effect for the agricultural uses of pyrethroids and pyrethrins are similar to the ones for the non-agricultural uses and they are described in **Section 4.2** of **Part II** of the PRA.

5. Exposure Assessment

5.1. Use and Usage Information: Agricultural Uses and Considerations

Pyrethroids are used on numerous crops. BEAD-provided information indicated that there are a number of agricultural uses for pyrethroids that constitute the majority of the usage for these chemicals: *i.e.,* ***alfalfa, corn, sweet corn, cotton, soybean, sunflowers,***

wheat and rice. For the applicable chemicals, EFED modeled the above mentioned uses using aerial applications (most conservative approach). Rice uses were modeled separately. In addition, a few other crops that could involve less usage were also modeled, which included ***one vegetable crop*** (*e.g.*, cucurbit vegetables, fruiting vegetables, or brassica (head and stem) vegetables), one specialty crop (blueberries, if applicable to the chemical), ***and one tree crop that could use airblast*** methods of application (*e.g.*, citrus fruits or tree nuts).

In the reregistration process for permethrin and cypermethrin, the Agency determined that the existing spray drift language for pyrethroid agricultural products needed to be updated to comply with FIFRA. Because of similarities in use patterns and concern for exposure to aquatic resources, the same changes are appropriate for all pyrethroid products used on agricultural crops. In a letter from the Agency dated February 21, 2008, all pyrethroid registrants with affected products were instructed to incorporate the revised spray drift language onto their agricultural labels, and submit the amended labels to the Agency[2].

"BUFFER ZONES

Vegetative Buffer Strip

Constuct and maintain a minimum 10-foot-wide vegetative filter strip of grass or other permanent vegetation between the field edge and down gradient aquatic habitat (such as, but not limited to, lakes; reservoirs; rivers; permanent streams; marshes or natural ponds; estuaries; and commercial fish farm ponds).

Only apply products containing (*name of pyrethroid*) onto fields where a maintained vegetative buffer strip of at least 10 feet exists between the field and down gradient aquatic habitat.

For guidance, refer to the following publication for information on constructing and maintaining effective buffers:

Conservation Buffers to Reduce Pesticide Losses. Natural Resources Conservation Services. USDA, NRCS. 2000. Fort Worth, Texas. 25 pp.
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_023819.pdf

Buffer Zone for Ground Application (groundboom, overhead chemigation, or airblast)

Do not apply within 25 feet of aquatic habitats (such as, but not limited to, lakes, reservoirs, rivers, streams, marshes, ponds, estuaries, and commercial fish ponds).

Buffer Zone for ULV Aerial Application

[2] Information is available at the following URL: https://www.epa.gov/ingredients-used-pesticide-products/updated-spray-drift-language-pyrethroid-agricultural-use, accessed June 29, 2016.

Do not apply within 450 feet of aquatic habitats (such as, but not limited to, lakes, reservoirs, rivers, streams, marshes, ponds, estuaries, and commercial fish ponds).

Buffer Zone for Non-ULV Aerial Application

Do not apply within 150 feet of aquatic habitats (such as, but not limited to, lakes, reservoirs, rivers, streams, marshes, ponds, estuaries, and commercial fish ponds)."

"Spray Drift Requirements

Wind Direction and Speed

Only apply this product if the wind direction favors on-target deposition.

Do not apply when the wind velocity exceeds 15 mph.

Temperature Inversion

Do not make aerial or ground applications into temperature inversions.

Inversions are characterized by stable air and increasing temperatures with height above the ground. Mist or fog may indicate the presence of an inversion in humid areas. The applicator may detect the presence of an inversion by producing smoke and observing a smoke layer near the ground suface.

Droplet Size

Use only Medium or coarser spray nozzles (for ground and non-ULV aerial application) according to ASAE (S572) definition for standard nozzles. In conditions of low humidity and high temperatures, applicators should use a coarser droplet size.

Additional Requirements for Ground Applications

Wind speed must be measured adjacent to the application site on the upwind side, immediately prior to application.

For ground boom applications, apply using a nozzle height of no more than 4 feet above the ground or crop canopy.

For airblast applications, turn off outward pointing nozzles at row ends and when spraying the outer two rows. To minimize spray loss over the top in orchard applications, spray must be directed into the canopy.

Additional Requirements for Aerial Applications

The spray boom should be mounted on the aircraft as to minimize drift caused by wingtip or rotor vortices. The minimum practical boom length should be used and must not exceed 75% of the wing span or 80% rotor diameter.

Flight speed and nozzle orientation must be considered in determining droplet size.

Spray must be released at the lowest height consistent with pest control and flight safety. Do not release spray at a height greater than 10 feet above the crop canopy unless a greater height is required for aircraft safety.

When applications are made with a cross-wind, the swath will be displaced downwind. The applicator must compensate for this displacement at the downwind edge of the application area by adjusting the path of the aircraft upwind."

The maximum application rates and minimum interval between applications for the different crops assessed are provided in the tables of **Section 5.3.1** (*Description of Model Inputs*).

5.2. Environmental Fate of Synthetic Pyrethroids and Pyrethrins

A brief discussion about some environmental fate properties of the pyrethroids was provided in the **Section 1.2** (*Risk Conclusions*). A comprehensive review about the physicochemical and environmental fate properties of several pyrethroids was published earlier in 2002 (Laskowski, 2002). Since then, during the Registration Review process, new environmental fate studies were requested and submitted to the Agency. See the **Attachment I** for the nomenclature (*e.g.*, common names, chemical names), CAS numbers, as well as structures of the pyrethroids and pyrethrins; refer to the **Attachment III** for detailed environmental fate assessments for individual synthetic pyrethroids and pyrethrins. **Section 5.2** of **Part II** of the "*Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins*" contain a summary of environmental fate properties for these compounds. Refer to those sections for additional detals. For specific environmental fate properties and values of each of the pyrethroids and pyrethrins used to calculate EECs in this part of the PRA, refer to the tables in the **Section 5.3.1** (*Description of Model Inputs*).

5.3. Modeling Approach

EFED currently obtains estimated exposure concentrations (EECs) for uses in agricultural areas by modeling PRZM scenarios in the Pesticide in Water Calculator (PWC v.1.52). For agricultural uses, exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models Pesticide Root Zone Model (PRZM) and Varying Volume Water Body Model (VVWM). A graphical user interface PWC v.1.52 (February 23, 2016), developed by the EPA, was used to facilitate inputting

chemical and use specific parameters into the appropriate input files and chemical files. The PWC estimates pesticide concentrations in surface or ground water bodies that result from pesticide applications to land. The calculator was designed for regulatory applications as applied in the Office of Pesticide Programs, USEPA, as well as PMRA, Health Canada. The PWC calculator uses PRZM v.5.02 (February 23, 2016) and the VVWM v.1.02 (February 23, 2016), a replacement for the older EXAMS model).

The Pesticide in Flooded Application Model (PFAM v.1.99906, dated February 18, 2016) is used to model the rice uses of cypermethrins, cyhalothrins and pyrethrins. This model is a pre-release version of PFAM v.2.0, and it has undergone CRP evaluation. PFAM is used by the Agency to estimate pesticide concentrations in surface water from the use of pesticides in flooded fields, such as rice paddies. PFAM simulates water and pest management practices, pesticide degradation in soil and aquatic environments, as well as discharge of paddy waters to lotic or lentic user defined waterbodies (**Figure 2**). The water body depth may change due to precipitation, refill, drainage, evaporation, and weir-height changes. The model consists of two regions—a water column and a benthic region. Each individual region is completely mixed and at equilibrium with all phases within the individual region, and equilibrium within each region follows a linear isotherm. The two regions are coupled by a first-order mass-transfer process. Chemical transformation processes (*i.e.*, hydrolysis, bacterial metabolism, photolysis, and sorption) within each region are formulations that were heavily borrowed from the USEPA EXAMS model (Burns, 2000). Changes in water body conditions (temperature, water levels, wind speed, *etc.*) and the resulting changes in degradation rates occur on a daily time step. The selection of a daily time step was mainly because of the availability of a large amount of daily meteorological data (Burns *et al.*, 2007) and the USEPA's historical use of EXAMS on a daily time step.

Additional information about EFED's aquatic models is provided in the Agency's website at http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment (accessed June 27, 2016).

5.3.1. Description of Model Inputs

Model input parameters for the synthetic pyrethroids lie in two categories: use information parameters, and environmental fate input parameters. The use information includes the application rate, number of applications, interval between applications, method of application and associated value of spray drift and application efficiency, *etc.* Additionally, the specific modeling scenario for each of the modeled uses are presented. Furthermore, the maximum use scenario was modeled (*e.g.*, for a crop that is applied through ground or aerial methods, aerial applications were modelled). One possible exception is the airblast (citrus or tree nuts). In this case, the airblast method of application was selected, as opposed to the possible aerial applications.

In order to simulate applications to agricultural crops, and given the large number of crops per use, a batch run file was prepared and multiple runs were performed

simultaneously in the PWC. Then *the scenario yielding the highest EECs related to a high use area was presented in the EEC tables and the RQ tables*. For example, for corn there are thirteen PRZM scenarios across the U.S. as follows: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, and TX corn. *Note again that all these scenarios were run in batch mode in the PWC.*

Additionally, the fate input parameters include for example, the pH 7 hydrolysis, aqueous photolysis, aerobic soil metabolism, aerobic aquatic metabolism, and anaerobic aquatic metabolism representative half-lives, vapor pressure, and solubility.

The tables below provide model input parameters used in this assessment, the sources and justification for the selected values. The first table for each of the chemicals gives information about maximum application rate, number of applications, interval between application, etc.

Table 13. Pyrethrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift[1]	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[2]	Incorp. depth (cm)	PHI (days)
01: CA, IL, MN, NC, PA, TX alfalfa/ Alfalfa	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
02: CA wine grapes, NY grapes, OR berries/ Blueberries	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
03: FL citrus, CA citrus, TX grapefruit/ Citrus	Assumed Airblast	0.0416	0.99	0.0560 (0.050)	10	3		0	0
04: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
05: FL, OR sweet corn/ Sweet Corn	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
06: CA, MS, NC, TX cotton/ Cotton	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	14
07: MS soybean/ Soybean	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
08: CA corn, ND wheat/ Sunflower	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
09: CA, ND, TX, OR wheat/ Wheat	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
10: FL pepper, CA, FL, PA tomato, PA and TX vegetables/ Fruiting Vegetables	Aerial	0.0901	0.95	0.0560 (0.050)	10	3		0	0
11: AR, CA, LA, MS, MO and TX rice/ Rice[3]	Aerial	N/A	N/A	0.0560 (0.050)	10	3		0	0[3]

[1]Assumptions: aerial application, boom height 10 ft, wind speed 10 mph, buffer distance 0 ft, DSD = ASABE Medium, carrier water, 2 gal/A. For the airblast application, Sparse (young, dormant). For aerial and airblast applications, buffer zone was assumed to be 0 ft.
[2]The date of first application was variable for each crop scenario.
[3] For rice, a 10 day water holding period is required for all applications when rice fields are flooded.

Table 14. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Pyrethrin 1[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	328.4 g/mole	USEPA 2006[2]
Vapor Pressure	2×10^{-5} torr	USEPA 2006[2]
Solubility in Water	0.2 mg/L	USEPA 2006[2]
Photolysis in Water (34°N)	0.49 days	MRID 43096601, 43567501, 43567601 11.8 days for the combination of pyrethrin and the (E)-Isomer of pyrethrin 1; irradiated with sunlight in Irvine, California (33º41' N, 117º15' W)
Aerobic Soil Metabolism Half-lives (25°C)	7.26 days	MRID 43499803, 49687101 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 9.5 days at 25ºC, and 5.53, 3.51, 0.742 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 9.5, 3.91, 2.48, 0.525 days; average 4.1038 days; standard deviation 3.8558 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Hydrolysis Half-life at pH 7	0	MRID 43188201, 43567502 Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 10.25 days	MRID 43499802; 49123501 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 10.5 days at 25ºC, and 6.44, 5.37 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 10.5, 3.85, 3.80 days; average 6.050 days; standard deviation 3.8539 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	258 days	MRID 43499801 Single available value multiplied by 3 (86 days x 3).
Soil Water Partition Coefficient (K_F)	301.5 mL/g	MRID 43096603 Average of the following four values: 198, 268, 430, 310 mL/g. The K_F model represents the mobility better than the K_{FOC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_F dataset is less than for the K_{FOC} dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1" dated October 22, 2009.
2 USEPA 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 15. Bifenthrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift[1]	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[5]	Incorp. depth (cm)	PHI (days)
01: FL cucumber, CA, MI, MO, NJ, TX melons/ Cucurbit Vegetables	Aerial	0.031	0.95	0.1121 (0.1)	3	7		0	3
02: CA wine grapes, NY grapes, OR berries/ Blueberries (and other Bushberries)	Aerial	0.031	0.95	0.1121 (0.1)	5	7		0	1

Table 15. Bifenthrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift[1]	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[5]	Incorp. depth (cm)	PHI (days)
03: FL citrus, TX grapefruit/ Citrus[3]	Ground to bare soil	0.0071	0.99	0.5604 (0.5)	1	N/A		0	1
04: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	At plant ground, foliar aerial	0.0071; 0.031	0.95	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	3[2]	Assume 14[4]		0	30
05: FL, OR sweet corn/ Sweet Corn	Aerial	0.0071; 0.031	0.95	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	3[2]	Assume 14[4]		0	30
06: CA, MS, NC, TX cotton/ Cotton	Aerial	0.031	0.95	0.1121 (0.1)	5 (3 in CA)	3		0	14
07: MS soybean/ Soybean[3]	Aerial	0.031	0.95	0.1121 (0.1)	3	30		0	18
08: CA almond, GA pecan, OR filbert/ Tree Nuts	Airblast	0.015	0.99	1 @ 0.1121 (0.1) + 2 @ 0.2242 (0.2)	3	15		0	21 pecans, 7 others
09: CA cole crops, FL cabbage/ Brassica Vegetables	Aerial	0.031	0.95	0.1121 (0.1) (1 app could be at plant)	5	7		0	7
10: CA lettuce/ Lettuce	Aerial	0.031	0.95	0.1121 (0.1)	5	7		0	7

[1]Assumptions: aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft. For ground application, assumed high boom and ASABE Medium/Coarse DSD, and a buffer zone of 25 ft.
[2]One application could occur at plant, at 0.2 lb a.i./A, 5-7 inch T-band, in-furrow or broadcast. Seasonal rate is 0.3 lb a.i./A/year.
[3]Not permitted in CA, unless in a supplemental label.
[4]Assumption is valid between the at-plant and the subsequent application.
[5]The date of first application was variable for each crop scenario.

Table 16. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Bifenthrin[1]

Fate Property	Value (unit)	Source/Comment[1]
Molecular Weight	422.9 g/mole	Laskowski 2002[2]
Vapor Pressure (25°C)	1.80×10^{-7} torr	Laskowski 2002[2]
Solubility in Water (22ºC)	1.4×10^{-5} mg/L	Laskowski 2002[2] (MRID 00132518, Acc. No. 251725)
Photolysis in Water (40°N)	49 days	MRID 48882501
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 169.2 days	Accession No.: 073174, 073225, 141502, 251278, 251728, 254401, 254411, 264642, 532540; MRID 00132540, 00141202, 00152266, 48882502. Represents the 90th percentile of the upper confidence bound on the mean for the following seven values: 97, 116, 155, 128, 132, 250, 111 days at 25°C; average 141.286 days; standard deviation 51.296 days; one sided student's t value $t_{90,n-1}$ = 1.440.

Table 16. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Bifenthrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Hydrolysis Half-life at pH 7	0	MRID 00132539, 49138403; Stable
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 466.2 days	MRID 48882504 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 276, 92.9 days at 20°C; average 184.45 days; standard deviation 129.5 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 650.2 days	MRID 49364001 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 587, 618 days at 20°C; average 602.5 days; standard deviation 21.92 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Soil water partition coefficient (K_d)	3104 mL/g	MRID 49175401 Average of the following six values: 3966, 3823, 2458, 2384, 2744, 3250 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset).
Foliar half-life	35	Default value.
Post-harvest foliar pesticide disposition	Surface applied	Default value.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 17. Deltamethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift[1]	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[4]	Incorp. depth (cm)	PHI (days)
01: GA onion, WA onion, CA garlic, CA onion/ Bulb Vegetables	Aerial	0.029	0.95	0.0314 (0.028)	4	5		0	1
02: ID potato, ME potato, CA potato, WA potato, FL potato, NC sweet potato/ Tuberous and Corm Vegetables	Aerial	0.029	0.95	0.0314 (0.028)	5	3		0	3
08: CA almond, GA pecan, OR filbert/ Tree Nuts	Airblast	0.015	0.99	0.0370 (0.033)	5	7		0	21
04: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	Aerial	0.029	0.95	2 @ 0.0163 (0.0145) + 3 @ 0.0247 (0.022)	5	21		0	21
05: FL, OR sweet corn/ Sweet Corn	Aerial	0.029	0.95	0.0314 (0.028)	16	1		0	1
06: CA, MS, NC, TX cotton/ Cotton	Aerial	0.029	0.95	0.0336 (0.03)	10	5		0	21
07: MS soybean/ Soybean	Aerial	0.029	0.95	1 @ 0.0179 (0.016) + 3 @ 0.0314 (0.028)	4	Assume 5		0	21
08: ND wheat/ Sunflower[3]	Aerial	0.029	0.95	0.0168 (0.015)[2]	3	Assume 5		0	21

Table 17. Deltamethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns									
Run Number: PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift[1]**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App.[4]**	**Incorp. depth (cm)**	**PHI (days)**
10: FL cucumber, CA, MI, MO, NJ, TX melons/ Cucurbit Vegetables	Aerial	0.029	0.95	0.0314 (0.028)	6	3		0	3
10: FL pepper, CA, FL, PA tomato, PA and TX vegetables/ Fruiting Vegetables	Aerial	0.029	0.95	0.0314 (0.028)	6	5		0	1

[1]Assumptions: aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft.
[2]For sunflowers, the maximum rate is 0.018 lb a.i./A. The maximum seasonal rate was divided by 3 applications.
[3]Except in California.
[4]The date of first application was variable for each crop scenario.

Table 18. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Deltamethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	505.2 g/mole	Laskowski 2002[2]
Vapor Pressure (25ºC)	9.32×10^{-11} torr	Laskowski 2002
Solubility in Water (20ºC)	0.000200 mg/L	Laskowski 2002
Photolysis in Water (40°N)	86 days	MRID 42114818 Highest available value. Artificial light was compared to natural sunlight, but the latitude was not stated in the DER. Assumed to be 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 50.5 days	MRID 41677404, 41677405, 42114820 Represents the 90th percentile of the upper confidence bound on the mean for the following six values: 52.5, 54.6, 46.2, 50.2, 22, 26 days at 25°C; average 41.917 days; standard deviation 14.212 days; n = 6; one sided student's t value $t_{90,n-1}$ = 1.476.
Hydrolysis Half-life at pH 7	0	MRID 41651038; Stable
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 86.1 days	MRID 44977005, 48988201 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 25.9, 120.3, 21.2, 9.29 days at 20°C; average 44.1725 days; standard deviation 51.2309 days; one sided student's t value $t_{90,n-1}$ = 1.638. Half-lives based on the sum of deltamethrin plus the *alpha*-R-isomer.
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 138.6 days	MRID 49114109 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 98.9, 60.7 days at 20°C; average 79.8 days; standard deviation 27.011 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	449,000 mL/g_{OC}	MRID 41651039, 42976501 Average of the following four values: 317000, 255000, 516000, 708000 mL/g. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35	Default value.

Table 18. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Deltamethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

[1] Inputs determined in accordance with EFED *"Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 19. Permethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift[1]	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[5]	Incorp. depth (cm)	PHI (days)
01: CA, IL, MN, NC, PA, TX alfalfa/ Alfalfa	Aerial	0.032	0.95	0.2242 (0.2)/ cutting[2]	4[2]	30		0	14[3]
02: CA wine grapes, NY grapes, OR berries/ Blueberries	Aerial	0.032	0.95	0.3362 (0.3)	8	Assume 10		0	Assume 14
03: CA almonds, GA pecans/ Tree Nuts (based on pistachios)	Assume Airblast	0.015	0.99	0.3362 (0.3)	3	10		0	0
04: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	Aerial	0.032	0.95	0.1681 (0.15)	3	7		0	30
05: FL, OR sweet corn/ Sweet Corn	Aerial	0.032	0.95	0.2242 (0.2)	4	3		0	1
06: CA lettuce/ Leafy Greens (based on the rate for lettuce)	Aerial	0.032	0.95	0.2242 (0.2)	4[4]	7		0	Assume 14
07: MS soybean/ Soybean	Aerial	0.032	0.95	0.2242 (0.2)	2	10		0	60
08: CA cole crops, FL cabbage/ Brassica Vegetables (based on maximum rate on broccoli)	Aerial	0.032	0.95	0.2242 (0.2)	4	5		0	1
09: FL pepper, CA, FL, PA tomato, PA and TX vegetables/ Fruiting Vegetables (based on the rate for bell peppers)	Aerial	0.032	0.95	0.2242 (0.2)	4	5		0	3
10: FL cucumber, CA, MI, MO, NJ, TX melons/ Cucurbit Vegetables (based on rate for watermelons)	Aerial	0.032	0.95	0.2242 (0.2)	6	7		0	0

[1]Assumptions: aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft.
[2]Assumed 4 applications/year, based on BEAD's recommendation.
[3]A 14 day PHI applies to applications above 0.1 lb a.i./A.
[4]Up to 6 applications are allowed in HI.
[5]The date of first application was variable for each crop scenario.

Table 20. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Permethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	391.3 g/mole	Laskowski 2002[2]
Vapor Pressure	1.48×10^{-8} torr	Laskowski 2002[2]; MRID 42109801
Solubility in Water	0.0055 mg/L	Laskowski 2002[2]
Photolysis in Water (40°N)	94 days	MRID 40242801, 49542801 Highest available value.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 211 days	MRID 42410002, 49622001 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 37 days at 25ºC, and 12.3, 50.4, 431 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 37, 8.70, 35.6, 305 days; average 96.575 days; standard deviation 139.559 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Hydrolysis Half-life (at pH 6)	0	MRID 00102043; Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 56.7 days	MRID 43938201, Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 38.18, 42.88 days at 25ºC, and 89.1, 9.77 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 38.18, 42.88, 63.0, 6.91 days; average 37.743 days; standard deviation 23.203 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 193 days	MRID 43982001 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 144 days at 25ºC, and 262, 116 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 144, 185, 82.0 days; average 137.00 days; standard deviation 51.856 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Soil Water Partition Coefficient (K_d)	3186.8 mL/g	MRID 45170102, 49624901 Average of the following nine values: 1450, 1970, 2710, 2530, 5877, 2991, 3373, 411, 7369 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset). Study 41868001 was not found to be appropriate for use in risk assessment.
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 21. Esfenvalerate Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[2]	Incorp. depth (cm)
CA cole crops, FL cabbage/ Brassica (head & stem) Vegetables	Foliar, Aerial	0.0293	0.95	0.0560 (0.05)	10	1		0
NY grapes, OR berries/ Blueberries (*except CA*)[3]	Foliar, recommend Ground	0.027	0.99	0.0560 (0.05)	5	5		0

Table 21. Esfenvalerate Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns								
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App.[2]**	**Incorp. depth (cm)**
CA almond, GA pecan, OR filbert/ Tree Nuts (based on rate on almonds)	Foliar, assumed airblast	0.015	0.99	0.112 (0.1)	4	5		0
CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	At plant or Foliar, assume Aerial	0.0293	0.95	0.0560 (0.05)	10	3		0
FL, OR sweet corn/ Sweet Corn	Foliar, Aerial	0.0293	0.95	0.0560 (0.05)	16	1		0
CA, MS, NC, TX cotton/ Cotton	At plant or Foliar, assume Aerial	0.0293	0.95	0.0560 (0.05)	10	3		0
MS soybean/ Soybeans	Foliar, Aerial	0.0293	0.95	0.0560 (0.05)	5	3		0
CA corn, ND wheat/ Sunflowers	Foliar, Aerial	0.0293	0.95	0.0560 (0.05)	5	3		0
FL cucumber, CA, MI, MO, NJ, TX melons/ Cucurbit Vegetables	Foliar, Aerial	0.0293	0.95	0.0560 (0.05)	8	8		0
FL pepper, CA, FL, PA tomato, PA and TX vegetables (based on the rate for tomatoes)/ Fruiting Vegetables	Foliar, Aerial	0.0293	0.95	0.0560 (0.05)	10	3		0

[1]Assumptions: aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft. For ground application, assumed high boom and ASABE Medium/Coarse DSD, and a buffer zone of 25 ft.
[2]The date of first application was variable for each crop scenario.
[3]Do not apply within 7 days of pollination; Do not apply through irrigation; *Ground* application recommended.

Table 22. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Esfenvalerate[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	419.9 g/mole	USEPA 2010
Vapor Pressure (25ºC)	4.7×10^{-7} torr	46725304, Comb 2002 (6.3×10^{-5} Pa, OECD 109)
Solubility in Water	0.006 mg/L	Open Lit., (Laskowski 2002), (European Commission 2005)
Photolysis in Water (40°N)	9 days (all isomers)	MRID 40443801 Use the highest available value among the following: 6 days @ pH 5, SS-isomer, and 9 days, for all isomers. Assumed to be 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	225 days (SS-isomer)	MRID 00146578 Represents EFED's conservative assumption value due to limited studies (based on 1 soil, 75 days x 3)[1].
Hydrolysis Half-life	0	MRID 40999303 Minimal degradation in 30 days for all isomers @ pH 5, 7, 9
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 80.4 days	MRID 49140401 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 17.2 & 48.2 days; average 32.7 days; standard deviation 21.92 days; one sided student's t value $t_{90,n-1}$ = 3.078.

Table 22. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Esfenvalerate[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 138.3 days	MRID 49140402 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 11.5, 73.7 days at 20°C; average 42.6 days; standard deviation 43.98 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	251,717 mL/g_{OC}	MRID 45555102 Average of the following six values: 85700, 140000, 141700, 171700, 375000, 596200 mL/g. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 23. Cypermethrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[2]	Incorp. depth (cm)
CA, IL, MN, NC, PA, TX alfalfa/ Alfalfa	Aerial	0.0293	0.95	0.056 (0.05)	3	7		0
CA wine grapes, NY grapes, OR berries/ Blueberries:	Aerial	0.0293	0.95	0.056 (0.05)	6	7		0
FL citrus, CA citrus, TX grapefruit/ Citrus:	Assume Airblast	0.015	0.99	0.056 (0.05)	4	14		0
CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	Aerial	0.0293	0.95	0.056 (0.05)	4	3		0
FL, OR sweet corn/ Sweet Corn	Aerial	0.0293	0.95	0.056 (0.05)	6	3		0
CA, MS, NC, TX cotton/ Cotton	Aerial	0.0293	0.95	0.056 (0.05)	6	3		0
MS soybean/ Soybean	Ground	0.0071	0.99	0.056 (0.05)	6	7		0
CA corn, ND wheat/ Sunflower	Ground	0.0071	0.99	0.056 (0.05)	1	--		0
CA, ND, TX, OR wheat/ Wheat	Aerial	0.0293	0.95	0.056 (0.05)	5	14		0
CA cole crops, FL cabbage; FL cucumber, CA, MI, MO, NJ, TX melons; FL pepper, CA, FL, PA tomato, PA and TX vegetables]/ Brassica, Fruiting or Cucurbit Vegetables	Aerial	0.0293	0.95	0.056 (0.05)	6	4		0
AR, CA, LA, MS, MO and TX rice/ Rice[3]	Aerial	0.0293	0.95	0.056 (0.05)	4	7		0[3]

Table 23. Cypermethrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns								
PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App.[2]**	**Incorp. depth (cm)**

[1]Assumptions: aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft.
[2]The date of first application was variable for each crop scenario.
[3] For rice, a 7 day water holding period is required for all applications when rice fields are flooded.

Table 24. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cypermethrin and *Zeta*-cypermethrin

Fate Property	Value (unit)	Source/Comment[1]
Molecular Weight	416.3 g/mole	http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm [2]
Vapor Pressure (@25°C)	1.7×10^{-9} torr	http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm [2]
Solubility in Water (@20°C)	0.009 mg/L	http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm [2]
Photolysis in Water (40°N, @25°C)	36.2 days	MRID 42395701 Assumed latitude of 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	73 days x 3 = 219 days	MRID 42129001 IORE value reported
Hydrolysis Half-life (at pH 7)	210 days	MRID 42620501 Alkaline (pH 9) hydrolysis rate extrapolated to pH 7
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	9.5 days x 3 = 25.5 days	MRID 45920801 Represents the average of two labels (cyclopropyl and phenyl) in one system
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	17.7 x 3 = 53.1 days	MRID 44876105 Represents the combination of two labels (phenyl and cyclopropyl) in one system (clay loam sediment): IORE result
Soil Water Partition Coefficient (K_{OC})	141,700 mL/g_{OC}	MRID 42129003 Average of the following four values: 328,500 (sand), 134,900 (sandy loam), 82,600 (silty loam), 20,800 (clay loam)
Foliar Half-life	35 days	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2. Lewis, K.A., Green, A., Tzilivakis, J. and Warner, D. (2015). The Pesticide Properties Data Base (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2015.
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 25. Cyfluthrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[2]	Incorp. depth (cm)	PHI (days)
CA, IL, MN, NC, PA, TX alfalfa/ Alfalfa	Aerial	0.029	0.95	0.049 (0.044)	8	5		0	7
CA wine grapes, NY grapes, OR berries/ Grapes	Aerial	0.0293	0.95	0.056 (0.05)	4	14		0	3
FL citrus, CA citrus, TX grapefruit/ Citrus	Assume Airblast	0.015	0.99	0.112 (0.1)	2	7		0	0
CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	Aerial	0.029	0.95	0.049 (0.044)	4	7		0	21
FL, OR sweet corn/ Sweet Corn	Aerial	0.029	0.95	0.049 (0.044)	10	2		0	0
CA, MS, NC, TX cotton/ Cotton	Aerial	0.0293	0.95	0.056 (0.05)	6	3		0	0
MS soybean/ Soybeans	Aerial	0.029	0.95	0.049 (0.044)	4	7		0	15
CA corn, ND wheat/ Sunflowers	Aerial	0.029	0.95	0.049 (0.044)	3	7		0	30
CA, ND, TX, OR wheat/ Wheat	Aerial	0.0289	0.95	0.043 (0.038)	2	3		0	30
CA cole crops, FL cabbage; FL cucumber, CA, MI, MO, NJ, TX melons; FL pepper, CA, FL, PA tomato, PA and TX vegetables]/ Brassica, Fruiting and/or Cucurbit Vegetables	Aerial	0.0293	0.95	0.056 (0.05)	12	7		0	0

[1]Assumptions: aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft.
[2]The date of first application was variable for each crop scenario.

Table 26. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cyfluthrin and *Beta*-cyfluthrin[1]

Fate Property	Value (unit)	Source/Comment[1,2,3]
Molecular Weight	434.29 g/mole	Product Chemistry
Vapor Pressure (25ºC)	1.5×10^{-8} torr	Laskowski (2002)[4]
Henry's Law Constant (25°C)	3.7×10^{-6} Atm·m^3/mol	Laskowski (2002)[4]
Solubility in Water (25ºC)	2.32×10^{-3} ppm	Laskowski (2002)[4] Solubility is low in water and varies between stereoisomers.
Photolysis in Water (38°N)	0.7 days	MRID 45022102 Cyfluthrin degraded with an EFED-calculated first order kinetics nonlinear half-life ($t_{1/2}$) of 0.7 days (r^2 = 0.93; linear $t_{1/2}$ = 4.5 days, r^2 = 0.75). Natural sunlight, 38°N.

Table 26. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Cyfluthrin and *Beta*-cyfluthrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1,2,3]**
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ Combined t_{input} = 72.68 days	MRID 00131494, 48350602, 49272603, 49272605, 49272606 Represents the 90th percentile of the upper confidence bound on the mean for the following nine values: 73.5 (cyfluthrin), 94.8 days (cyfluthrin) at 25°C, and 174 (DFOP, *beta*-cyfluthrin), 39.7 (IORE, cyfluthrin), 105 (IORE, cyfluthrin), 25.7 (IORE, *beta*-cyfluthrin), 69.2 (IORE, *beta*-cyfluthrin), 20.6 (IORE, *beta*-cyfluthrin), 20.3 (IORE, *beta*-cyfluthrin) at 20°C; the corrected half-lives at 25°C, are as follows[5]: 73.5, 94.8, 123, 28.1, 74.2, 18.2, 48.9, 14.6, 14.4; average 54.4111 days; standard deviation 39.2291 days; n = 9; one sided student's t value $t_{90,n-1}$ = 1.397.
Hydrolysis Half-life	0	00131493, 00137539, 45022101 Stable at pH 5 and 7; 2.1 days at pH 9.
Aerobic Aquatic Metabolism[2,3] Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ Combined t_{input} = 44.58 days	MRID 46824101, 49272609 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 10.4 (IORE, cyfluthrin), 55.2 (DFOP, cyfluthrin) days at 22°C; and 27.8 days (IORE, *beta*-cyfluthrin) at 20°C; the corrected half-lives at 25°C, are as follows[5]: 8.44, 44.8, 19.7 days; average 24.3133 days; standard deviation 18.6138 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Anaerobic Aquatic Metabolism[2,3] Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ Combined t_{input} = 25.59 days	MRID 49272610 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 26.2, 10.3, 9.41 days (all half-lives IORE, *beta*-cyfluthrin) at 20°C; average 15.3033 days; standard deviation 9.4473 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	184,864 mL/g_{oc}	MRID 00131495, 00137544, 45022103, 49272602 Average of the following nine values: 124,000, 180,290, 117,946, 73,484, 274,149, 253,221, 226,230, 230,000, and 184,458 mL/g_{oc}. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, and the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35 days	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

[1] Inputs determined in accordance with EFED *"Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-calculate-representative-half-life-values#current
[3] http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/standard-operating-procedure-using-nafta-guidance
[4] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
[5] USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 27. Cyhalothrins (*Lambda*- and *Gamma*-) Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App.[2]**	**Incorp. depth (cm)**
CA, IL, MN, NC, PA, TX alfalfa/ Alfalfa	Aerial	0.0286	0.95	0.0336 (0.03) per cutting	4	NS – 3		0

Table 27. Cyhalothrins (*Lambda*- and *Gamma*-) Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	Max. No. of Apps. @ Max. Rate	Min. Interval Between Apps. (days)	Day of First App.[2]	Incorp. depth (cm)
FL cucumber, CA, MI, MO, NJ, TX melons/ Cucurbit Vegetables	Aerial	0.0286	0.95	0.0336 (0.03)	6	5		0
FL citrus, CA citrus, TX grapefruit/ Citrus	Assume Airblast	0.015	0.99	0.0448 (0.04)	6	NS – 3		0
CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, TX corn/ Corn	Aerial	0.0286	0.95	0.0336 (0.03)	4	3		0
FL, OR sweet corn/ Sweet Corn	Aerial	0.0286	0.95	0.0336 (0.03)	16	NS – 3		0
CA, MS, NC, TX cotton/ Cotton	Aerial	0.029	0.95	0.0448 (0.04)	5	3		0
MS soybean/ Soybeans	Aerial	0.0286	0.95	0.0336 (0.03)	2	5		0
CA corn, ND wheat/ Sunflowers	Aerial	0.0286	0.95	0.0336 (0.03)	4	5		0
CA, ND, TX, OR wheat/ Wheat	Aerial	0.0286	0.95	0.0336 (0.03)	2	5		0
CA cole crops, FL cabbage; FL pepper, CA, FL, PA tomato, PA and TX vegetables]/ Brassica (head and stem) and Fruiting Vegetables	Aerial	0.0286	0.95	0.0336 (0.03)	12	5		0
AR, CA, LA, MS, MO and TX rice/ Rice[3]	Aerial	0.029	0.95	0.0448 (0.04)	3	3 first applic. & 5-7 for subsequent applications; assume 5		0[3]

[1]Assumptions: Aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft.
[2]The date of first application was variable for each crop scenario.
[3] For rice, a 7 day water holding period is required for all applications when rice fields are flooded.

Table 28. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for *Lambda*- and *Gamma*-cyhalothrin[1]

Fate Property	Value (unit)	Source/Comment[1]
Molecular Weight	449.86 g/mole	TOXNET/ HSDB
Vapor Pressure (20°C)	1.56×10^{-9} torr	Laskowski 2002[2]
Solubility in Water (pH 6.5 and 20ºC)	5×10^{-3} mg/L	Laskowski 2002[2]
Photolysis in Water (40°N)	13 days	MRID 46394702
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 52.0 days	MRID 00151607, 44861504, 45447410, 45447411, 45447410. Represents the 90th percentile of the upper confidence bound on the mean for the following five values: 28.2, 36.9, 46.2, 46.8, 60.5 days at 25°C; average 43.72 days; standard deviation 12.09 days; one sided student's t value $t_{90,n-1}$ = 1.533.
Hydrolysis Half-life at pH 7	0	MRID 00151604, 45447409; Stable

Table 28. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for *Lambda*- and *Gamma*-cyhalothrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 47.87 days	MRID 44861506, 45447412, 44367402 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 21.1, 34.1, 40.1, 52.9 days at 25°C; average 37.05 days; standard deviation 13.21 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 6084 days	MRID 44367401, 49540101 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 142, 6320, 57.7 days at 25°C; average 2173 days; standard deviation 3591 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Soil water partition coefficient (K_d)	2673 mL/g	MRID 44861503, 45447413 Average of the following 18 K_d values: 3810, 1970, 5880, 2100, 4490, 6890, 7610, 3470, 2400, 4870, 672, 751, 826, 239, 555, 601, 630, 355 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset).
Foliar half-life	35 days	Default value.
Post-harvest foliar pesticide disposition	Surface applied	Default value.

[1] Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 29. Fenpropathrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns

Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App.[2]**	**Incorp. depth (cm)**	**PHI (days)**
CA cole crops, FL cabbage/ Brassica (head and stem) Vegetables	Aerial	0.0335	0.95	0.336 (0.3)	2.7	7		0	7
CA wine grapes, NY grapes, OR berries/ Bushberries and caneberries	Aerial	0.0335	0.95	0.336 (0.3)	2 per cc	NS-14		0	3
FL citrus, CA citrus, TX grapefruit/ Citrus	Assume Airblast	0.015	0.99	0.448 (0.4)	2 per cc	NS-10		0	1
FL cucumber, CA, MI, MO, NJ, TX melons/ Cucurbit Vegetables	Aerial	0.0335	0.95	0.336 (0.3)	2.7	7		0	7
NC, OR, PA apple/ Pome Fruits	Aerial	0.0349	0.95	0.448 (0.4)	2 per cc	NS-10		0	14
CA, MS, NC, TX cotton/ Cotton	Aerial	0.0335	0.95	0.336 (0.3)	4	7		0	21
GA Peaches, MI Cheeries, WA Orchards/ Stone Fruits	Aerial	0.0349	0.95	0.448 (0.4)	2 per cc	10		0	3
CA almond, GA pecan, OR filbert/ Tree Nuts	Aerial	0.0349	0.95	0.448 (0.4)	2 per cc	NS-10		0	3
NC peanuts/ Peanuts	Aerial	0.0335	0.95	0.336 (0.3)	2 per cc	NS-7		0	14

Table 29. Fenpropathrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC, Crop Use Patterns									
Run Number, PWC Scenario/ Uses Represented	**Method of App.**	**Spray Drift**	**App. Efficiency**	**Max. App. Rate kg a.i./ha (lb a.i./A)**	**Max. No. of Apps. @ Max. Rate**	**Min. Interval Between Apps. (days)**	**Day of First App.[2]**	**Incorp. depth (cm)**	**PHI (days)**
FL pepper, CA, FL, PA tomato, PA and TX vegetables/ Fruiting Vegetables	Aerial	0.0335	0.95	0.336 (0.3)	2.7	7		0	3

[1]Assumptions: Aerial application, boom height 10 ft, wind speed 15 mph, buffer distance 150 ft, DSD = ASABE Medium. For airblast application, assumed sparse/young dormant combination orchard, and a buffer zone of 25 ft.
[2]The date of first application was variable for each crop scenario.

Table 30. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Fenpropathrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	349.43 g/mole	Laskowski 2002[2]
Vapor Pressure (25°C)	1.39 x 10^{-8} torr	Laskowski 2002[2]
Solubility in Water (22ºC)	10.3 µg/L	MRID 44370001
Photolysis in Water (40°N)	0.125	MRID 49491401 indicates a 3 hour (0.125 day) half-life. MRID 4397227 indicated that fenpropathrin was stable when exposed to natural sunlight in a solution buffered with 8% acetonitrile. The value from the newest available study was used as the model input.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 497 days fenpropathrin = 1146 fenpropathrin plus unextracted residues	MRID 15525902, 49316001 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 155 (SFO) at 25ºC, and 386 (Slow DFOP), 709 (Slow DFOP), 702 (slow DFOP) days at 20°C; average (temperature corrected to 25ºC) 356 days; standard deviation 171 days; one sided student's t value $t_{90,n-1}$ = 1.64. For parent plus unextracted residues the corresponding values are 248 at 25ºC, and 633, 1060, and 2030 at 25ºC. Mean=720; standard deviation=520.
Hydrolysis Half-life at pH 7	0	MRID 131438, 141320, 42599901; stable
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 1,168 days for fenpropathrin =87,432 days for fenpropathrin plus unextracted residues	MRID 49316003 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 88.7 (SFO), 618 (T_{IORE}) days for fenrpropathrin (days at 20°C; average 353 days; standard deviation 374 days; one sided student's t value $t_{90,n-1}$ = 3.07; 43,300 (T_{IORE}) and 818 (Slow DFOP) days for fenrpropathrin plus unextracted residues (days at 20°C; average 22,059 days; standard deviation 30,039 days; one sided student's t value $t_{90,n-1}$ = 3.07
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 674 days for fenpropathrin	MRID 49370003, 44370004, 49316004 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 78 and 67 days at 25°C and 1250 at 20ºC. Temperature corrected values for 25ºC; average 129 days; standard deviation 307 days; one sided student's t value $t_{90,n-1}$ = 1.88. Unextracted residues were less than 10% in all systems.

Table 30. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Fenpropathrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Organic-c1rbon normalized solid-water distribution coefficient (K_{OC})	207,560 mL/g_{OC}	MRID 49541801 Average of the following five values: 114640, 296784, 136916, 303212, and 186248 mL/g_{OC}. The K_{OC} model represents the mobility better than the $K_d$model (binding does correlate with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset). Values from MRID 44370002 were not used because the equilibrium solution was $Ca(NO_3)_2$.
Foliar half-life	35 days	Value recommended for T-REX model. Deviation from the 2009 input parameter guidance.
Post-harvest foliar pesticide disposition	Surface applied	Default value.
Air Diffusion Coefficient (Cm^2/day)	0	This function was not utilized because significant volatilization was not expected.
1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009. 2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. *Rev. Environ. Contam. Toxicol.* 2002; 174:49-170.		

For the modeling of rice use for three chemicals, many of the input parameters are similar to those used in the PWC. Besides the environmental fate input parameters, the model offers several options related to the flooding and release of the water, and crop parameters, for example. **Tables 31 to 33** show the input parameters for the three chemicals for which rice modeling was conducted (Chemical and Applications tabs), followed by the tables showing the flood events.

Table 31. PFAM inputs specific to Pyrethrins

Input Parameter	Value	Source	Comment
Chemical Tab			
Water Column Half-life (days)	10.25 at 25ºC	MRID 43499802; 49123501	Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 10.5 days at 25ºC, and 6.44, 5.37 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 10.5, 3.85, 3.80 days; average 6.050 days; standard deviation 3.8539 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Benthic Compartment Half-Life (days)	258 at 25ºC	MRID 43499801	Single available value multiplied by 3 (86 days x 3).
Un-flooded Soil Half-life (days)	7.26 at 25ºC	MRID 43499803, 49687101	Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 9.5 days at 25ºC, and 5.53, 3.51, 0.742 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 9.5, 3.91, 2.48, 0.525 days; average 4.1038 days; standard deviation 3.8558 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Aqueous Near Surface Half-life (days)	0.49	MRID 43096601, 43567501, 43567601	Value at 34°N Latitude.
Hydrolysis Half-life (days)	0	MRID 43188201, 43567502	Stable at pH 7.

Input Parameter	Value	Source	Comment
Organic Carbon Partition Coefficient (K_{OC}) (mL/g_{OC})	35,171	MRID 43096603	Average of four values. It should be noted that the K_F model represents the mobility better than the K_{FOC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_F dataset is less than for the K_{FOC} dataset).
Molecular Weight (g/mol)	328.4	USEPA 2006[1]	–
Vapor Pressure (torr)	2×10^{-5} at 25°C	USEPA 2006[1]	–
Solubility (mg/L)	0.2 at 20°C	USEPA 2006[1]	–
Heat of Henry (J/mol)	48,780	HENRYWIN	Estimated using HENRYWIN program in EPISuite.
Henry Reference Temperature (°C)	25	User defined.	Assumed. Temperature of vapor pressure measurement.
Applications Tab			
Distribution of Days or Specific Days	Specific Days	--	Default for ecological exposure
First Day of Application (Month-day)	AR: 5/7 CA: 5/6 LA: 4/14 MS: 5/13 MO: 5/9 TX: 4/13	--	Assumed for Arkansas, California, Louisiana, Mississippi, Missouri, Texas
Application Rate (lbs a.i./A)	0.05 lbs a.i./A x 10 apps or 0.0560 kg a.i./ha x 10	Appendix A	3-day intervals
Application Timing	Not specified	Appendix A	Given the restriction of a 10-day water holding period, applications are assumed to occur during flooding.
Slow release (day^{-1})	0	--	Default; this is used if the formulation slowly releases the pesticide over time.
Drift factor	0	--	Default
Holding Period Duration (days)	10	Appendix A	For rice, a 10 day water hold is required for all applications when rice fields are flooded.

[1] USEPA 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006.

Table 32. PFAM inputs specific to Cyhalothrins

Input Parameter	Value	Source	Comment
Chemical Tab			
Water Column Half-life (days)	47.87 at 25°C	MRID 44861506, 45447412, 44367402	Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 21.1, 34.1, 40.1, 52.9 days at 25°C; average 37.05 days; standard deviation 13.21 days; one sided student's t value $t_{90,n-1}$ = 1.638.

Input Parameter	Value	Source	Comment
Benthic Compartment Half-Life (days)	6,084 at 25ºC	MRID 44367401, 49540101	Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 142, 6320, 57.7 days at 25°C; average 2173 days; standard deviation 3591 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Un-flooded Soil Half-life (days)	52.0 at 25ºC	MRID 00151607, 44861504, 45447410, 45447411, 45447410	Represents the 90th percentile of the upper confidence bound on the mean for the following five values: 28.2, 36.9, 46.2, 46.8, 60.5 days at 25°C; average 43.72 days; standard deviation 12.09 days; one sided student's t value $t_{90,n-1}$ = 1.533.
Aqueous Near Surface Half-life (days)	13	MRID 46394702	Value at 40 □N Latitude.
Hydrolysis Half-life (days)	0	MRID 00151604, 45447409	Stable at pH 7.
Organic Carbon Partition Coefficient (K_{OC}) (mL/g_{OC})	210,482	MRID 44861503, 45447413	Average of 18 K_{OC} values. It should be noted that the K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset).
Molecular Weight (g/mol)	449.86	TOXNET/ HSDB	–
Vapor Pressure (torr)	1.56×10^{-9} at 20°C	Laskowski (2002)	Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170. Solubility in pH 6.5 water.
Solubility (mg/L)	0.005 at 20°C	Laskowski (2002)	Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
Heat of Henry (J/mol)	48,780	HENRYWIN	Estimated using HENRYWIN program in EPISuite.
Henry Reference Temperature (°C)	20	User defined.	Temperature of vapor pressure and water solubility measurements.
Applications Tab			
Distribution of Days or Specific Days	Specific Days	--	Default for ecological exposure
First Day of Application (Month-day)	AR: 5/7 CA: 5/6 LA: 4/14 MS: 5/13 MO: 5/9 TX: 4/13	--	Assumed for Arkansas, California, Louisiana, Mississippi, Missouri, Texas
Application Rate (lbs a.i./A)	0.04 lbs a.i./A x 3 apps or 0.0448 kg a.i./ha x 3	EPA Reg. No. 100-998	Typicall 5-7 days as needed by scouting.
Application Timing	Apply as required by scouting.	EPA Reg. No. 100-998	Given the restriction of a 7-day water holding period, applications are assumed to occur during flooding.
Slow release (day^{-1})	0	--	Default; this is used if the formulation slowly releases the pesticide over time.

Input Parameter	Value	Source	Comment
Drift factor	0	--	Default
Holding Period Duration (days)	7	EPA Reg. No. 100-998	Do not release flood water within 7 days of an application.

Table 33. PFAM inputs specific to Cypermethrins

Input Parameter	Value	Source	Comment
Chemical Tab			
Water Column Half-life (days)	25.5 at 25ºC	MRID 45920801	Represents the average of two labels (cyclopropyl & phenyl) in one system. 3X single available value of 9.5 days.
Benthic Compartment Half-Life (days)	53.1 at 25ºC	MRID 44876105	Represents the combination of two labels (phenyl & cyclopropyl) in one system (clay loam sediment): IORE result. 3X single available value of 17.7 days.
Un-flooded Soil Half-life (days)	219 at 25ºC	MRID 42129001	3X the single available value of 73 days (IORE).
Aqueous Near Surface Half-life (days)	36.2	MRID 42395701	Value at 40^0N Latitude.
Hydrolysis Half-life (days)	0	MRID 42620501	If the chemical undergoes both aquatic metabolism and hydrolysis and the aerobic aquatic and anaerobic aquatic metabolism inputs are not corrected for hydrolysis, enter zero as the hydrolysis input. Alkaline (pH 9) hydrolysis rate extrapolated to pH 7, half-life is 210 days.
Organic Carbon Partition Coefficient (K_{OC}) (mL/g_{OC})	141,700	MRID 42129003	Average of the following four values: 328,500 (sand), 134,900 (sandy loam), 82,600 (silty loam), 20,800 (clay loam) mL/g_{OC}.
Molecular Weight (g/mol)	416.3	PPDB	Lewis, K.A., Green, A., Tzilivakis, J. and Warner, D. (2015). The Pesticide Properties Data Base (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2015: http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm
Vapor Pressure (torr)	1.7×10^{-9} at 25°C	PPDB	Lewis, K.A., Green, A., Tzilivakis, J. and Warner, D. (2015). The Pesticide Properties Data Base (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2015: http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/197.htm
Solubility (mg/L)	0.009 at 20°C	PPDB	Lewis, K.A., Green, A., Tzilivakis, J. and Warner, D. (2015). The Pesticide Properties Data Base (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, 2006-2015: ((
Heat of Henry (J/mol)	48,780	HENRYWIN	Estimated using HENRYWIN program in EPISuite. Estimated for cypermethrin, since *zeta*-cypermethrin is not in the database.

Input Parameter	Value	Source	Comment
Henry Reference Temperature (°C)	25	User defined.	Assumed. Temperature of vapor pressure measurement.
Applications Tab			
Distribution of Days or Specific Days	Specific Days	--	Default for ecological exposure
First Day of Application (Month-day)	AR: 5/7 CA: 5/6 LA: 4/14 MS: 5/13 MO: 5/9 TX: 4/13	--	Assumed for Arkansas, California, Louisiana, Mississippi, Missouri, Texas
Application Rate (lbs a.i./A)	0.05 lbs a.i./A x 4 apps or 0.0560 kg a.i./ha x 4	EPA Reg. No. 279-3126	7-day intervals
Application Timing	Apply as needed, based on scouting.	EPA Reg. No. 279-3126	Given the restriction of a 7-day water holding period, applications are assumed to occur during flooding.
Slow release (day^{-1})	0	--	Default; this is used if the formulation slowly releases the pesticide over time.
Drift factor	0	--	Default
Holding Period Duration (days)	7	EPA Reg. No. 279-3126	The holding time for floodwater release is 7 days after application.

Table 34 shows a summary of the Crop, Physical and Watershed tabs for the three pyrethroids with rice use.

Table 34. Summary of model inputs for the Crop, Physical and Watershed tabs for Pyrethrins, Cypermethrins and Cyhalothrins

Parameter	Value	Source or Comment
Crop Tab		
Zero Height Reference Month/Day (State)	5/11 (AR) 5/23 (CA) 4/24 (LA) 5/12 (MS) 5/15 (MO) 4/19 (TX)	See metadata file
Days from Zero Height to Full Height	115 (AR) 125 (CA) 102 (LA) 111 (MS) 118 (MO) 103 (TX)	See metadata file

Parameter	Value	Source or Comment
Days from Zero Height to Removal	136 (AR) 139 (CA) 123 (LA) 132 (MS) 139 (MO) 124 (TX)	See metadata file
Maximum Fractional Areal Coverage	1.0 (All)	See metadata file
Physical Tab		
Meteorological files	AR (w13963) CA (w23232) LA (w03937) MS (w03940) TX (w13958) MO (w13994)	Meteorological data available EPA Models web site (SAMSON data). Stations correspond to Little Rock, AR (w13963), Sacramento, CA (w23232), Lake Charles, LA (w03937), Jackson, MS (w03940), and Austin, TX (w13958)
Latitude	AR 36.2° CA 38.6° LA 31° MS 32° TX 30° MO 39°	Corresponds to latitude of meteorological station.
Area of Application (m^2)	Ecological Risk Assessment: 100,000	This input does not have an impact on the concentration estimated inside the rice paddy and for the Ecological Risk Assessment.
Weir Leakage (m/d)	0	PFAM default
Benthic Leakage (m/d)	0	PFAM default
Mass transfer coefficient (m/s)	$1x10^{-8}$	PFAM default
Reference depth (m)	0.1016	Set to same depth as initial weir height, per PFAM guidance.
Benthic depth (m)	0.05	PFAM default
Benthic porosity	0.50	PFAM default
Dry bulk density (g/cm^3)	1.35	PFAM default
F_{OC} Water Column on SS	0.04	PFAM default
F_{OC} benthic	0.01	PFAM default
SS (mg/L)	30	PFAM default
Water column DOC (mg/L)	5.0	PFAM default
Chlorophyll CHL (mg/L)	0.005	PFAM default
Dfac	1.19	PFAM default
Q10	2	PFAM default
Watershed Tab		
Calculate Downstream waterbody concentrations	NO	Select NO for ecological risk assessments.
Area of Surrounding Watershed (m^2)	Does not apply to ecological risk assessments.	--
Curve Number of Surrounding Watershed		
Base flow (m^3/s)		
Width of waterbody (m)		
Depth of waterbody (m)		
Length of waterbody (m)		

CA=California; AR=Arkansas; LA=Louisiana; TX=Texas; MS=Mississippi; MO=Missouri

Tables 35 to 44 tables show the input parameters for the Floods tab in PFAM for the ten available modeling scenarios. For the majority of the states there are two available scenarios: one simulates a winter flood and the other simulates no winter flooding event. As shown in the tables, these scenarios do not include turnover.

Table 35. Arkansas, Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO AR Winter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				May 4				Midpoint of typical plant date is 5/1. First flush occurs Plant + 3 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				4				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood Field 5/4
122	0	122	0	122	0	122	0	Drain field 14 days prior to harvest (9/3)
181	0.1016	181	0.1016	181	0.1016	181	0	Flood field for winter Flood 11/1
271	0	271	0	271	0	271	0	Drain field after winter flood 1/30

Table 36. Arkansas, No Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO AR noWinter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				May 4				Midpoint of typical plant date is 5/1. First flush occurs Plant + 3 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				2				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood Field 5/4
122	0	122	0	122	0	122	0	Drain field 14 days prior to harvest (9/3)

Table 37. California, Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO CA Winter noTurn.pfs)

Parameter	Value	Source or Comment
Floods Tab		
Reference Date	May 3	Midpoint of typical plant date is 5/13. Flooding occurs at Plant -10 days.

Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				4				Number of events need to capture flooding and releases over an entire year.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood Field 5/3
145	0	145	0	145	0	145	0	Drain field 14 days prior to harvest (09/25)
182	0.1016	182	0.1016	182	0.1016	182	0	Winter flood (11/1)
272	0	272	0	272	0	272	0	Drain (01/30)

Table 38. Louisiana, Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO LA Winter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				April 11				Midpoint of typical plant date is 4/14. First flush occurs Plant – 3 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				4				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood Field (4/11)
122	0	122	0	122	0	122	0	Drain field (8/11)
204	0.1016	204	0.1016	204	0.1016	204	0	Winter flood (11/1)
294	0	294	0	294	0	294	0	Drain (01/30)

Table 39. Louisiana, No Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO LA noWinter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				April 11				Midpoint of typical plant date is 4/14. First flush occurs Plant – 3 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				2				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood Field (4/11)
122	0	122	0	122	0	122	0	Drain field (8/11)

Table 40. Mississippi, Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO MS Winter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				May 10				Midpoint of typical plant date is 5/2. First flush occurs Plant + 8 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				4				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1524	0	0.1524	0	0.1524	0	0	Flood field 5/10
125	0	125	0	125	0	125	0	Drain field 9 days prior to harvest (9/12)
175	0.1524	175	0.1524	175	0.1524	175	0	Winter flood (11/1)
265	0	265	0	265	0	265	0	Drain (01/30)

Table 41. Mississippi, No Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO MS noWinter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				May 10				Midpoint of typical plant date is 5/2. First flush occurs Plant + 8 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				2				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1524	0	0.1524	0	0.1524	0	0	Flood field 5/10
125	0	125	0	125	0	125	0	Drain field 9 days prior to harvest (9/12)

Table 42. Missouri, Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO MO Winter noTurn.pfs)

Parameter				Value				Source or Comment
Reference Date				May 6				Midpoint of typical plant date is 5/5. First flush occurs Plant + 1 day.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				4				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood field at 4” (5/6)
127	0	127	0	127	0	127	0	Drain field 21 days prior to harvest (9/10)

Parameter				Value				Source or Comment
179	0.1016	179	0.1016	179	0.1016	179	0	Winter flood (11/1)
269	0	269	0	269	0	269	0	Drain (01/30)

Table 43. Missouri, No Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO MO noWinter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				May 6				Midpoint of typical plant date is 5/5. First flush occurs Plant + 1 day.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				2				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood field at 4" (5/6)
127	0	127	0	127	0	127	0	Drain field 21 days prior to harvest (9/10)

Table 44. Texas, Winter Flood, Input Parameters in the Flood Tab (scenario name: ECO TX Winter noTurn.pfs)

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				April 10				Midpoint of typical plant date is 4/9. First flush occurs Plant + 1 day.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				4				Number of events need to capture flooding and releases over an entire year and simulate the holding period.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.0762	0	0.0762	0	0.0762	0	0	Flood field at 3 inches (4/10)
119	0	119	0	119	0	119	0	Drain field 14 days prior to harvest (8/7)
205	0.1016	205	0.1016	205	0.1016	205	0	Winter flood (11/1)
295	0	295	0	295	0	295	0	Drain (01/30)

For modeling of three chemicals, the above presented flooding events were modified by the addition of one event after the last application (*i.e.*, ~10 days after the last application for pyrethrins, or ~7 days after the last application for cypermethrins and cyhalothrins), at the same fill, weir and minimum level than the previous event; however, for the additional event turnover is set to 0.017 $days^{-1}$. **Table 45** and **Figure 3** show an example, for the pyrethrins, using the California scenario with winter flood.

Applications of pyrethrins and pyrethroids were set to occur after the first flooding period, and for ecological exposure, as explained above, one event was added after the last

application and the specified holding period (*i.e.*, 10 days or 7 days). For example, for pyrethrins applications to the California scenario with winter flood (**Table 45**), the first flooding event occurs in May 3 (day 0, which is also the reference date) and a depth of 0.1016 m (4 inches). After flooding is established, 10 applications of pyrethrins at 0.05 lb a.i./A (0.0560 kg a.i./ha) and 3-day intervals occur from May 6 to June 2. This is the maximum application rate, maximum number of applications, and the minimum interval between applications. The number of flooding events is increased from 4 in the original scenario to 5. The added flooding event occurs on day 40 after the reference date (June 12), at the same fill, weir and minimum level than the previous flood event (0.1016 m), but a turnover value of 0.017 days^{-1}. The additional flooding event is shaded in **Table 45**. Further, **Figure 3** shows graphically the sequence of events for the example California scenario. The red lines in the graph are the ten applications; the pink line is the added turnover of 0.017 days^{-1} at 40 days. The figure is taken from the PFAM shell.

The PFAM model results are shown in the results tables (**Tables 46 to 55**), in **Section 5.3.2**.

Table 45. Example of input parameters in the Flood tab for the California, Winter Flood scenario, modified for Pyrethrins (original scenario name ECO CA Winter noTurn.pfs)[1]

Parameter				Value				Source or Comment
Floods Tab								
Reference Date				May 3				Midpoint of typical plant date is 5/13. Flooding occurs at Plant -10 days.
Gradual or sharp transition				Sharp				This simulates the release of water from rice paddy.
Number of Events				5				Number of events need to capture flooding and releases over an entire year. One added event.
Fill Level		Weir		Min. Level		Turn over		Comments
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0.1016	0	0.1016	0	0.1016	0	0	Flood Field 5/3
40	0.1016	40	0.1016	40	0.1016	40	0.017	Event occurs 6/12 or ~10 days after the last pyrethrins application, which is the specified water holding period.
145	0	145	0	145	0	145	0	Drain field 14 days prior to harvest (9/25)
182	0.1016	182	0.1016	182	0.1016	182	0	Winter flood (11/1)
272	0	272	0	272	0	272	0	Drain (1/30)

1 Changes are marked in shaded cells.

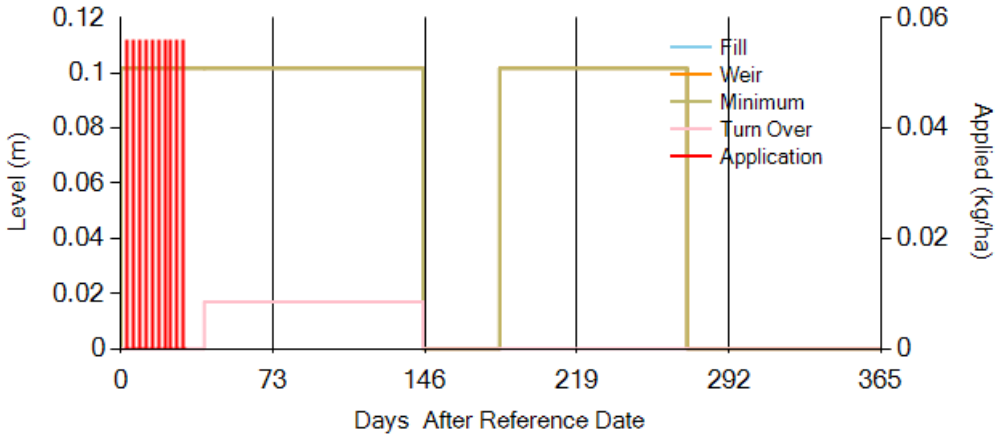


Figure 3. Graphic representation of application and flooding events for pyrethrins in CA
(Reference date or day 0 is May 3)

5.3.2. Model Results

The modeling results are presented in **Tables 46 to 55**. ***Note that all the scenarios described in the above tables were run in batch mode in the PWC, however, only the scenarios yielding the highest EECs, and located in high pyrethroid use areas, were presented in the results tables.*** The water column and pore water EECs are the freely dissolved pyrethroid or pyrethrin concentrations. This is the fraction of the chemical that is bioavailable. For some of the chemicals, the calculated EEC was above the limit of solubility. In such instances, the value was set to the solubility limit. The results obtained for the applications on rice fields for three of the chemicals are provided in the same tables below.

Table 46. Water Column, Pore Water, and Sediment EECs for Pyrethrins[1]

Scenario / Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg-dw)	21-day average EEC (µg/kg-dw)
MN alfalfa/ Alfalfa	Aerial	0.0560 (0.050)	3	10	3	0.663	0.490	0.328	0.239	0.234	72.2	70.7
NY grapes/ Blueberries	Aerial	0.0560 (0.050)	90	10	3	1.64	0.958	0.621	0.563	0.553	170	167
FL citrus/ Citrus	Assume Airblast	0.0560 (0.050)	180	10	3	0.515	0.236	0.145	0.111	0.108	33.5	32.6
IL corn/ Corn	Aerial	0.0560 (0.050)	120	10	3	1.22	0.682	0.449	0.359	0.354	108	107
FL sweet corn/ Sweet Corn	Aerial	0.0560 (0.050)	40	10	3	0.591	0.402	0.257	0.166	0.161	50.0	48.5
NC cotton/ Cotton	Aerial	0.0560 (0.050)	130	10	3	1.54	0.739	0.508	0.430	0.424	130	128
MS soybean/ Soybean	Aerial	0.0560 (0.050)	130	10	3	0.725	0.410	0.255	0.176	0.170	53.2	51.3
ND wheat/ Sunflower	Aerial	0.0560 (0.050)	50	10	3	0.690	0.475	0.315	0.233	0.227	70.4	68.6
ND wheat/ Wheat	Aerial	0.0560 (0.050)	50	10	3	0.690	0.475	0.315	0.233	0.227	70.4	68.6
FL tomato/ Fruiting Vegetables	Aerial	0.0560 (0.050)	60	10	3	0.782	0.423	0.262	0.179	0.174	54.0	52.5
CA rice (Winter flood)/ Rice	Aerial[2]	0.0560 (0.050)	May 6	10	3	56.5	4.60	2.79	1.75	1.67	617	586

[1] EECs were rounded to three significant figures.
[2] The method of application (aerial or ground) does not affect the EECs obtained using PFAM.

Table 47. Water Column, Pore Water, and Sediment EECs for Bifenthrin[1]												
Scenario / Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
FL cucumber/ Cucurbit Vegetables	Aerial	0.1121 (0.1)	20	3	7	0.014* (0.231)	0.014* (0.0519)	0.014* (0.0449)	0.014* (0.0422)	0.014* (0.0419)	131	130
NY grapes/ Blueberries (and other Bushberries)	Aerial	0.1121 (0.1)	90	5	7	0.014* (2.51)	0.014* (0.469)	0.014* (0.420)	0.014* (0.398)	0.014* (0.397)	1234	1231
FL citrus/ Citrus[3]	Ground to bare soil	0.5604 (0.5)	210	1	N/A	0.014* (0.798)	0.014* (0.122)	0.014* (0.101)	0.014* (0.0919)	0.014* (0.0924)	285	287
IL corn/ Corn	At plant ground, foliar aerial	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	-14, 0	2[2]	Assume 14[4]	0.014* (1.74)	0.014* (0.309)	0.014* (0.264)	0.014* (0.245)	0.014* (0.243)	760	753
FL sweet corn/ Sweet Corn	Aerial	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	-14, 0	3[2]	Assume 14[4]	0.014* (0.296)	0.014* (0.0524)	0.014* (0.0456)	0.014* (0.0419)	0.014* (0.0417)	130	129
MS cotton/ Cotton	Aerial	0.1121 (0.1)	90	5 (3 in CA)	3	0.014* (1.86)	0.014* (0.291)	0.014* (0.257)	0.014* (0.247)	0.014* (0.248)	768	769
MS soybean/ Soybean[3]	Aerial	0.1121 (0.1)	90	3	30	0.014* (0.513)	0.014* (0.116)	0.014* (0.105)	0.014* (0.0963)	0.014* (0.0960)	299	298
GA pecan/ Tree Nuts	Airblast	1 @ 0.1121 (0.1) + 2 @ 0.2242 (0.2)	110	3	15	0.014* (1.20)	0.014* (0.177)	0.014* (0.167)	0.014* (0.162)	0.014* (0.162)	502	502

Table 47. Water Column, Pore Water, and Sediment EECs for Bifenthrin[1]												
Scenario / Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
CA cole crops/ Brassica Vegetables	Aerial	0.1121 (0.1) (1 app could be at plant)	10	5	7	0.014* (0.540)	0.014* (0.154)	0.014* (0.147)	0.014* (0.137)	0.014* (0.136)	425	422
CA lettuce/ Lettuce	Aerial	0.1121 (0.1)	45	5	7	0.014* (0.614)	0.014* (0.142)	0.014* (0.134)	0.014* (0.127)	0.014* (0.126)	394	391

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

[2]One application could occur at plant, at 0.2 lb a.i./A, 5-7 inch T-band, in-furrow or broadcast. Seasonal rate is 0.3 lb a.i./A/year.

[3]Not permitted in CA, unless in a supplemental label.

[4]Assumption is valid between the at-plant and the subsequent application.

Table 48. Water Column, Pore Water, and Sediment EECs for Deltamethrin[1]												
Scenario / Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
GA onion/ Bulb Vegetables	Aerial	0.0314 (0.028)	230	4	5	0.0639	0.00281	0.00192	0.00160	0.00151	718	678
WA potato/ Tuberous and Corm Vegetables	Aerial	0.0314 (0.028)	90	5	3	0.0408	0.00177	0.00119	8.95×10^{-4}	8.61×10^{-4}	402	387
GA pecan/ Tree Nuts	Airblast	0.0370 (0.033)	110	5	7	0.108	0.00286	0.00223	0.00189	0.00193	145	138
IA corn/ Corn	Aerial	2 @ 0.0163 (0.0145) + 3 @ 0.0247 (0.022)	30	5	21	0.0835	0.00308	0.00223	0.00192	0.00185	862	831
FL sweet corn/ Sweet Corn	Aerial	0.0314 (0.028)	65	16	1	0.0840	0.00482	0.00319	0.00217	0.00208	974	934
MS cotton/ Cotton	Aerial	0.0336 (0.03)	70	10	5	0.200* (0.434)	0.0128	0.00846	0.00707	0.00670	3175	3009
MS soybean/ Soybean	Aerial	1 @ 0.0179 (0.016) + 3 @ 0.0314 (0.028)	130	4	Assume 5	0.0544	0.00169	0.00129	0.00107	0.00101	480	454
ND wheat/ Sunflowers[3]	Aerial	0.0168 (0.015)[2]	50	3	Assume 5	0.0120	6.31×10^{-4}	4.08×10^{-4}	3.02×10^{-4}	2.89×10^{-4}	136	130
FL cucumbers/ Cucurbit Vegetables	Aerial	0.0314 (0.028)	30	6	3	0.0309	0.00195	0.00129	8.56×10^{-4}	8.37×10^{-4}	384	376
FL tomatoes/ Fruiting Vegetables	Aerial	0.0314 (0.028)	60	6	5	0.0651	0.00227	0.00192	0.00149	0.00145	669	651

*EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from

Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.
[1]EECs were rounded to three significant figures.
[2]For sunflowers, the maximum rate is 0.018 lb a.i./A. The maximum seasonal rate was divided by 3 applications.
[3]Except in California.

Table 49. Water Column, Pore Water, and Sediment EECs for Permethrin[1]

Scenario / Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg-dw)	21-day average EEC (µg/kg-dw)
PA alfalfa/ Alfalfa	Aerial	0.2242 (0.2)/ cutting[2]	120	4[2]	30	0.574	0.0854	0.0784	0.0704	0.0693	224	221
NY grapes/ Blueberries	Aerial	0.3362 (0.3)	15	8	Assume 10	5.50* (10.3)	1.38	1.22	1.07	1.06	3413	3381
GA pecans/ Tree Nuts (based on pistachios)	Assume Airblast	0.3362 (0.3)	130	3	10	2.20	0.239	0.198	0.177	0.175	565	558
IL corn/ Corn	Aerial	0.1681 (0.15)	100	3	7	1.07	0.130	0.115	0.114	0.113	363	360
FL sweet corn/ Sweet Corn	Aerial	0.2242 (0.2)	60	4	3	0.670	0.0847	0.0741	0.0647	0.0635	206	202
CA lettuce/ Leafy Greens (based on the rate for lettuce)	Aerial	0.2242 (0.2)	45	4[3]	7	1.10	0.143	0.121	0.108	0.107	345	341
MS soybean/ Soybean	Aerial	0.2242 (0.2)	100	2	10	0.724	0.0950	0.0806	0.0747	0.0724	238	231
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	Aerial	0.2242 (0.2)	40	4	5	0.831	0.147	0.124	0.105	0.104	335	332
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	Aerial	0.2242 (0.2)	80	4	5	0.924	0.126	0.109	0.0918	0.0897	293	286
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	Aerial	0.2242 (0.2)	15	6	7	1.04	0.128	0.114	0.0992	0.0969	316	309

*EECs marked with an asterisk were set to 5.50 ppb because they exceeded the limit of solubility of permethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1]EECs were rounded to three significant figures. [2]Assumed 4 applications/year, based on BEAD's recommendation. [3]Up to 6 applications are allowed in HI.

Table 50. Water Column, Pore Water, and Sediment EECs for Esfenvalerate[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
CA cole crops/ Brassica (head & stem) Vegetables	Foliar, Aerial	0.0560 (0.05)	10	10	1	0.369	0.0275	0.0227	0.0198	0.0195	5000	4930
NY grapes/ Blueberries (*except CA*)[3]	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.900	0.0427	0.0288	0.0237	0.0232	5970	5840
GA pecan/ Tree Nuts (based on rate on almonds)	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.899	0.0340	0.0269	0.0226	0.0230	5690	5330
IL corn/ Corn	At plant or Foliar, assume Aerial	0.0560 (0.05)	120	10	3	0.851	0.0384	0.0269	0.0254	0.0249	6390	6270
FL sweet corn/ Sweet Corn	Foliar, Aerial	0.0560 (0.05)	40	16	1	0.422	0.0211	0.0169	0.0134	0.0131	3370	3300
NC cotton/ Cotton	At plant or Foliar, assume Aerial	0.0560 (0.05)	130	10	3	1.25	0.0439	0.0374	0.0327	0.0322	8230	8110
MS soybean/ Soybeans	Foliar, Aerial	0.0560 (0.05)	130	5	3	0.303	0.0139	0.0111	0.00968	0.00951	2440	2390
ND wheat/ Sunflowers	Foliar, Aerial	0.0560 (0.05)	50	5	3	0.165	0.00972	0.00711	0.00612	0.00588	1540	1480
FL cucumber/ Cucurbit Vegetables	Foliar, Aerial	0.0560 (0.05)	30	8	8	0.241	0.0115	0.0100	0.00798	0.00768	2010	1930
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	Foliar, Aerial	0.0560 (0.05)	60	10	3	0.443	0.0201	0.0168	0.0129	0.0126	3250	3170

[1] EECs were rounded to three significant figures.

Table 51. Water Column, Pore Water, and Sediment EECs for Cypermethrin[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
PA alfalfa/ Alfalfa	Aerial	0.056 (0.05)	60	3	7	0.0847	0.00677	0.00395	0.00304	0.00285	431	404
NY grapes/ Blueberries:	Aerial	0.056 (0.05)	90	6	7	0.938	0.0562	0.0392	0.0309	0.0295	4380	4180
FL citrus/ Citrus:	Assume Airblast	0.056 (0.05)	180	4	14	0.270	0.0150	0.00928	0.00719	0.00661	1020	937
IL corn/ Corn	Aerial	0.056 (0.05)	120	4	3	0.461	0.0265	0.0172	0.0139	0.0131	1970	1860
FL sweet corn/ Sweet Corn	Aerial	0.056 (0.05)	40	6	3	0.193	0.0117	0.00878	0.00630	0.00581	893	823
MS cotton/ Cotton	Aerial	0.056 (0.05)	90	6	3	0.908	0.0353	0.0293	0.0227	0.0207	3220	2930
MS soybean/ Soybean	Ground	0.056 (0.05)	130	6	7	0.480	0.0254	0.0201	0.0167	0.0163	2370	2310
ND wheat/ Sunflower	Ground	0.056 (0.05)	50	1	N/A	0.0403	0.00202	0.00146	0.00117	0.00111	166	157
ND wheat/ Wheat	Aerial	0.056 (0.05)	50	5	14	0.221	0.0128	0.00923	0.00766	0.00731	1090	1040
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	Aerial	0.056 (0.05)	140	6	4	0.318	0.0177	0.0143	0.0103	0.00983	1460	1390
CA rice (Winter flood)/ Rice	Aerial[2]	0.056 (0.05)	May 6	4	7	3.97* (55.4)	0.672	0.410	0.242	0.226	34300	32100

* EECs marked with an asterisk were set to 3.97 ppb because they exceeded the limit of solubility of cypermethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

[2] The method of application (aerial or ground) does not affect the EECs obtained using PFAM.

Table 52. Water Column, Pore Water, and Sediment EECs for Cyfluthrin[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
PA alfalfa/ Alfalfa	Aerial	0.049 (0.044)	60	8	5	0.0865	0.00601	0.00403	0.00211	0.00172	390	318
NY grapes/ Grapes	Aerial	0.056 (0.05)	90	4	14	0.535	0.0212	0.0127	0.00906	0.00751	1680	1390
FL citrus/ Citrus	Assume Airblast	0.112 (0.1)	180	2	7	0.197	0.00717	0.00435	0.00277	0.00201	512	372
IL corn/ Corn	Aerial	0.049 (0.044)	120	4	7	0.246	0.0102	0.00577	0.00441	0.00380	815	703
FL sweet corn/ Sweet Corn	Aerial	0.049 (0.044)	40	10	2	0.127	0.00971	0.00542	0.00279	0.00253	516	468
MS cotton/ Cotton	Aerial	0.056 (0.05)	90	6	3	0.728	0.0233	0.0140	0.00964	0.00732	1780	1350
MS soybean/ Soybeans	Aerial	0.049 (0.044)	130	4	7	0.147	0.00663	0.00419	0.00320	0.00292	592	540
ND wheat/ Sunflowers	Aerial	0.049 (0.044)	50	3	7	0.0523	0.00315	0.00180	0.00107	0.00088	271	223
ND wheat/ Wheat	Aerial	0.043 (0.038)	50	2	3	0.0434	0.00197	0.00104	0.000578	0.000481	107	88.9
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	Aerial	0.056 (0.05)	60	12	7	0.358	0.0168	0.0115	0.00745	0.00574	1380	1060

[1] EECs were rounded to three significant figures.

Table 53. Water Column, Pore Water, and Sediment EECs for Cyhalothrins[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
PA alfalfa/ Alfalfa	Aerial	0.0336 (0.03) per cutting	60	4	NS – 3	0.0884	0.0471	0.0435	0.0422	0.0421	113	113
FL cucumber/ Cucurbit Vegetables	Aerial	0.0336 (0.03)	30	6	5	0.186	0.0955	0.0926	0.0902	0.0900	241	241
FL citrus/ Citrus	Assume Airblast	0.0448 (0.04)	180	6	NS – 3	0.273	0.0970	0.0920	0.0916	0.0914	246	244
IL corn/ Corn	Aerial	0.0336 (0.03)	120	4	3	0.279	0.0972	0.0930	0.0930	0.0929	249	248
FL sweet corn/ Sweet Corn	Aerial	0.0336 (0.03)	40	16	NS – 3	0.230	0.123	0.119	0.116	0.115	310	307
MS cotton/ Cotton	Aerial	0.0448 (0.04)	90	5	3	0.740	0.238	0.227	0.227	0.227	607	607
MS soybean/ Soybeans	Aerial	0.0336 (0.03)	130	2	5	0.0768	0.0339	0.0326	0.0322	0.0322	86.1	86.1
ND wheat/ Sunflowers	Aerial	0.0336 (0.03)	50	4	5	0.0964	0.0578	0.0545	0.0532	0.0531	142	142
ND wheat/ Wheat	Aerial	0.0336 (0.03)	50	2	5	0.0674	0.0290	0.0272	0.0264	0.0263	70.6	70.3
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	Aerial	0.0336 (0.03)	10	12	5	0.361	0.195	0.193	0.191	0.190	511	508

Table 53. Water Column, Pore Water, and Sediment EECs for Cyhalothrins[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg-dw)**	**21-day average EEC (µg/kg-dw)**
CA rice (Winter flood)/ Rice	Aerial[2]	0.0448 (0.04)	May 6	3	~3 first app & 5-7 for subse-quent apps. Assume 5.	5.00* (44.3)	0.385	0.230	0.147	0.147	310	310

* EECs marked with an asterisk were set to 5.00 ppb because they exceeded the limit of solubility of *lambda*-cyhalothrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

[2] The method of application (aerial or ground) does not affect the EECs obtained using PFAM.

Table 54. Water Column, Pore Water, and Sediment EECs for Fenpropathrin[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
CA cole crops/ Brassica (head and stem) Vegetables	Aerial	0.336 (0.3)	10	2.7	7	1.02	0.161	0.153	0.146	0.145	30300	30100
NY grapes/ Bushberries and caneberries	Aerial	0.336 (0.3)	90	2 per cc	NS-14	3.35	0.303	0.266	0.252	0.251	52300	52100
FL citrus/ Citrus	Assume Airblast	0.448 (0.4)	180	2 per cc	NS-10	1.30	0.130	0.116	0.110	0.109	22800	22600
FL cucumber/ Cucurbit Vegetables	Aerial	0.336 (0.3)	30	2.7	7	0.970	0.0980	0.0903	0.0877	0.0873	18200	18100
PA apple/ Pome Fruits	Aerial	0.448 (0.4)	200	2 per cc	NS-10	2.08	0.179	0.169	0.160	0.159	33300	33100
MS cotton/ Cotton	Aerial	0.336 (0.3)	90	4	7	3.70	0.344	0.310	0.303	0.301	63010	62600
MI cherries/ Stone Fruits	Aerial	0.448 (0.4)	60	2 per cc	10	3.18	0.339	0.305	0.295	0.293	61400	61000
GA pecan/ Tree Nuts	Aerial	0.448 (0.4)	80	2 per cc	NS-10	2.02	0.172	0.154	0.150	0.148	31200	30800
NC peanuts/ Peanuts	Aerial	0.336 (0.3)	20	2 per cc	NS-7	2.72	0.191	0.161	0.155	0.153	32300	31900
FL tomato/ Fruiting Vegetables	Aerial	0.336 (0.3)	60	2.7	7	1.10	0.112	0.102	0.0975	0.0968	20300	20200

[1] Water column and pore-water EECs were rounded to three significant figures.

Table 55. Water Column, Pore Water, and Sediment EECs for Fenpropathrin plus Unextracted Residues[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application (days since emergence)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
CA cole crops/ Brassica (head and stem) Vegetables	Aerial	0.336 (0.3)	10	2.7	7	1.44	0.219	0.211	0.204	0.204	42500	42500
NY grapes/ Bushberries and caneberries	Aerial	0.336 (0.3)	90	2 per cc	NS-14	3.44	0.323	0.285	0.274	0.274	57100	57100
FL citrus/ Citrus	Assume Airblast	0.448 (0.4)	180	2 per cc	NS-10	1.63	0.170	0.148	0.140	0.140	29200	29200
FL cucumber/ Cucurbit Vegetables	Aerial	0.336 (0.3)	30	2.7	7	1.43	0.137	0.128	0.122	0.121	25400	25200
PA apple/ Pome Fruits	Aerial	0.448 (0.4)	200	2 per cc	NS-10	3.01	0.242	0.224	0.214	0.212	44700	44300
MS cotton/ Cotton	Aerial	0.336 (0.3)	90	4	7	3.95	0.376	0.344	0.333	0.331	69500	69100
MI cherries/ Stone Fruits	Aerial	0.448 (0.4)	60	2 per cc	10	3.56	0.386	0.354	0.341	0.339	71200	70800
GA pecan/ Tree Nuts	Aerial	0.448 (0.4)	80	2 per cc	NS-10	2.41	0.208	0.186	0.178	0.176	37200	36800
NC peanuts/ Peanuts	Aerial	0.336 (0.3)	20	2 per cc	NS-7	2.94	0.214	0.185	0.179	0.178	37400	37200
FL tomato/ Fruiting Vegetables	Aerial	0.336 (0.3)	60	2.7	7	1.47	0.149	0.135	0.128	0.126	26800	26300

[1] Water column and pore-water EECs were rounded to three significant figures.

5.4. Monitoring Data

Part of the available information on the occurrence of pyrethroids in U.S. agricultural surface waters was reviewed and is summarized here with a focus on the following question:

> Which pyrethroids are commonly detected in agricultural surface waters and sediments?
>
> What is their level of detection?
>
> How do detections compare to the modeled estimated environmental concentrations (EECs)?

5.4.1. Pyrethroid Working Group Monitoring Report

PWG provided a comprehensive review covering available monitoring data for synthetic pyrethroids in surface water and sediment across the United States as of July 31, 2013 (Giddings, *et al.*, MRID 49314703). The PWG report includes both agricultural and non-agricultural monitoring and an extensive number of sources. Besides the eight pyrethroids involved in this assessment, tefluthrin, which is also supported by PWG, was included. It was reported that the limits of detection and quantitation were variable across studies. Greater than 1000 articles, public records, and databases from the open literature and public reports were evaluated for usability. These reports were classified, according to certain criteria (not provided in this summary) as good, usable, or unusable. Only good or usable reports are further described in the study. The report indicated that the following number of analytical results for pyrethroids were recorded, using a variety of analytical methods, from agricultural, urban, mixed or undeveloped sites. The focus of this summary is on the agricultural samples and eight pyrethroids; tefluthrin is excluded from this brief summary.

- Whole (unfiltered) water: 18,500 analytical results in 4,900 whole (unfiltered) water samples (referred as *whole water* samples), of which 98% are from CA. Of the 4,786 whole water samples with suitable results (*e.g.*, not expressed as a range or as 'trace'), 3190 (67%) were from agricultural land use sites (3102 from flowing water, 88 static, and 0 marine).
- Filtered water: 2,500 analytical results in 308 filtered water samples, of which 74% are from CA.
- Suspended sediment: 1,629 analytical results in 200 suspended sediment samples, all from CA.
- Sediment samples: 12,500 analytical results in about 1850 sediment samples, of which 76% are from CA. Of the 1797 sediment samples with suitable results and for which organic carbon normalized concentrations were available or

calculated, 811 (45%) were from agricultural land use sites (743 flowing water, 68 static, and 0 marine).

Whole Water

The following table and figure summarize the pyrethroid concentrations in whole water samples from *agricultural flowing water*-sites. Fenpropathrin was the most frequently detected pyrethroid in agricultural flowing whole water samples, with 10% detections. By contrast, in urban settings, the detections were only 1%. For bifenthrin the frequency of detection was 7% and for the remaining chemicals, it was 1-2%.

Table 56. Pyrethroid Concentration Distributions in Whole (Unfiltered) Water Samples from Agricultural Flowing Water Sites

Chemical	Number of Samples	Detections (%)	Concentrations (ng/L)				
			90th	95th	99th	Maximum	Limit of Solubility
Bifenthrin	1418	7	<RL	6.1	428	2300	14
Cyfluthrin	1504	2	<RL	<RL	4.0	158	2,320
L-Cyhalothrin	1688	2	<RL	<RL	3.0	140	5,000
Cypermethrin	1676	1	<RL	<RL	2.8	519	3,970
Deltamethrin	229	1	<RL	<RL	2.8	37	200
Esfenvalerate	1740	1	<RL	<RL	2.0	166	6,000
Fenpropathrin	202	10	0.42	8.1	44	64	10,300
Permethrin	3054	2	<RL	<RL	82	17458	5,500

RL = reporting limit

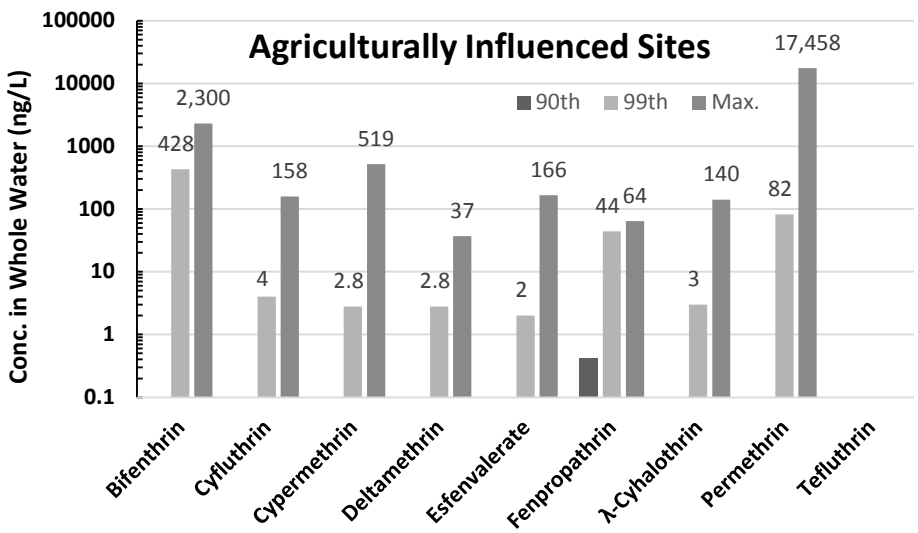


Figure 4. Graphic Depiction of the Pyrethroid Concentration Distributions in Whole (Unfiltered) Water Samples from Agricultural Flowing Water Sites

The last column in the **Table 56** above shows the limit of solubility for each of the pyrethroids in ng/L. The maximum whole water bifenthrin and permethrin concentrations exceeded this limit. The study authors commented that whole water samples (including

both, urban and agricultural), contain varying amounts of suspended particulate matter (*e.g.*, soils/sediments). Since pyrethroids tend to sorb to organic matter, both particulate and dissolved, the concentrations in whole water are likely dominated by the particulate bound or DOC associated material.

Regarding whole water samples from static bodies of water, only three publications were included, of which two presented data in agricultural bodies of water. Smith *et al.* (2007) reported results from 85 water whole samples from Beasley Lake, MS, receiving agricultural drainage. Samples were collected from 1997-2005 and analyzed for bifenthrin and *lambda*-cyhalothrin. Bifenthrin was detected in 43 samples (51%) and the maximum detection was at 76 ng/L, while lambda-cyhalothrin was detected in 48 samples (56%) with a maximum of 119 ng/L. It was reported that the number of detections decreased with time as a result of shift from conventional to reduced tillage in the watershed. In another report (Moore *et al.* 2007), Beasley Lake and two other oxbow lakes in the area were tested for the same chemicals. Bifenthrin was detected in two lakes at 2-28 ng/L, while *lambda*-cyhalothrin was detected in three lakes at 7-9 ng/L. Two whole water samples from an estuary in CA were tested for esfenvalerate and permethrin. These two compounds were not detected.

Filtered Water

In the PWG report, there are seven reports that provide results of filtered water samples, including agricultural and non-agricultural use sites. The USGS had investigated whether filtering water samples using their Standard Operating Procedure (SOP) could cause loss of dissolved pyrethroid onto glass fiber filters. They found that less than 5% was lost and it was therefore presumed that the concentrations in filtered water would depict dissolved pyrethroid concentrations.

The frequency of non-detections was reported to be 95%, out of 2510 analyses of 308 filtered water samples. Only 23 pyrethroid detections from 16 samples (all in CA) were reported (0.9% of the analyses and 5% of the samples). Most of the detections were from agriculturally dominated sites. In agricultural settings, there were detections of *lambda*-cyhalothrin, cypermethrin, esfenvalerate and permethrin (**Table 57**). The highest concentrations were lower than those reported in **Table 56** (unfiltered water samples), by orders of magnitude.

It should be noted that filtering does not remove dissolved organic matter, which can decrease the bioavailable pyrethroid. The amount bioavailable is dependent on the concentration of dissolved organic carbon and K_{DOC}. According to the report, of the 16 samples with detections, the DOC was reported for 12 water samples: for the majority of the samples, the DOC was 4.3-7.7 mg/L and one sample at 15 mg/L DOC. Based on K_{DOC} values reported in the open literature for pyrethroids, the study authors concluded that the results in **Table 57** could be overestimates of the real freely dissolved pyrethroids concentrations.

Table 57. All Detections in Filtered Water Samples

Chemical	No. of Detects	Highest Conc. (ng/L)	Site of Highest Concentration	Source
Bifenthrin	9	15	Urban creek, Roseville	Urban
		12.0	Irrigation tailwater, Pajaro R. estuary upper	Ag
Cyfluthrin	2	7	Urban creek, Roseville	Urban
L-Cyhalothrin	2	64.7	Vegetated tailwater ditch, Salinas Valley	Ag
Cypermethrin	1	11.6	Vegetated tailwater ditch, Salinas Valley	Ag
Deltamethrin	0	--	--	--
Esfenvalerate	1	1.29	Vegetated tailwater ditch, Salinas Valley	Ag
Fenpropathrin	0	--	--	--
Permethrin	8	15	Irrigation tailwater, Pajaro R. estuary upper	Ag

Ag = agricultural; -- = no detections

Sediment Samples

For each pyrethroid there are between 1,100 and 1,700 individual sediment analyses, of which between 320 and 725 are from agricultural flowing water sites. As expected based on the physical-chemical properties, the pyrethroid frequency of detections was higher in sediment than in water. The most frequently detected chemicals were bifenthrin and permethrin in agricultural flowing water sites (23% detects), but all the remaining pyrethroids were detected in between 2 and 10% of the sediment samples, **Table 58**. According to the study authors, the majority of the flowing water site sediments were from depositional areas, and the concentrations are likely to overestimate the concentrations that would be observed in non-depositional areas, which are the preferred habitat for many species. The authors also compared the sediment concentrations in California urban flowing water sites against other states. They found that the 95th percentile concentration was higher in CA than in other states. The frequency of detections in CA was higher than in other states, with the exception is *lambda*-cyhalothrin, for which they were the same.

Table 58. Pyrethroid Concentration Distributions in Sediment Samples from Agricultural Flowing Water Sites

Chemical	Number of Samples	Detections (%)	Sediment Concentrations (µg/g_{OC})			
			90th	95th	99th	Maximum
Bifenthrin	724	23	0.30	0.87	3.8	8.8
Cyfluthrin	631	4	<RL	0.08	0.41	0.63
L-Cyhalothrin	719	10	<RL	0.16	1.3	35
Cypermethrin	621	4	<RL	<RL	1.3	75
Deltamethrin	319	2	<RL	<RL	0.02	0.13
Esfenvalerate	698	10	0.03	0.19	1.6	7.0
Fenpropathrin	319	9	<RL	0.43	5.5	11
Permethrin	662	23	0.78	3.0	14	47

RL = reporting limit

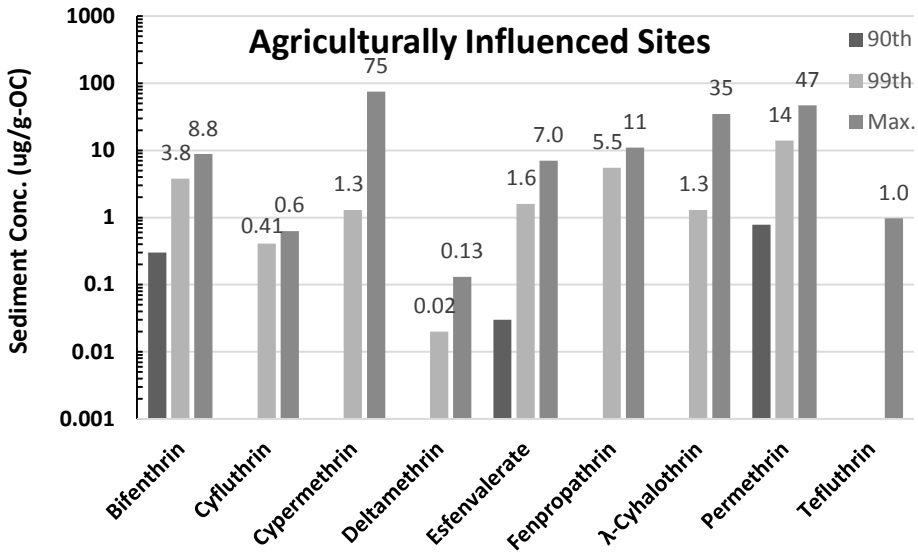


Figure 5. Graphic Depiction of the Pyrethroid Concentration Distributions in Sediment Samples from Agricultural Flowing Water Sites

The number of sediment samples from static bodies of water sites was limited, compared to flowing water sites, and the study authors concluded that the sediment concentrations were lower and the detections were less frequent in static bodies of water sites than in flowing water sites. Additionally, 204 estuarine/marine sediment samples were included in the report, from three studies, many of which are from urban sites. Based on the limited number of samples, compared to sediments from flowing water sites, the authors concluded that "[f]or the 3 studies combined, bifenthrin was detected in 27% of samples, cyfluthrin in 13%, permethrin in 5%, cypermethrin 4%, and deltamethrin, esfenvalerate, fenpropathrin, and *lambda*-cyhalothrin in less than 3%." The highest concentrations for all of the pyrethroids were bifenthrin at 5.9 $\mu g/g_{OC}$ in a CA coastal site receiving urban runoff, permethrin at 5.1 $\mu g/g_{OC}$ in Switzer Creek, and cyfluthrin at 6.9 $\mu g/g_{OC}$ in Switzer Creek (San Diego Bay), all of which are urban sampling sites. These highest concentrations are lower than for the flowing water samples.

Suspended Sediments

Finally, there are 200 samples of suspended sediments, all from CA, with pyrethroids detected in 53% of the samples. The most frequently detected pyrethroids were permethrin and bifenthrin (35-37% detects). For 120 of the 200 samples, organic carbon content was available. Permethrin and bifenthrin were also the most frequently detected pyrethroids in these 120 samples (45 and 35%, respectively). The highest concentration was for permethrin, with 7.0 $\mu g/g_{OC}$; however, these samples were not categorized by use site in the report (*i.e.*, urban *vs.* agricultural).

5.4.2. Comparison of Monitored and Modeled Concentrations

Monitoring data, similar to those discussed above, are an important resource for

regulators. These type of data are available for pesticides that have been in use for many years. Quality monitoring data can be used to supplement modeling EECs developed using the PWC. Monitoring results are not expected to be similar to modeled EECs, as the waters where samples are collected are not the same as the conceptual model simulated and usage where the samples are collected may be different from that simulated; however, monitoring data provide evidence on how conservative modeled EECs are, and of the potential for exposure to pesticides. In addition, monitoring programs are typically not designed to capture a true peak concentration. In order to capture true peak concentrations, sampling needs to be intensive within the time period the pesticide is applied and through the runoff events following application. The comparison of water and sediment EECs against monitoring results in the following sections is limited to results obtained using the PWC. Results from the PFAM model (rice use) are excluded.

Water

A comparison of water monitored and modeled concentrations (EECs), based on PWG data is presented in the following table.

Table 59. Comparison of Maximum and 90th Percentile Monitored Whole, and Filtered Water Concentrations in Agricultural Environments, against Maximum Modeled Water Column EECs

Chemical	90th Percentile Whole Water Monitored Conc. from PWG Report (ng/L)[1]	Maximum Whole Water Monitored Conc. from PWG Report (ng/L)[1]	Maximum Filtered Water Monitored Conc. from PWG Report (ng/L)[2]	Maximum Modeled EEC[3] (ng/L)
Bifenthrin	<RL	2300	12.0	14[4]
Cyfluthrin	<RL	158	--	728
L-Cyhalothrin	<RL	140	64.2	740
Cypermethrin	<RL	519	11.6	938
Deltamethrin	<RL	37	--	200[4]
Esfenvalerate	<RL	166	1.29	1250
Fenpropathrin	0.42	64	--	3700
Permethrin	<RL	17458	15	5500[4]

[1] See **Table 56**. Results for the flowing water samples in agricultural settings.
[2] See **Table 57**. There is a limited number of samples with detections.
[3] Excluding the rice use.
[4] Concentration was capped at the limit of solubility of the chemical.

Comparison of the concentrations from whole (unfiltered) water against modelled concentrations, it was found that the modelled concentrations were higher than the monitored concentrations for all of the chemicals, except permethrin and bifenthrin. The permethrin and bifenthrin concentrations were limited by their solubility in the modeled result. However, this type of comparison is of limited value, since the whole water concentrations include pyrethroid in the water, suspended particulate or sediment, and dissolved organic matter (*i.e.*, these results are for whole or unfiltered water concentrations); meanwhile, the modeled EECs represent freely dissolved (FD) chemical.

Further, the concentrations in filtered water for all of the five chemicals for which data was available, were lower than the maximum modeled concentrations.

Given that the monitored values are whole water (unfiltered) concentrations, EFED proceeded to search further how to estimate freely dissolved pyrethroid concentrations in U.S. water, based on whole (or unfiltered) water pyrethroid concentrations. Equation *A*2 of the KABAM User's Guide describes the calculation of Φ, the fraction of the overlying water (or water column) concentration of the pesticide that is freely dissolved, which depends on the particulate organic carbon (POC), dissolved organic carbon (DOC) and the octanol/water partition coefficient (K_{OW}, USEPA 2009b, Appendix A of the user's guide). **Table 60** shows the definitions of each parameter of the equation, and units.

$$\textit{Equation } 2 \quad \Phi = \frac{1}{1 + (X_{POC} * \alpha_{POC} * K_{OW}) + (X_{DOC} * \alpha_{DOC} * K_{OW})}$$

Table 60. Derivation of available pesticide fraction in water (Φ; unitless) and its associated parameters [Based on Table *A*2 of the KABAM manual and Arnot and Gobas (2004)]

Symbol	Definition	Value	Units
X_{POC}	Concentration of particulate organic carbon in water	user defined	kg/L
X_{DOC}	Concentration of dissolved organic carbon in water	user defined	kg/L
K_{OW}	Octanol water partition coefficient	user defined	none
α_{POC}	Proportionality constant to describe the similarity of phase partitioning of POC in relation to octanol	0.35	none
α_{DOC}	Proportionality constant to describe the similarity of phase partitioning of DOC in relation to octanol	0.08	none

Furthermore, EFED searched the National POC/DOC Database (USEPA, 2003) for typical POC and DOC concentrations in U.S. waters. **Table 61** shows some of the values for streams/rivers (based on n = 69,589).

Table 61. National Default Values Streams/Rivers Median, 10th and 90th Percentile, POC and DOC in the U.S.[1]

Stream/Rivers	DOC (mg/L)	POC (mg/L)
Median	3.8	0.6
10th	1	0.1[2]
90th	11.6	3.1

[1] Based on the National POC/DOC Database (USEPA 2003).
[2] Estimated POC, since 10th value was reported as 0 mg/L

Tables 62 to 64 show estimated freely dissolved (FD) monitored concentrations, assuming the 10th, median, and 90th POC and DOC values presented in **Table 61**, and the monitored concentrations presented in **Table 59**. Light shaded cells mean EECs are within 10x or one order of magnitude of the estimated FD concentration. Dark shaded cell means

EEC is less than the estimated FD concentration by greater than a 10x factor. Cells with no shade mean the FD estimated concentration is below the EEC by a factor of greater than 10x. In all three tables, except for bifenthrin, the ratio of EEC/FD concentration (either, maximum and 90th from PWG study), indicated that each of the FD concentrations were, either within one order of magnitude of the maximum EEC, or below the EEC. The only exception, which was bifenthrin, was a concentration limited by the extremely low solubility of the chemical, while for these calculations initially the monitored concentrations were not limited (see footnote 3 and associated values in each table, and in parenthesis).

Table 62. Comparison of Maximum and 90th Percentile Monitored Whole Water Concentrations, Estimated as Freely Dissolved Concentrations, in Agricultural Environments, against Modeled Water Column EECs
(*Assuming 10th Percentile DOC = 1 mg/L, and estimated POC = 0.1 mg/L*)

Chemical	Maximum Water Column Monitored Conc. FD (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD (ng/L)[1]	Maximum Water Column Modeled EEC FD (ng/L)[2]	Max. EEC/ Maximum Water Column Conc. FD[1]	Max. EEC/ 90th Percentile Water Column Conc. FD[1]
Bifenthrin	1785[3] (14)	<RL	14[3]	0.0078 (1.0)	N/A
Cyfluthrin	143	<RL	728	5.1	N/A
L-Cyhalothrin	65.1	<RL	740	11.4	N/A
Cypermethrin	371	<RL	938	2.5	N/A
Deltamethrin	37	<RL	200[3]	5.4	N/A
Esfenvalerate	158	<RL	1,250	7.89	N/A
Fenpropathrin	57	0.38	3,700	64.5	9823
Permethrin	15250[3] (5500)	<RL	5,500[3]	0.36 (1.0)	N/A

FD = freely dissolved; DOC = dissolved organic carbon; POC = particulate organic carbon; <RL = less than reporting limit; N/A=not applicable. Light shaded cells mean EECs are within 10x of the estimated freely dissolved concentration. Dark shaded cell means EEC is less than the estimated freely dissolved concentration by greater than a 10x factor (in this instance, the freely dissolved concentration was estimated to be above the limit of solubility). Unshaded cells mean the EEC is above the freely dissolved estimated concentration by a factor of greater than 10.

[1] Based on flowing whole (unfiltered) water samples, see **Table 56**.

[2] Maximum EEC for the agricultural uses of pyrethroids (excluding the rice use).

[3] This concentration exceeds the limit of solubility of the chemical.

Table 63. Comparison of Maximum and 90th Percentile Monitored Whole Water Concentrations, Estimated as Freely Dissolved Concentrations, in Agricultural Environments, against Modeled Water Column EECs
(*Assuming Median DOC = 3.8 mg/L, and POC = 0.6 mg/L*)

Chemical	Maximum Water Column Monitored Conc. FD (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD (ng/L)[1]	Maximum Water Column Modeled EEC FD (ng/L)[2]	Max. EEC/ Maximum Water Column Conc. FD[1]	Max. EEC/ 90th Percentile Water Column Conc. FD[1]
Bifenthrin	1004[3] (14)	<RL	14[3]	0.0014 (1.0)	N/A
Cyfluthrin	107	<RL	728	6.8	N/A
L-Cyhalothrin	22.8	<RL	740	32.6	N/A
Cypermethrin	187	<RL	938	5.0	N/A
Deltamethrin	36	<RL	200[3]	5.5	N/A
Esfenvalerate	137	<RL	1,250	9.1	N/A
Fenpropathrin	42	0.28	3,700	87.5	13338
Permethrin	10599[3] (5500)	<RL	5,500[3]	0.52 (1.0)	N/A

FD = freely dissolved; DOC = dissolved organic carbon; POC = particulate organic carbon; <RL = less than reporting limit; N/A=not applicable. Light shaded cells mean EECs are within 10x of the estimated freely dissolved concentration. Dark shaded cell means EEC is less than the estimated freely dissolved concentration by greater than a 10x factor (in this instance, the freely dissolved concentration was estimated to be above the limit of solubility). Unshaded cells mean the EEC is above the freely dissolved estimated concentration by a factor of greater than 10.

[1] Based on flowing whole (unfiltered) water samples, see **Table 56** (PWG report).

[2] Maximum EEC for the agricultural uses of pyrethroids (excluding the rice use).

[3] Concentration exceeded the limit of solubility of the chemical.

Table 64. Comparison of Maximum and 90th Percentile Monitored Whole Water Concentrations, Estimated as Freely Dissolved Concentrations, in Agricultural Environments, against Modeled Water Column EECs
(*Assuming 90th Percentile DOC = 11.6 mg/L, and POC = 3.1 mg/L*)

Chemical	Maximum Water Column Monitored Conc. FD (ng/L)[1]	90th Percentile Water Column Monitored Conc. FD (ng/L)[1]	Maximum Water Column Modeled EEC FD (ng/L)[2]	Max. EEC/ Maximum Water Column Conc. FD[1]	Max. EEC/ 90th Percentile Water Column Conc. FD[1]
Bifenthrin	380[4] (14)	<RL	14[3]	0.037 (1.0)	N/A
Cyfluthrin	54.9	<RL	728	13.3	N/A
L-Cyhalothrin	6.63	<RL	740	111	N/A
Cypermethrin	65.0	<RL	938	14.4	N/A
Deltamethrin	35	<RL	200[3]	5.8	N/A
Esfenvalerate	90.3	<RL	1,250	13.9	N/A
Fenpropathrin	21	0.14	3,700	174	26500
Permethrin	4940	<RL	5,500[3]	1.1	N/A

FD = freely dissolved; DOC = dissolved organic carbon; POC = particulate organic carbon; <RL = less than reporting limit; N/A=not applicable. Light shaded cells mean EECs are within 10x of the estimated freely dissolved concentration. Dark shaded cell means EEC is less than the estimated freely dissolved concentration by greater than a 10x factor (in this instance, the freely dissolved concentration was estimated

to be above the limit of solubility). Unshaded cells mean the EEC is above the freely dissolved estimated concentration by a factor of greater than 10.

[1] Based on flowing whole (unfiltered) water samples, see **Table 56**.

[2] Maximum EEC for the agricultural uses of pyrethroids (excluding the rice use).

[3] Concentration exceeded the limit of solubility of the chemical.

Comparisons of modeled and monitored concentrations involve a high degree of uncertainty (both, uncertainties in the model, and in missing the peak concentration when sampling). There is a general expectation that EFED's modeled concentrations should be greater than monitored concentrations. Assuming low and median DOC and POC, most of the modeling results are within an order of magnitude difference, which indicates that EFED's modeling is not beyond the realm of environmental realism.

Sediment

A comparison of sediment monitored and modeled concentrations, based on PWG data is presented below. Light shaded cells mean modelled EECs are greater than the maximum sediment monitored concentrations. Unshaded cells mean modelled EEC is less than the maximum monitored concentration. Cells with bold font mean that the modelled EEC differs from the maximum monitored concentration by a factor of greater than 10. Comparison of the modelled and the maximum monitored sediment concentration shows that for six out of eight of the chemicals, the modelled concentrations were above the monitored concentrations (for deltamethrin, by a factor of greater than 10). For *lambda*-cyhalothrin the monitored and modelled concentrations were within a factor of 10; for cypermethrin, the modelled concentration was 17 times lower than the monitored concentration.

Table 65. Comparison of Maximum and 90th Percentile Sediment Monitored Concentration in Agricultural Environments against Modeled EECs

Chemical	Number of Samples	Detections (%)	90th Percentile Sediment Monitored Conc.[1] (µg/kg$_{OC}$)	Maximum Sediment Monitored Conc.[1] (µg/kg$_{OC}$)	Maximum Sediment Modeled EEC[2] (µg/kg$_{OC}$)	EEC/ Maximum Sediment Monitored Conc.
Bifenthrin	724	23	300	8,800	30,850	3.51
Cyfluthrin	631	4	<RL	630	1,780	2.83
Lambda-Cyhalothrin	719	10	<RL	35,000	15,175	0.43
Cypermethrin	621	4	<RL	75,000	4,380	**0.06**
Deltamethrin	319	2	<RL	130	3,175	**24.4**
Esfenvalerate	698	10	30	7,000	8,230	1.17
Fenpropathrin	319	9	<RL	11,000	63,010	5.73
Permethrin	662	23	780	47,000	85,325	1.82

Light shaded cells mean modelled EECs are greater than the maximum sediment monitored concentrations. Unshaded cells mean modelled EEC is less than the maximum monitored concentration. Cells with bold font mean that the modelled EEC differs from the maximum monitored concentration by a factor of greater than 10.

[1] Based on sediment samples from agricultural flowing water use sites in PWG report, see **Table 58**..

[2] Maximum EEC for the agricultural uses of pyrethroids, except for the rice use. When the EEC was expressed in µg/kg-dw, it was approximated to µg/kg$_{OC}$ by dividing by 0.04, which is the fraction of organic

carbon in the sediment of the standard pond.

The above examples of comparison between monitored and modelled data is at best an approximation due to many factors such as (1) Modelled EECs appear to be conservative enough, since for the majority of the chemicals the modelled EEC was higher than the maximum sediment OC normalized concentration (for six of eight chemicals); (2) This summary is based on the maximum observed concentrations in order to identify sites having the highest EECs indicating their vulnerability, but it is noted that these values may have been influenced by contamination from other sources such as spills and transported pesticides from areas upstream or with airborne particles and/or drift; (3) Ideally, only targeted monitoring data, for an identified vulnerable site, may be compared to modeling data using parameters representing the same site. Monitoring data needed for comparison should represent only one area and should be extensive (daily or weekly); (4) It is important to point out that the ultimate maximum exposure EECs in receiving water bodies is dependent on the mass of pesticide transferred into the water body; (5) In flowing waters, such as rivers and streams, observed concentrations are expected to be influenced by the flow status of the rivers and streams because higher dilution will occur at high flow compared to low flow; and, (6) EECs are also influenced by the pesticide fate and transport properties as well as the receiving water characteristic such as type of suspended matter (content of dissolved/suspended organic carbon and other colloidal materials). Such contents may additionally influence the bioavailability of the pesticide and its toxic effects.

6. Aquatic Receptors and Ecological Effects Characterization

In ecological risk assessments, effects characterization describes the types of effects a pesticide can produce in an aquatic (or terrestrial) organism. This characterization is based chiefly on registrant-submitted studies that describe acute and chronic effects toxicity information for various aquatic and terrestrial animals and plants. Data from the open literature are also considered; in this case, when updated ECOTOX queries were available, papers were screened to see if data from any of those studies contained apical toxicity endpoints (*e.g.*, survival, growth, reproduction, development) that were more sensitive than available data from submitted studies and, if so, reviewed according to approved procedures (USEPA, 2011). Acute and chronic laboratory studies with pyrethroids and pyrethrins with aquatic organisms provide information regarding survival, growth, and reproduction. Data on the technical grade active ingredient (TGAI) and the effects on freshwater and estuarine/marine fish and invertebrates, aquatic vascular and nonvascular plants (algae), and freshwater and estuarine/marine sediment dwelling organisms are used to evaluate the potential risk from aquatic exposure resulting from runoff or spray drift from the assessed uses. Refer to **Section 6** of **Part II** of the PRA for a summary of the endpoints selected for use in this assessment. Further information about the endpoints listed in **Section 6** of **Part II** of the PRA (which are the most sensitive ones across species tested), including species, study identification, and effects observed, is presented in the **Attachment II**. For a comprehensive list of toxicity data for each chemical, see the **Attachment IV**. The endpoints selected for RQ calculations are presented in the footnotes to each of the RQ tables in **Section 7.1** (*Risk Estimation*).

7. Risk Characterization

Risk characterization provides the final step in the risk assessment process. In this step, exposure and effects characterization are integrated to provide an estimate of risk relative to established levels of concern (LOCs; **Section 7.1**). The results are then interpreted for the risk manager through a risk description and synthesized into an overall conclusion (**Section 7.2**). In addition, the risk description also contains a discussion of relevant sources of uncertainty in the risk assessment and sensitivity of the risk assessment findings to important methodological assumptions.

7.1. Risk Estimation

Results of the exposure modelling and toxicity effects data are used to evaluate the likelihood of adverse ecological effects on non-target species. For the assessment of pyrethroids and pyrethrins, the risk quotient (RQ) method is used to compare exposure and measured toxicity values (refer to **Appendix A**). Estimated environmental concentrations (EECs) are divided by the most sensitive acute and chronic toxicity values. The RQs are then compared to the Agency's levels of concern (LOCs). These LOCs, summarized in **Appendix A**, are the Agency's interpretive policy and are used to analyse potential risk to non-target organisms and the need to consider regulatory action. These criteria are used to

indicate when a pesticide's use as directed on the label has the potential to cause adverse effects on non-target organisms. LOCs currently address the following risk presumption categories:

Aquatic Animals:

- **Acute risk** – potential for acute risk to non-target organisms which may warrant regulatory action in addition to restricted use classification,
- **Acute risk, listed species** – listed species may be potentially affected by use,
- **Chronic risk** – potential for chronic risk may warrant regulatory action, listed species may potentially be affected through chronic exposure.

The reader is reminded, as stated in **Section 5.1.1** (*Agricultural Uses and Considerations*), that "BEAD-provided information indicated that there are a number of agricultural uses for pyrethroids that constitute the majority of the usage for these chemicals: *i.e.*, ***alfalfa, corn, sweet corn, cotton, soybean, sunflowers, wheat and rice***. For the applicable chemicals, EFED modeled the above mentioned uses using aerial applications (note: rice uses were modeled separately). In addition, other crops that could involve less usage were also modeled, which included ***one vegetable crop*** (*e.g.*, cucurbit vegetables, fruiting vegetables, or brassica (head and stem) vegetables), one specialty crop (blueberries), ***and one tree crop that could be applied using airblast*** methods of application (e.g., citrus fruits or tree nuts)."

In addition, as stated in **Section 5.3.1** (*Description of Model Inputs*), "In order to simulate applications to agricultural crops, and given the large number of crops per use, a batch run file was prepared and multiple runs were performed simultaneously in the PWC. Then the scenario yielding the highest EECs related to a high use area was presented in the EEC tables and the RQ tables. For example, for corn there are thirteen PRZM scenarios across the U.S. as follows: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, and TX corn. *Note again that all these scenarios were run in batch mode in the PWC*."

7.1.1. Freshwater and Estuarine/Marine Fish Risk Quotients

For bifenthrin, all of the acute freshwater fish RQs exceeded the listed (endangered and/or threatened) species LOC (0.05), but none of these RQs exceed the non-listed species LOC (0.5). In all cases, the RQ was *0.09*, since the acute EECs were limited by the solubility of bifenthrin, which is quite low. The chronic LOC (1.0) was exceeded for all the scenarios, with RQs of **3.5**. Similarly, the chronic EECs were limited by the low solubility of bifenthrin.

For estuarine/marine fish exposed to bifenthrin there were no exceedances of any of the acute or chronic listed and/or non-listed LOCs for estuarine/marine fish. On an acute basis, the RQs were <0.01 for all the scenarios. The chronic RQ = 0.14 for all the scenarios.

Table 71. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Bifenthrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
FL cucumber/ Cucurbit Vegetables	0.014* (0.231)	0.014* (0.0449)	*0.09*	**3.5**	<0.01	0.14
NY grapes/ Blueberries (and other Bushberries)	0.014* (2.51)	0.014* (0.420)	*0.09*	**3.5**	<0.01	0.14
FL citrus/ Citrus[3]	0.014* (0.798)	0.014* (0.101)	*0.09*	**3.5**	<0.01	0.14
IL corn/ Corn	0.014* (1.74)	0.014* (0.264)	*0.09*	**3.5**	<0.01	0.14
FL sweet corn/ Sweet Corn	0.014* (0.296)	0.014* (0.0456)	*0.09*	**3.5**	<0.01	0.14
MS cotton/ Cotton	0.014* (1.86)	0.014* (0.257)	*0.09*	**3.5**	<0.01	0.14
MS soybean/ Soybean	0.014* (0.513)	0.014* (0.105)	*0.09*	**3.5**	<0.01	0.14
GA pecan/ Tree Nuts	0.014* (1.20)	0.014* (0.167)	*0.09*	**3.5**	<0.01	0.14
CA cole crops/ Brassica Vegetables	0.014* (0.540)	0.014* (0.147)	*0.09*	**3.5**	<0.01	0.14
CA lettuce/ Lettuce	0.014* (0.614)	0.014* (0.134)	*0.09*	**3.5**	<0.01	0.14

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.15 ppb [for Rainbow Trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 0.004 ppb [no acceptable data were submitted or found in the open literature on the chronic toxicity of bifenthrin to freshwater fish; the value used is based on the most sensitive chronic NOAEC reported for pyrethroids (*i.e.*, tefluthrin, MRID 41705101)].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 17.8 ppb [for Sheepshead Minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.1 ppb [for Sheepshead Minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to deltamethrin on an acute basis, all the scenarios with the exception of the ND wheat scenario representing sunflowers, exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively). The acute RQs ranged from 0.30 to 2.7. Further, none of the chronic RQs exceeded the LOC (1.0). The highest chronic RQ was 0.50, for the MS cotton scenario.

For estuarine/marine fish exposed to deltamethrin the acute RQs were the same than for freshwater fish (different species were tested, but the endpoint turned out to be the same); therefore the same exceedances apply. None of the chronic RQs exceeded the LOC of 1.0. On an acute basis, the RQs were 0.02 to *0.34* and the chronic RQs were 0.02 to 0.35.

Table 72. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
GA onion/ Bulb Vegetables	0.0639	0.00192	**1.6**	0.11	*0.11*	0.08
WA potato/ Tuberous and Corm Vegetables	0.0408	0.00119	**1.0**	0.07	*0.07*	0.05
GA pecan/ Tree Nuts	0.108	0.00223	**2.7**	0.13	*0.19*	0.09
IA corn/ Corn	0.0835	0.00223	**2.1**	0.13	*0.14*	0.09
FL sweet corn/ Sweet Corn	0.0840	0.00319	**2.1**	0.19	*0.14*	0.13
MS cotton/ Cotton	0.200* (0.434)	0.00846	**5.0**	0.50	*0.34*	0.35
MS soybean/ Soybean	0.0544	0.00129	**1.4**	0.08	*0.09*	0.05
ND wheat/ Sunflowers[3]	0.0120	4.08×10^{-4}	*0.30*	0.02	0.02	0.02
FL cucumbers/ Cucurbit Vegetables	0.0309	0.00129	**0.77**	0.08	*0.05*	0.05
FL tomatoes/ Fruiting Vegetables	0.0651	0.00192	**1.6**	0.11	*0.11*	0.08

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.15 ppb [for Rainbow trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 0.017 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.58 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.024 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

For the pyrethrins and freshwater fish, all of the scenario RQs exceeded the listed species acute LOC (0.05), while none of the scenarios exceeded the chronic LOC. The highest acute RQ was *0.32*, for the NY grapes scenario, representing blueberries. The highest chronic RQ was only 0.33 for the same scenario.

For estuarine/marine fish exposed to pyrethrins there were five RQs exceeding the acute listed species LOC (0.05), but not the non-listed species LOC (0.5). The highest acute RQ was *0.10*. None of the chronic RQs exceeded the LOC. On an acute basis, the RQs ranged from 0.03 to *0.10*. The chronic RQs ranged from 0.21 to 0.89 for all the scenarios.

For the uses of pyrethrins on rice, the EECs and RQs were around one order of magnitude higher than for the other agricultural uses. The acute and chronic RQs for freshwater and estuarine/marine fish exceeded the listed and non-listed species LOCs (RQs ranging from 1.5 to 11).

Table 73. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
MN alfalfa/ Alfalfa	0.663	0.328	*0.13*	0.17	0.04	0.47
NY grapes/ Blueberries	1.64	0.621	*0.32*	0.33	*0.10*	0.89
FL citrus/ Citrus	0.515	0.145	*0.10*	0.08	0.03	0.21
IL corn/ Corn	1.22	0.449	*0.24*	0.24	*0.08*	0.64
FL sweet corn/ Sweet Corn	0.591	0.257	*0.12*	0.14	0.04	0.37
NC cotton/ Cotton	1.54	0.508	*0.30*	0.27	*0.10*	0.73
MS soybean/ Soybean	0.725	0.255	*0.14*	0.13	*0.05*	0.36
ND wheat/ Sunflower	0.690	0.315	*0.14*	0.17	0.04	0.45
ND wheat/ Wheat	0.690	0.315	*0.14*	0.17	0.04	0.45
FL tomato/ Fruiting Vegetables	0.782	0.262	*0.15*	0.14	*0.05*	0.37
CA rice (Winter flood)/ Rice	56.5	2.79	**11**	**1.5**	**3.5**	**4.0**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 5.1 ppb [for Rainbow Trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 1.9 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 16 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.7 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to permethrin, all the scenario RQs exceeded the acute listed and non-listed of LOCs (0.05 and 0.5, respectively). The acute RQs ranged from **0.85** for the FL sweet corn to **7.0** for the NY grape scenario representing blueberries. On a chronic basis, all of the scenario RQs exceeded the non-listed LOC (1.0). The chronic RQs ranged from **1.4** for the FL sweet corn to **23** for the NY grape scenario representing blueberries.

For estuarine/marine fish exposed to permethrin on an acute basis all the RQs exceeded the listed species LOC (0.05) and in three cases the non-listed species LOC (0.5). The three scenario RQs that exceeded the non-listed species LOC were the NY grapes (representing blueberries), GA pecan (tree nuts), and CA lettuce. The remaining scenarios exceeded only the acute listed species LOC. The acute RQs ranged from *0.26* to **2.5**. Only the NY grapes (representing blueberries) and GA pecan (tree nuts) exceeded the chronic LOC (RQs of **2.5** and **1.0**, respectively; LOC = 1.0).

Table 74. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.574	0.0784	**0.73**	**1.5**	*0.26*	0.55
NY grapes/ Blueberries	5.50* (10.3)	1.22	**7.0**	**23**	**2.5**	**8.53**
GA pecans/ Tree Nuts (based on pistachios)	2.20	0.198	**2.8**	**3.8**	**1.0**	**1.38**
IL corn/ Corn	1.07	0.115	**1.4**	**2.2**	*0.49*	0.80
FL sweet corn/ Sweet Corn	0.670	0.0741	**0.85**	**1.4**	*0.30*	0.52
CA lettuce/ Leafy Greens (based on the rate for lettuce)	1.10	0.121	**1.4**	**2.3**	**0.50**	0.85
MS soybean/ Soybean	0.724	0.0806	**0.92**	**1.6**	*0.33*	0.56
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	0.831	0.124	**1.1**	**2.4**	*0.38*	0.87
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	0.924	0.109	**1.2**	**2.1**	*0.42*	0.76
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	1.04	0.114	**1.3**	**2.2**	*0.47*	0.80

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 5.50 ppb because they exceeded the limit of solubility of permethrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.79 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.052 ppb [for Bluegill sunfish, *Lepomis macrochirus*, based on an ACR].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Atlantic Silverside, *Menidia menidia*]. Chronic RQ = use-specific 60-day EEC / 0.143 ppb [for Atlantic Silverside, *Menidia menidia*].

For freshwater fish exposed to esfenvalerate, all the agricultural scenarios exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively). The range of RQs was 1.16 to 8.80. The highest acute RQ is for the NC cotton scenario. Five out of ten scenarios exceeded the chronic non-listed species LOC (LOC = 1.0). The highest chronic RQ was for the NC cotton scenario, with and RQ of 2.2.

For estuarine/marine fish exposed to esfenvalerate, for three of the scenarios the acute RQ exceeded or approached the listed species LOC (LOC = 0.05). For these scenarios, the RQs were <0.05 to <0.06. For all the remaining scenarios, the acute RQs did not exceed the listed and/or non-listed species LOCs (LOC = 0.05 and 0.5, respectively). All the chronic RQs were ≤0.06 and did not exceed the non-listed LOC (LOC = 1.0).

Table 75. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head & stem) Vegetables	0.369	0.0227	**2.6**	**1.3**	<0.02	0.04
NY grapes/ Blueberries (*except CA*)[3]	0.900	0.0288	**6.3**	**1.7**	*<0.05*	0.05
GA pecan/ Tree Nuts (based on rate on almonds)	0.899	0.0269	**6.3**	**1.6**	*<0.05*	0.04
IL corn/ Corn	0.851	0.0269	**6.0**	**1.6**	<0.04	0.04
FL sweet corn/ Sweet Corn	0.422	0.0169	**3.0**	0.99	<0.02	0.03
NC cotton/ Cotton	1.25	0.0374	**8.8**	**2.2**	*<0.06*	0.06
MS soybean/ Soybeans	0.303	0.0111	**2.1**	0.65	<0.02	0.02
ND wheat/ Sunflowers	0.165	0.00711	**1.2**	0.42	<0.01	0.01
FL cucumber/ Cucurbit Vegetables	0.241	0.0100	**1.7**	0.59	<0.01	0.02
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	0.443	0.0168	**3.1**	0.99	<0.02	0.03

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.142 ppb [for Bluegill, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.017 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 19.3 ppb [>19.3 ppb estimated from sheepshead minnow, *Cyprinodon variegatus*, TEP toxicity data, along with a rainbow trout adjustment factor for estimating TGAI toxicity from TEP data]. Chronic RQ = use-specific 60-day EEC / 0.63 ppb [for sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to cypermethrin, seven of the scenarios exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively). The remaining scenarios exceeded only the acute listed species LOC. None of the chronic RQs exceeded the non-listed species LOC (LOC = 1.0). The highest chronic RQ was 0.77 for the NY grape scenario, representing blueberries.

For estuarine/marine fish exposed to cypermethrin, the acute RQ for three of the scenarios exceeded the acute listed and non-listed LOC (LOCs = 0.05 and 0.5, respectively). The remaining scenario RQs exceeded only the acute non-listed LOC, with the exception of the ND wheat scenario representing sunflowers, which did not exceed the LOCs. None of the chronic RQs exceeded the LOC (LOC = 1.0).

For the uses of cypermethrin (*zeta*-) on rice, the EECs and RQs were around one order of magnitude higher than for the other agricultural uses. The peak EEC was set to the limit of solubility, since the modelled EEC exceeded this value. The acute and chronic RQs for freshwater and estuarine/marine fish exceeded the listed and non-listed species LOCs (RQs ranging from 3.3 to 10).

Table 76. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Cypermethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0847	0.00395	*0.22*	0.08	*0.09*	0.03
NY grapes/ Blueberries:	0.938	0.0392	**2.4**	0.77	**0.99**	0.32
FL citrus/ Citrus:	0.270	0.00928	**0.69**	0.18	*0.28*	0.07
IL corn/ Corn	0.461	0.0172	**1.2**	0.34	*0.49*	0.14
FL sweet corn/ Sweet Corn	0.193	0.00878	*0.49*	0.17	*0.20*	0.07
MS cotton/ Cotton	0.908	0.0293	**2.3**	0.57	**0.96**	0.23
MS soybean/ Soybean	0.480	0.0201	**1.2**	0.39	**0.51**	0.16
ND wheat/ Sunflower	0.0403	0.00146	*0.10*	0.03	0.04	0.01
ND wheat/ Wheat	0.221	0.00923	**0.57**	0.18	*0.23*	0.07
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.318	0.0143	**0.82**	0.28	*0.33*	0.11
CA rice (Winter flood)/ Rice	3.97* (55.4)	0.410	**10**	**8.0**	**4.2**	**3.3**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 3.97 ppb because they exceeded the limit of solubility of cypermethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.39 ppb [for Rainbow Trout, *Oncorhynchus mykiss*, conducted with *beta*-cypermethrin]. Chronic RQ = use-specific 60-day EEC / 0.051 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.95 ppb [for sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.125 ppb [no valid chronic study, estimated using an ACR].

For freshwater fish exposed to cyfluthrin, all the scenarios exceeded the acute listed and non-listed species LOCs (LOCs = 0.05 and 0.5, respectively). The highest RQ was 10.1 for the MS cotton scenario. Three of the chronic RQs did not exceed the non-listed species LOC (LOC = 1.0), while for the remaining scenarios the RQs ranged from 1.0 to 3.3.

For estuarine/marine fish exposed to cyfluthrin, five out of ten of the acute RQs exceeded the listed species LOC (LOC = 0.05; RQs ranged from 0.06 to 0.18). None of the chronic RQs exceeded the non-listed species LOC.

Table 77. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Cyfluthrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0865	0.00403	**1.3**	0.96	0.02	0.16
NY grapes/ Grapes	0.535	0.0127	**7.9**	**3.0**	*0.13*	0.51
FL citrus/ Citrus	0.197	0.00435	**2.9**	**1.0**	*0.05*	0.17
IL corn/ Corn	0.246	0.00577	**3.6**	**1.4**	*0.06*	0.23
FL sweet corn/ Sweet Corn	0.127	0.00542	**1.9**	**1.3**	0.03	0.22
MS cotton/ Cotton	0.728	0.0140	**10.1**	**3.3**	*0.18*	0.56
MS soybean/ Soybeans	0.147	0.00419	**2.2**	**1.0**	0.04	0.17
ND wheat/ Sunflowers	0.0523	0.00180	**0.77**	0.43	0.01	0.07
ND wheat/ Wheat	0.0434	0.00104	**0.64**	0.25	0.01	0.04
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.358	0.0115	**5.2**	**2.7**	*0.09*	0.46

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.068 ppb [for Rainbow Trout, *Oncorhynchus mykiss*, conducted with *beta*-cyfluthrin]. Chronic RQ = use-specific 60-day EEC / 0.0042 ppb [NOAEC estimated or calculated for Rainbow Trout, *Oncorhynchus mykiss* for *beta*-cyfluthrin from cyfluthrin data].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 4.05 ppb [for sheepshead minnow, *Cyprinodon variegatus* for cyfluthrin]. Chronic RQ = use-specific 60-day EEC / 0.025 ppb [for sheepshead minnow, *Cyprinodon variegatus* for cyfluthrin].

For freshwater fish exposed to *lambda*-cyhalothrin, all of the scenarios exceeded the acute listed and non-listed species LOCs (LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 2.3 to 26. On a chronic basis, only the ND wheat scenario did not exceed the LOC for the non-listed species (LOC = 1.0; RQ = 0.88). The highest chronic RQ was 7.3 for the MS cotton scenario.

For estuarine/marine fish exposed to *lambda*-cyhalothrin, all the acute RQs exceeded the listed species LOC, plus the MS cotton scenario additionally exceeded the non-listed species LOC (RQ = 0.92). All the chronic RQs were ≤0.91 and none exceeded the LOC (chronic LOC = 1.0).

For the uses of cyhalothrins (*lambda*-) on rice, the EECs and RQs were up to one order of magnitude higher than for the other conventional agricultural uses. The peak EEC was set to the limit of solubility, since the modelled EEC exceeded this value. The acute and chronic RQs for freshwater and estuarine/marine fish exceeded the listed and non-listed species LOCs, with the exception of the chronic RQ for estuarine/marine fish, which did not exceed, but approached the chronic LOC (RQ = 0.92).

Table 78. Acute and Chronic RQs for Freshwater Fish Exposed to *Lambda*-Cyhalothrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0884	0.0435	**3.0**	**1.4**	*0.11*	0.17
FL cucumber/ Cucurbit Vegetables	0.186	0.0926	**6.4**	**3.0**	*0.23*	0.37
FL citrus/ Citrus	0.273	0.0920	**9.4**	**3.0**	*0.34*	0.37
IL corn/ Corn	0.279	0.0930	**9.6**	**3.0**	*0.35*	0.37
FL sweet corn/ Sweet Corn	0.230	0.119	**7.9**	**3.8**	*0.29*	0.48
MS cotton/ Cotton	0.740	0.227	**26**	**7.3**	**0.92**	0.91
MS soybean/ Soybeans	0.0768	0.0326	**2.6**	**1.1**	*0.10*	0.13
ND wheat/ Sunflowers	0.0964	0.0545	**3.3**	**1.7**	*0.12*	0.22
ND wheat/ Wheat	0.0674	0.0272	**2.3**	0.88	*0.08*	0.11
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	0.361	0.193	**12**	**6.2**	*0.45*	0.77
CA rice (Winter flood)/ Rice	5.00* (44.3)	0.230	**172**	**7.4**	**6.20**	0.92

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 5.00 ppb because they exceeded the limit of solubility of *lambda*-cyhalothrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.029 ppb [for Bluegill sunfish, *Lepomis macrochirus*, conducted with *gamma*-cyhalothrin]. Chronic RQ = use-specific 60-day EEC / 0.031 ppb [for Fathead Minnow, *Pimephales promelas*, conducted with *lambda*-cyhalothrin].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.807 ppb [for sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.25 ppb [for sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to fenpropathrin, there were multiple exceedances of acute and chronic LOCs. On an acute basis, the CA cole crops and FL cucumber scenarios exceeded the acute listed species LOC (0.05). Meanwhile, the remaining scenarios exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively). The acute RQs ranged from 0.44 for the FL cucumber scenario to 1.7 for the MS cotton scenario.

On a chronic basis for fenpropathrin and freshwater fish, the RQs exceeded the LOC (1.0) for all of the scenarios. The chronic RQs ranged from 1.5 for the FL cucumber scenario to 5.2 for the MS cotton scenario.

For estuarine/marine fish exposed to fenpropathrin there were multiple exceedances of the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), and none of the chronic RQs exceeded the chronic LOC (1.0). Four out of 10 scenarios exceeded the acute listed species LOC. The lowest acute RQ was 0.31 for the FL cucumber scenario. The

remaining six scenarios also exceeded the acute non-listed species LOC. The highest acute RQ was 1.2 for the MS cotton scenario. The chronic RQs were ≤0.38 for all ten scenarios.

Table 79. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Fenpropathrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	1.02	0.153	*0.46*	**2.6**	*0.33*	0.19
NY grapes/ Bushberries and caneberries	3.35	0.266	**1.5**	**4.4**	**1.1**	0.33
FL citrus/ Citrus	1.30	0.116	**0.59**	**1.9**	*0.42*	0.14
FL cucumber/ Cucurbit Vegetables	0.970	0.0903	*0.44*	**1.5**	*0.31*	0.11
PA apple/ Pome Fruits	2.08	0.169	**0.95**	**2.8**	**0.67**	0.21
MS cotton/ Cotton	3.70	0.310	**1.7**	**5.2**	**1.2**	0.38
MI cherries/ Stone Fruits	3.18	0.305	**1.4**	**5.1**	**1.0**	0.38
GA pecan/ Tree Nuts	2.02	0.154	**0.92**	**2.6**	**0.65**	0.19
NC peanuts/ Peanuts	2.72	0.161	**1.2**	**2.7**	**0.88**	0.20
FL tomato/ Fruiting Vegetables	1.10	0.102	**0.50**	**1.7**	*0.35*	0.13

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.06 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 3.1 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.81 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

Besides runs performed for the parent alone, for fenpropathrin additional runs were performed for the parent plus the unextracted residues.

For freshwater fish exposed to fenpropathrin plus the unextracted residues, there were multiple exceedances of acute and chronic LOCs. On an acute basis all the scenarios exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). The acute RQ range was 0.65 for the FL cucumber and CA cole crops scenarios to 1.8 for the MS cotton scenario.

On a chronic basis for fenpropathrin plus the unextracted residues, the RQs exceeded the LOC (1.0) for all of the scenarios. The RQs exceeded the chronic LOCs, in the range of 2.1 for the FL cucumber scenario to 1.8 for the MS cotton scenario.

For estuarine/marine fish exposed to fenpropathrin plus the unextracted residues there were also multiple exceedances of the acute listed and non-listed species LOCs (0.05 and 0.5, respectively); however, none of the scenarios exceeded the chronic LOC (1.0). Three of the scenarios had RQs in the range of 0.46 to 0.47, exceeding only the listed species

LOC (FL cucumber, CA cole crops and FL tomato). The remaining scenarios exceeded also the non-listed species LOC. Overall, the range of RQs was 0.46 to 1.3 (for the MS cotton scenario).

On a chronic basis, for estuarine/marine fish and fenpropathrin plus the unextracted residues, none of the RQs exceeded the LOC. The RQs were ≤0.44 for all the scenarios tested.

In general, it was found that the risk picture for the parent alone, compared to the parent plus the unextracted residues were similar.

Table 80. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Fenpropathrin plus Unextracted Residues

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	1.44	0.211	**0.65**	**3.5**	*0.46*	0.26
NY grapes/ Bushberries and caneberries	3.44	0.285	**1.6**	**4.8**	**1.1**	0.35
FL citrus/ Citrus	1.63	0.148	**0.74**	**2.5**	**0.53**	0.18
FL cucumber/ Cucurbit Vegetables	1.43	0.128	**0.65**	**2.1**	*0.46*	0.16
PA apple/ Pome Fruits	3.01	0.224	**1.4**	**3.7**	**0.97**	0.28
MS cotton/ Cotton	3.95	0.344	**1.8**	**5.7**	**1.3**	0.42
MI cherries/ Stone Fruits	3.56	0.354	**1.6**	**5.9**	**1.1**	0.44
GA pecan/ Tree Nuts	2.41	0.186	**1.1**	**3.1**	**0.78**	0.23
NC peanuts/ Peanuts	2.94	0.185	**1.3**	**3.1**	**0.95**	0.23
FL tomato/ Fruiting Vegetables	1.47	0.135	**0.67**	**2.3**	*0.47*	0.17

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.06 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 3.1 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.81 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

7.1.2. Freshwater and Estuarine/Marine Invertebrates Risk Quotients

For freshwater invertebrates exposed to bifenthrin, all the acute RQs exceeded the listed and non-listed LOCs (acute LOCs = 0.05 and 0.5, respectively). The acute RQs were 28.4 for all the scenarios. On a chronic basis, the RQs exceeded the LOC (chronic LOC = 1.0) for all the scenarios. The chronic RQs were 280 for all the scenarios. These RQs represent EECs at the limit of solubility of bifenthrin (the highest RQ is at the limit of solubility of 0.0140 µg/L).

For estuarine/marine invertebrates exposed to bifenthrin, all the RQs exceeded the acute listed (LOC = 0.05) and non-listed (LOC = 0.5) species LOCs. The acute RQs were 3.5 for all the scenarios. On a chronic basis, also all the scenarios exceeded the LOC (LOC = 1.0). The chronic RQ was >23 for all the scenarios (at the limit of solubility).

Table 81. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Bifenthrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
FL cucumber/ Cucurbit Vegetables	0.014* (0.231)	0.014* (0.0519)	**28.4**	**280**	**3.5**	**>23**
NY grapes/ Blueberries (and other Bushberries)	0.014* (2.51)	0.014* (0.469)	**28.4**	**280**	**3.5**	**>23**
FL citrus/ Citrus[3]	0.014* (0.798)	0.014* (0.122)	**28.4**	**280**	**3.5**	**>23**
IL corn/ Corn	0.014* (1.74)	0.014* (0.309)	**28.4**	**280**	**3.5**	**>23**
FL sweet corn/ Sweet Corn	0.014* (0.296)	0.014* (0.0524)	**28.4**	**280**	**3.5**	**>23**
MS cotton/ Cotton	0.014* (1.86)	0.014* (0.291)	**28.4**	**280**	**3.5**	**>23**
MS soybean/ Soybean[3]	0.014* (0.513)	0.014* (0.116)	**28.4**	**280**	**3.5**	**>23**
GA pecan/ Tree Nuts	0.014* (1.20)	0.014* (0.177)	**28.4**	**280**	**3.5**	**>23**
CA cole crops/ Brassica Vegetables	0.014* (0.540)	0.014* (0.154)	**28.4**	**280**	**3.5**	**>23**
CA lettuce/ Lettuce	0.014* (0.614)	0.014* (0.142)	**28.4**	**280**	**3.5**	**>23**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.000493 ppb [for amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.000050 ppb [for amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00397 ppb [for Mysid Shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.0006 ppb [<0.0006 ppb, for Mysid Shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to deltamethrin, all the acute RQs exceeded the listed and non-listed LOCs (acute LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 60 for the ND wheat scenario (representing sunflowers) to 1000 for the MS cotton scenario. On a chronic basis, all of the RQs exceeded the LOC (chronic LOC = 1.0). The chronic RQs ranged from 24 to 490.

For estuarine/marine invertebrates exposed to deltamethrin, all the scenario's acute RQs exceeded the listed and non-listed species LOC (LOCs = 0.05 and 0.5, respectively). The highest acute RQ was 54 for MS cotton scenario (at the limit of solubility). On a chronic basis, all the RQs exceeded the chronic LOC (1.0), except for the ND wheat scenario (representing sunflowers). Chronic RQs ranged from 0.86 to 18.

Table 82. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
GA onion/ Bulb Vegetables	0.0639	0.00281	**320**	**110**	**17**	**6.0**
WA potato/ Tuberous and Corm Vegetables	0.0408	0.00177	**200**	**68**	**11**	**3.8**
GA pecan/ Tree Nuts	0.108	0.00286	**540**	**110**	**29**	**6.1**
IA corn/ Corn	0.0835	0.00308	**420**	**120**	**23**	**6.6**
FL sweet corn/ Sweet Corn	0.0840	0.00482	**420**	**190**	**23**	**10**
MS cotton/ Cotton	0.200* (0.434)	0.0128	**1000**	**490**	**54**	**27**
MS soybean/ Soybean	0.0544	0.00169	**270**	**65**	**15**	**3.6**
ND wheat/ Sunflowers	0.0120	6.31×10^{-4}	**60**	**24**	**3.2**	**1.3**
FL cucumbers/ Cucurbit Vegetables	0.0309	0.00195	**150**	**75**	**8.4**	**4.1**
FL tomatoes/ Fruiting Vegetables	0.0651	0.00227	**330**	**87**	**18**	**4.8**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0002 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0037 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00047 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to the pyrethrins, all of the scenario acute RQs exceeded the listed and non-listed species LOCs (acute LOC = 0.05 for listed species and 0.5 for non-listed species). The acute RQs ranged from 0.87 to 2.2. Furthermore, all of

the chronic RQs exceeded the LOC (chronic LOC = 1.0). The chronic RQs ranged from 5.9 to 24.

For estuarine/marine invertebrates exposed to the pyrethrins, there were exceedances of the acute non-listed species LOC for all of the scenarios. For two of the scenarios, there were, in addition, exceedances of acute non-listed LOC (acute listed species LOC = 0.05, and non-listed LOC = 0.5). These scenarios included NY grapes (representing blueberries) and MS cotton. The acute RQs ranged from 0.29 to 0.68. Additionally, all the chronic RQs exceeded the LOC (LOC = 1.0), except for the FL citrus scenario, which was borderline, approaching the LOC (RQ = 0.94). The chronic RQs ranged from 0.94 to 3.8.

For the uses of pyrethrins on rice, the EECs and RQs were about one order of magnitude higher than for the other conventional agricultural uses. The acute and chronic RQs for freshwater and estuarine/marine invertebrates exceeded the listed and non-listed species LOCs (all RQs ≥ 18 for rice).

Table 83. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
MN alfalfa/ Alfalfa	0.663	0.490	**0.87**	**12**	*0.35*	**2.0**
NY grapes/ Blueberries	1.64	0.958	**2.2**	**24**	**0.68**	**3.8**
FL citrus/ Citrus	0.515	0.236	**0.68**	**5.9**	*0.37*	0.94
IL corn/ Corn	1.22	0.682	**1.6**	**17**	*0.49*	**2.7**
FL sweet corn/ Sweet Corn	0.591	0.402	**0.78**	**10**	*0.29*	**1.6**
NC cotton/ Cotton	1.54	0.739	**2.0**	**18**	**0.53**	**3.0**
MS soybean/ Soybean	0.725	0.410	**0.95**	**10**	*0.29*	**1.6**
ND wheat/ Sunflower	0.690	0.475	**0.91**	**12**	*0.34*	**1.9**
ND wheat/ Wheat	0.690	0.475	**0.91**	**12**	0.34	**1.9**
FL tomato/ Fruiting Vegetables	0.782	0.423	**1.0**	**11**	*0.30*	**1.7**
CA rice (Winter flood)/ Rice	56.5	4.60	**74**	**115**	**40**	**18**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.76 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.04 ppb [for midge, *Chironomus dilutus*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 1.4 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.25 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to permethrin the acute RQs exceeded the listed and non-listed species LOCs (acute LOCs = 0.05 and 0.5, respectively) for all the scenarios tested. The range of acute RQs was 87 to 830. On a chronic basis, all the scenario RQs

also exceeded the LOC (chronic LOC = 1.0). The highest chronic RQ was 580 (sediment-based) for the NY grapes scenario, representing blueberries.

For estuarine/marine invertebrates exposed to permethrin, all the RQs exceeded the acute and chronic listed and non-listed species LOCs (all acute RQs > 0.5; all chronic RQs > 1.0). The highest acute and chronic RQs were 310 and 580, respectively, for the NY grapes scenario (blueberries).

Table 84. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.574	0.0854	**87**	**20**	**32**	**36**
NY grapes/ Blueberries	5.50* (10.3)	1.38	**830**	**329**	**310**	**580**
GA pecans/ Tree Nuts (based on pistachios)	2.20	0.239	**330**	**60**	**120**	**100**
IL corn/ Corn	1.07	0.130	**160**	**31**	**59**	**54**
FL sweet corn/ Sweet Corn	0.670	0.0847	**100**	**20**	**37**	**35**
CA lettuce/ Leafy Greens (based on the rate for lettuce)	1.10	0.143	**170**	**34**	**61**	**60**
MS soybean/ Soybean	0.724	0.0950	**110**	**23**	**40**	**40**
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	0.831	0.147	**130**	**35**	**46**	**61**
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	0.924	0.126	**140**	**30**	**51**	**53**
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	1.04	0.128	**160**	**30**	**58**	**53**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 5.50 ppb because they exceeded the limit of solubility of permethrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0066 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0042 ppb [for the amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.018 ppb [for Stone crab, *Menippe mercenaria*]. Chronic RQ = use-specific 21-day EEC / 0.0024 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to esfenvalerate, all the acute RQs exceeded the listed and non-listed LOCs (LOCs = 0.05 and 0.5, respectively). Furthermore, all the chronic RQs also exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 195 to 1470, while the chronic RQs ranged from 315 to 1420.

For estuarine/marine invertebrates exposed to esfenvalerate, the acute RQs for all the scenarios exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively). The acute RQs ranged from 35.4 to 268. In addition, all the chronic RQs exceeded the

LOC (LOC = 1.0). The chronic RQs ranged from 57.2 to 258. The highest acute and chronic RQs were both for the NC cotton scenario.

Table 85. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head & stem) Vegetables	0.369	0.0275	**435**	**890**	**79.2**	**162**
NY grapes/ Blueberries (*except CA*)	0.900	0.0427	**1060**	**1380**	**193**	**251**
GA pecan/ Tree Nuts (based on rate on almonds)	0.899	0.0340	**1060**	**1100**	**193**	**200**
IL corn/ Corn	0.851	0.0384	**1004**	**1240**	**183**	**226**
FL sweet corn/ Sweet Corn	0.422	0.0211	**498**	**683**	**90.6**	**124**
NC cotton/ Cotton	1.25	0.0439	**1470**	**1420**	**268**	**258**
MS soybean/ Soybeans	0.303	0.0139	**357**	**450**	**65.0**	**81.8**
ND wheat/ Sunflowers	0.165	0.00972	**195**	**315**	**35.4**	**57.2**
FL cucumber/ Cucurbit Vegetables	0.241	0.0115	**284**	**372**	**51.7**	**67.6**
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	0.443	0.0201	**522**	**650**	**95.1**	**118**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.000848 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0000309 ppb [for the amphipod, *Hyalella azteca* acute data and ACR of 27 from mysid studies].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00466 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00017 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to cypermethrin, all the acute RQs exceeded the listed and non-listed LOCs (LOCs = 0.05 and 0.5, respectively). Furthermore, all the chronic RQs also exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 72 to 1675, while the chronic RQs ranged from >40 to >1124. The highest RQs were for the NY grapes scenario, representing blueberries.

For estuarine/marine invertebrates exposed to cypermethrin, all the acute and chronic RQs exceeded the listed and non-listed species LOCs (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5; chronic LOC = 1.0). The acute RQs ranged from 7.5 to 174. The chronic RQs ranged from 10 to 281.

For the uses of cypermethrin (*zeta*-) on rice, the EECs and RQs were up to one order of magnitude higher than for the other conventional agricultural uses. The peak EEC was limited by the solubility of the compound, since the modelled EEC was greater than this value. The acute and chronic RQs for freshwater and estuarine/marine invertebrates exceeded the listed and non-listed species LOCs (RQ ≥ 735 for rice).

Table 86. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Cypermethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0847	0.00677	**151**	**>135**	**16**	**34**
NY grapes/ Blueberries:	0.938	0.0562	**1675**	**>1124**	**174**	**281**
FL citrus/ Citrus:	0.270	0.0150	**482**	**>300**	**50**	**75**
IL corn/ Corn	0.461	0.0265	**823**	**>530**	**85**	**133**
FL sweet corn/ Sweet Corn	0.193	0.0117	**345**	**>234**	**36**	**59**
MS cotton/ Cotton	0.908	0.0353	**1620**	**>706**	**168**	**177**
MS soybean/ Soybean	0.480	0.0254	**857**	**>508**	**89**	**127**
ND wheat/ Sunflower	0.0403	0.00202	**72**	**>40**	**7.5**	**10**
ND wheat/ Wheat	0.221	0.0128	**395**	**>256**	**41**	**64**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.318	0.0177	**568**	**>354**	**59**	**89**
CA rice (Winter flood)/ Rice	3.97* (55.4)	0.672	**7090**	**>13440**	**735**	**3360**

* EECs marked with an asterisk were set to 3.97 ppb because they exceeded the limit of solubility of cypermethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00056 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.00005 ppb [<0.00005 ppb, for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0054 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.0002 ppb [for amphipod, *Leptocheirus plumulosus*].

For freshwater invertebrates exposed to cyfluthrin, all the scenario RQs exceeded the acute listed and non-listed species LOCs (acute LOCs = 0.05 and 0.5, respectively). On a chronic basis, all the scenario RQs exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 1.7 to 29. The chronic RQs ranged from 16 to 194.

For estuarine/marine invertebrates exposed to cyfluthrin, all the acute RQs exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively). On a chronic basis all the scenarios exceeded the chronic LOC (LOC = 1.0). The highest acute RQ was 331, and the highest chronic RQ was 333, both for the MS cotton scenario.

Table 87. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Cyfluthrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0865	0.00601	**3.5**	**50**	**39**	**86**
NY grapes/ Grapes	0.535	0.0212	**21**	**177**	**243**	**303**
FL citrus/ Citrus	0.197	0.00717	**7.9**	**60**	**90**	**102**
IL corn/ Corn	0.246	0.0102	**9.8**	**85**	**112**	**146**
FL sweet corn/ Sweet Corn	0.127	0.00971	**5.1**	**81**	**58**	**139**
MS cotton/ Cotton	0.728	0.0233	**29**	**194**	**331**	**333**
MS soybean/ Soybeans	0.147	0.00663	**5.9**	**55**	**67**	**95**
ND wheat/ Sunflowers	0.0523	0.00315	**2.1**	**26**	**24**	**45**
ND wheat/ Wheat	0.0434	0.00197	**1.7**	**16**	**20**	**28**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.358	0.0168	**14**	**140**	**163**	**240**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.025 ppb [for Water flea, *Daphnia magna* for cyfluthrin]. Chronic RQ = use-specific 21-day EEC / 0.00012 ppb [for amphipod, *Hyalella azteca* for cyfluthrin].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0022 ppb [for Mysid shrimp, *Americamysis bahia*, conducted with *beta*-cyfluthrin]. Chronic RQ = use-specific 21-day EEC/ 0.00007 ppb [estimated or calculated for mysid shrimp, *Mysidopsis bahia*, for *beta*-cyfluthrin based on cyfluthrin data].

For freshwater invertebrates exposed to *lambda*-cyhalothrin, all the acute RQs exceeded the listed and non-listed LOCs (LOCs = 0.05 and 0.5, respectively). Furthermore, all the chronic RQs also exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 843 to 9250, while the chronic RQs ranged from 135 to 1082. The highest RQs were for the MS cotton scenario.

For estuarine/marine invertebrates exposed to *lambda*-cyhalothrin, the acute RQs also exceeded the listed species LOC (LOC = 0.05) and non-listed species LOC (LOC = 0.5) for all the scenarios. The acute RQs ranged from 13.7 to 151. All the chronic RQs exceeded the LOC (LOC = 1.0), exhibiting a range of 145 to 1190. The highest RQs were for the MS cotton scenario.

For the uses of cyhalothrin (*lambda*-) on rice, the EECs and RQs were about one order of magnitude higher than for the other conventional agricultural uses. The peak EEC was limited by the solubility of the compound, since the modelled EEC was greater than this value. The acute and chronic RQs for freshwater and estuarine/marine invertebrates exceeded the listed and non-listed species LOCs (all RQ ≥ 1020 for rice).

Table 88. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to *Lambda*-Cyhalothrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0884	0.0471	**1105**	**214**	**18.0**	**236**
FL cucumber/ Cucurbit Vegetables	0.186	0.0955	**2325**	**434**	**37.9**	**478**
FL citrus/ Citrus	0.273	0.0970	**3413**	**441**	**55.6**	**485**
IL corn/ Corn	0.279	0.0972	**3488**	**442**	**56.8**	**486**
FL sweet corn/ Sweet Corn	0.230	0.123	**2875**	**559**	**46.8**	**615**
MS cotton/ Cotton	0.740	0.238	**9250**	**1082**	**151**	**1190**
MS soybean/ Soybeans	0.0768	0.0339	**960**	**154**	**15.6**	**170**
ND wheat/ Sunflowers	0.0964	0.0578	**1205**	**268**	**19.6**	**289**
ND wheat/ Wheat	0.0674	0.0290	**843**	**135**	**13.7**	**145**
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	0.361	0.195	**4513**	**886**	**73.5**	**975**
CA rice (Winter flood)/ Rice	5.00* (44.3)	0.385	**62500**	**1750**	**1020**	**1930**

* EECs marked with an asterisk were set to 5.00 ppb because they exceeded the limit of solubility of *lambda*-cyhalothrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00008 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.00022 ppb [for amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00491 ppb [for Mysid shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin]. Chronic RQ = use-specific 21-day EEC / 0.0002 ppb [for Mysid shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin].

For freshwater invertebrates exposed to fenpropathrin residues on an acute basis, the RQs exceeded the listed and non-listed species LOCs in all instances (acute LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 318 for the FL cucumber scenario to 1213 for the MS cotton scenario. On a chronic basis, the RQs exceeded the LOC (chronic LOC = 1.0) in all cases as well. The chronic RQs ranged from >65 to >229 for the FL cucumber and MS cotton scenarios, respectively. The chronic RQs are expressed as a greater than value, as a result of a non-definitive endpoint.

For estuarine/marine invertebrates exposed to fenpropathrin, for all the scenario combinations, the RQs exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). The range in acute RQs was 46 to as high as 176. Further, all the chronic RQs exceeded the LOC (chronic LOC = 1.0). The overall range of chronic RQs was 8.2 to 29.

Table 89. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Fenpropathrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	1.02	0.161	**334**	**>107**	**49**	**13**
NY grapes/ Bushberries and caneberries	3.35	0.303	**1098**	**>202**	**160**	**25**
FL citrus/ Citrus	1.30	0.130	**426**	**>87**	**62**	**11**
FL cucumber/ Cucurbit Vegetables	0.970	0.0980	**318**	**>65**	**46**	**8.2**
PA apple/ Pome Fruits	2.08	0.179	**682**	**>119**	**99**	**15**
MS cotton/ Cotton	3.70	0.344	**1213**	**>229**	**176**	**29**
MI cherries/ Stone Fruits	3.18	0.339	**1043**	**>226**	**151**	**28**
GA pecan/ Tree Nuts	2.02	0.172	**662**	**>115**	**96**	**14**
NC peanuts/ Peanuts	2.72	0.191	**892**	**>127**	**130**	**16**
FL tomato/ Fruiting Vegetables	1.10	0.112	**361**	**>75**	**52**	**9.3**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0015 ppb [<0.0015 ppb, for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.012 [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to fenpropathrin plus the unextracted residues on an acute basis, the RQs exceeded the listed and non-listed species LOCs in all instances (acute LOCs = 0.05 and 0.5, respectively). The acute RQs ranged from 469 for the FL cucumber scenario to 1295 for the MS cotton scenario. On a chronic basis, the RQs exceeded the LOC (chronic LOC = 1.0) in all cases as well. The chronic RQs ranged from >91 to >257 for the FL cucumber and MI cherries scenarios, respectively. The chronic RQs are expressed as a greater than value, as a result of a non-definitive endpoint.

For estuarine/marine invertebrates exposed to fenpropathrin plus the unextracted residues, for all the scenario combinations, the RQs exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). The range in acute RQs was 68 to as high as 188. Further, all the chronic RQs exceeded the LOC (chronic LOC = 1.0). The overall range of chronic RQs was 11 to 32.

Table 90. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Fenpropathrin plus Unextracted Residues

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	1.44	0.219	**472**	**>146**	**69**	**18**
NY grapes/ Bushberries and caneberries	3.44	0.323	**1128**	**>215**	**164**	**27**
FL citrus/ Citrus	1.63	0.170	**534**	**>113**	**78**	**14**
FL cucumber/ Cucurbit Vegetables	1.43	0.137	**469**	**>91**	**68**	**11**
PA apple/ Pome Fruits	3.01	0.242	**987**	**>161**	**143**	**20**
MS cotton/ Cotton	3.95	0.376	**1295**	**>251**	**188**	**31**
MI cherries/ Stone Fruits	3.56	0.386	**1167**	**>257**	**170**	**32**
GA pecan/ Tree Nuts	2.41	0.208	**790**	**>139**	**115**	**17**
NC peanuts/ Peanuts	2.94	0.214	**964**	**>143**	**140**	**18**
FL tomato/ Fruiting Vegetables	1.47	0.149	**482**	**>99**	**70**	**12**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0015 ppb [<0.0015 ppb, for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.012 [for Mysid shrimp, *Americamysis bahia*].

7.1.3. Freshwater Benthic Invertebrates Risk Quotients

In the following tables, the reader is reminded that the acute sediment concentrations are not used for RQ calculations. The nature of the OCSPP sediment toxicity studies is such that they yield only chronic endpoints.

For freshwater benthic organisms exposed to bifenthrin, there were exceedances of LOCs (acute listed and non-listed, and chronic). On an acute basis, all scenario RQs exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively). Given that the EECs were at the limit of solubility, the acute RQs were 28.4 in all instances. On a chronic basis (pore water based and sediment based), all scenario RQs exceeded the chronic LOC (1.0). The pore water-based chronic RQs were based on the limit of solubility and were 280 for all of the scenarios. The sediment-based chronic RQs are not limited by solubility and they ranged from 516 to 4920.

Table 91. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Bifenthrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
FL cucumber/ Cucurbit Vegetables	0.1121 (0.1)	Aerial	0.014* (0.0422)	0.014* (0.0419)	131	130	**28.4**	**280**		**520**
NY grapes/ Blueberries (and other Bushberries)	0.1121 (0.1)	Aerial	0.014* (0.398)	0.014* (0.397)	1234	1231	**28.4**	**280**		**4920**
FL citrus/ Citrus[3]	0.5604 (0.5)	Ground to bare soil	0.014* (0.0919)	0.014* (0.0924)	285	287	**28.4**	**280**		**1150**
IL corn/ Corn	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	At plant ground + foliar aerial	0.014* (0.245)	0.014* (0.243)	760	753	**28.4**	**280**		**3010**
FL sweet corn/ Sweet Corn	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	Aerial	0.014* (0.0419)	0.014* (0.0417)	130	129	**28.4**	**280**		**516**
MS cotton/ Cotton	0.1121 (0.1)	Aerial	0.014* (0.247)	0.014* (0.248)	768	769	**28.4**	**280**		**3080**
MS soybean/ Soybean[3]	0.1121 (0.1)	Aerial	0.014* (0.0963)	0.014* (0.0960)	299	298	**28.4**	**280**		**1190**
GA pecan/ Tree Nuts	1 @ 0.1121 (0.1) + 2 @ 0.2242 (0.2)	Airblast	0.014* (0.162)	0.014* (0.162)	502	502	**28.4**	**280**		**2010**
CA cole crops/ Brassica Vegetables	0.1121 (0.1) (1 app could be at plant)	Aerial	0.014* (0.137)	0.014* (0.136)	425	422	**28.4**	**280**		**1690**
CA lettuce/ Lettuce	0.1121 (0.1)	Aerial	0.014* (0.127)	0.014* (0.126)	394	391	**28.4**	**280**		**1560**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and

italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.000493 ppb [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000050 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC dry weight / 0.25 µg/kg-dw [for amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to deltamethrin, there were multiple exceedances of LOCs (acute listed and non-listed, and chronic). On an acute basis, all scenario RQs exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively). Acute RQs ranged from 1.5 to 35. On a chronic basis (pore water and sediment-based), all scenario RQs exceeded the chronic LOC. The lowest RQs were for the ND wheat scenario, representing sunflowers. The highest acute and chronic RQs were for the MS cotton scenario (RQs of 35 and 260, respectively).

Table 92. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Deltamethrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
GA onion/ Bulb Vegetables	0.0314 (0.028)	Aerial	0.00160	0.00151	718	678	**8.0**	**58**		**57**
WA potato/ Tuberous and Corm Vegetables	0.0314 (0.028)	Aerial	8.95×10^{-4}	8.61×10^{-4}	402	387	**4.5**	**33**		**32**
GA pecan/ Tree Nuts	0.0370 (0.033)	Airblast	0.00189	0.00193	849	867	**9.4**	**74**		**72**
IA corn/ Corn	2 @ 0.0163 (0.0145) + 3 @ 0.0247 (0.022)	Aerial	0.00192	0.00185	862	831	**9.6**	**71**		**69**
FL sweet corn/ Sweet Corn	0.0314 (0.028)	Aerial	0.00217	0.00208	974	934	**11**	**80**		**78**
MS cotton/ Cotton	0.0336 (0.03)	Aerial	0.00707	0.00670	3175	3009	**35**	**260**		**251**
MS soybean/ Soybean	1 @ 0.0179 (0.016) + 3 @ 0.0314 (0.028)	Aerial	0.00107	0.00101	480	454	**5.4**	**39**		**38**
ND wheat/ Sunflowers[3]	0.0168 (0.015)[2]	Aerial	3.02×10^{-4}	2.89×10^{-4}	136	130	**1.5**	**11**		**11**
FL cucumbers/ Cucurbit Vegetables	0.0314 (0.028)	Aerial	8.56×10^{-4}	8.37×10^{-4}	384	376	**4.3**	**32**		**31**
FL tomatoes/ Fruiting Vegetables	0.0314 (0.028)	Aerial	0.00149	0.00145	669	651	**7.5**	**56**		**54**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg$_{OC}$ [for *Hyalella azteca*].

For freshwater benthic organisms exposed to the pyrethrins, there were two scenarios that exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). The scenarios were NY grapes (representing blueberries), and NC cotton (RQs of 0.57 to 0.74). The remaining scenarios exceeded only the acute listed species LOC. The overall range in acute RQs was 0.15 to 0.74. On a chronic basis, all of the scenarios exceeded the chronic LOC (1.0). The RQs ranged from 4.0 to 14.

For the uses of pyrethrins on rice, the EECs and RQs were about one order of magnitude higher than for the other conventional agricultural uses. The acute and chronic RQs for freshwater benthic invertebrates exceeded the listed and non-listed species LOCs (RQs ≥ 2.3 acute, and 42 chronic, for rice). The sediment based chronic RQs were lower than the pore water based RQs.

Table 93. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Pyrethrins

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
MN alfalfa/ Alfalfa	0.0560 (0.050)	Aerial	0.239	0.234	72.2	70.7	*0.31*	**5.9**		**1.7**
NY grapes/ Blueberries	0.0560 (0.050)	Aerial	0.563	0.553	170	167	**0.74**	**14**		**4.1**
FL citrus/ Citrus	0.0560 (0.050)	Assumed Airblast	0.111	0.108	33.5	32.6	*0.15*	**2.7**		0.80
IL corn/ Corn	0.0560 (0.050)	Aerial	0.359	0.354	108	107	*0.47*	**8.9**		**2.6**
FL sweet corn/ Sweet Corn	0.0560 (0.050)	Aerial	0.166	0.161	50.0	48.5	*0.22*	**4.0**		**1.2**
NC cotton/ Cotton	0.0560 (0.050)	Aerial	0.430	0.424	130	128	**0.57**	**11**		**3.1**
MS soybean/ Soybean	0.0560 (0.050)	Aerial	0.176	0.170	53.2	51.3	*0.23*	**4.3**		**1.3**
ND wheat/ Sunflower	0.0560 (0.050)	Aerial	0.233	0.227	70.4	68.6	*0.31*	**5.7**		**1.7**
ND wheat/ Wheat	0.0560 (0.050)	Aerial	0.233	0.227	70.4	68.6	*0.31*	**5.7**		**1.7**
FL tomato/ Fruiting Vegetables	0.0560 (0.050)	Aerial	0.179	0.174	54.0	52.5	*0.24*	**4.4**		**1.3**
CA rice (Winter flood)/ Rice	0.0560 (0.050)	Aerial	1.75	1.67	617	586	**2.3**	**42**		**14**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.76 ppb [water column test for the Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.04 ppb [for Midge, *Chironomus dilutus*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 41 µg/kg$_{-dw}$ [for Midge, *Chironomus dilutus*].

For freshwater benthic organisms exposed to permethrin, all the scenarios exceeded the

acute listed and non-listed species LOCs (0.05 and 0.5, respectively), and the chronic LOC (1.0). The highest acute and chronic RQs were for NY grape scenario, representing blueberries (acute RQ = 162; chronic RQ = 457. For the remaining scenarios, RQs were below 30 (acute) and 80 (chronic), which may mean that the NY grape scenario is highly vulnerable for permethrin. The range in acute RQs was 9.8 to 162 and the range in chronic RQs was 27 to 457.

Table 94. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Permethrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.2242 (0.2)/ cutting	Aerial	0.0704	0.0693	224	221	**11**	**17**		**30**
NY grapes/ Blueberries	0.3362 (0.3)	Aerial	1.07	1.06	3413	3381	**162**	**252**		**457**
GA pecans/ Tree Nuts (based on pistachios)	0.3362 (0.3)	Assume Airblast	0.177	0.175	565	558	**27**	**42**		**75**
IL corn/ Corn	0.1681 (0.15)	Aerial	0.114	0.113	363	360	**17**	**27**		**49**
FL sweet corn/ Sweet Corn	0.2242 (0.2)	Aerial	0.0647	0.0635	206	202	**9.8**	**15**		**27**
CA lettuce/ Leafy Greens (based on the rate for lettuce)	0.2242 (0.2)	Aerial	0.108	0.107	345	341	**16**	**25**		**46**
MS soybean/ Soybean	0.2242 (0.2)	Aerial	0.0747	0.0724	238	231	**11**	**17**		**31**
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	0.2242 (0.2)	Aerial	0.105	0.104	335	332	**16**	**25**		**45**
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	0.2242 (0.2)	Aerial	0.0918	0.0897	293	286	**14**	**21**		**39**
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	0.2242 (0.2)	Aerial	0.0992	0.0969	316	309	**15**	**23**		**42**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0066 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0042 ppb [for the amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 7.4 µg/kg$_{-dw}$ [for the amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to esfenvalerate, the acute RQs exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively) for all the agricultural scenarios. The highest acute RQ is 38.6 for the NC cotton scenario. The chronic RQs exceeded the non-listed species LOC (1.0) for all the scenarios as well. The highest chronic RQ is 46.1 for the NC cotton scenario. The porewater-based RQs were similar to the sediment-based RQs.

Table 95. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Esfenvalerate

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head & stem) Vegetables	0.0560 (0.05)	Foliar, Aerial	0.0198	0.0195	5000	4930	**23.3**	**27.9**		**28.0**
NY grapes/ Blueberries (*except CA*)	0.0560 (0.05)	Foliar, recommend Ground	0.0237	0.0232	5970	5840	**27.9**	**33.1**		**33.2**
GA pecan/ Tree Nuts (based on rate on almonds)	0.112 (0.1)	Foliar, assumed airblast	0.0226	0.0230	5690	5330	**26.7**	**33**		**30.3**
IL corn/ Corn	0.0560 (0.05)	At plant or Foliar, assume Aerial	0.0254	0.0249	6390	6270	**30.0**	**36**		**35.6**
FL sweet corn/ Sweet Corn	0.0560 (0.05)	Foliar, Aerial	0.0134	0.0131	3370	3300	**15.8**	**19**		**18.8**
NC cotton/ Cotton	0.0560 (0.05)	At plant or Foliar, assume Aerial	0.0327	0.0322	8230	8110	**38.6**	**46**		**46.1**
MS soybean/ Soybeans	0.0560 (0.05)	Foliar, Aerial	0.00968	0.00951	2440	2390	**11.4**	**14**		**13.6**
ND wheat/ Sunflowers	0.0560 (0.05)	Foliar, Aerial	0.00612	0.00588	1540	1480	**7.22**	**8.4**		**8.41**
FL cucumber/ Cucurbit Vegetables	0.0560 (0.05)	Foliar, Aerial	0.00798	0.00768	2010	1930	**9.41**	**11**		**11.0**
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	0.0560 (0.05)	Foliar, Aerial	0.0129	0.0126	3250	3170	**15.2**	**18**		**18.0**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.000848 [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00070 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 176 µg/kg$_{OC}$ [for amphipod, *Hyalella azteca*].

For freshwater benthic invertebrates exposed to cypermethrin, all the acute and chronic RQs exceeded the listed and non-listed species LOCs (acute LOCs 0.05 and 0.5, respectively; chronic LOC = 1.0). The highest RQs were for the NY grapes scenario, representing blueberries (acute RQ = 55; chronic RQ >590). The porewater-based chronic RQs were slightly higher than the sediment-based chronic RQs.

For the uses of cypermethrin (*zeta*-) on rice, the EECs and RQs were about one order of magnitude higher than for the other conventional agricultural uses. The acute and chronic RQs for freshwater benthic invertebrates exceeded the listed and non-listed species LOCs (RQ ≥ 432 for rice).

Table 96. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Cypermethrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.056 (0.05)	Aerial	0.00304	0.00285	431	404	**5.4**	**>57**		**52**
NY grapes/ Blueberries:	0.056 (0.05)	Aerial	0.0309	0.0295	4380	4180	**55**	**>590**		**543**
FL citrus/ Citrus:	0.056 (0.05)	Assume Airblast	0.00719	0.00661	1020	937	**13**	**>132**		**122**
IL corn/ Corn	0.056 (0.05)	Aerial	0.0139	0.0131	1970	1860	**25**	**>262**		**242**
FL sweet corn/ Sweet Corn	0.056 (0.05)	Aerial	0.00630	0.00581	893	823	**11**	**>116**		**107**
MS cotton/ Cotton	0.056 (0.05)	Aerial	0.0227	0.0207	3220	2930	**41**	**>414**		**381**
MS soybean/ Soybean	0.056 (0.05)	Ground	0.0167	0.0163	2370	2310	**30**	**>326**		**300**
ND wheat/ Sunflower	0.056 (0.05)	Ground	0.00117	0.00111	166	157	**2.1**	**>22**		**20**
ND wheat/ Wheat	0.056 (0.05)	Aerial	0.00766	0.00731	1090	1040	**14**	**>146**		**135**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.056 (0.05)	Aerial	0.0103	0.00983	1460	1390	**18**	**>197**		**181**
CA rice (Winter flood)/ Rice	0.056 (0.05)	Aerial	0.242	0.226	34300	32100	**432**	**>4520**		**4169**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00056 ppb [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00005 ppb [<0.00005 ppb, for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 7.7 µg/kg$_{OC}$.

For freshwater benthic organisms exposed to cyfluthrin, none of the acute RQs exceeded the non-listed species LOC (0.5); however, all but two of the scenarios exceeded the listed species LOC (0.05). The range of acute RQs was 0.02 to 0.39. On a chronic basis, all the scenario RQs exceeded the LOC (chronic LOC = 1.0). The highest chronic RQ was 63 for the NY grapes scenario.

Table 97. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Cyfluthrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.049 (0.044)	Aerial	0.00211	0.00172	390	318	*0.08*	**14**		**14**
NY grapes/ Grapes	0.056 (0.05)	Aerial	0.00906	0.00751	1680	1390	*0.36*	**63**		**63**
FL citrus/ Citrus	0.112 (0.1)	Assume Airblast	0.00277	0.00201	512	372	*0.11*	**17**		**17**
IL corn/ Corn	0.049 (0.044)	Aerial	0.00441	0.00380	815	703	*0.18*	**32**		**32**
FL sweet corn/ Sweet Corn	0.049 (0.044)	Aerial	0.00279	0.00253	516	468	*0.11*	**21**		**21**
MS cotton/ Cotton	0.056 (0.05)	Aerial	0.00964	0.00732	1780	1350	*0.39*	**61**		**61**
MS soybean/ Soybeans	0.049 (0.044)	Aerial	0.00320	0.00292	592	540	*0.13*	**24**		**25**
ND wheat/ Sunflowers	0.049 (0.044)	Aerial	0.00107	0.00088	271	223	0.04	**7.3**		**10**
ND wheat/ Wheat	0.043 (0.038)	Aerial	0.000578	0.000481	107	88.9	0.02	**4.0**		**4.0**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.056 (0.05)	Aerial	0.00745	0.00574	1380	1060	*0.30*	**48**		**48**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.025 ppb [water column test for water flea, *Daphnia magna*, conducted on cyfluthrin]. Chronic pore water RQ = use-specific pore water 21-day EEC/ 0.00012 ppb [for amphipod, *Hyalella azteca*, conducted on cyflurthrin]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 22 µg/kg$_{OC}$ [for amphipod, *Hyalella azteca*, conducted on cyfluthrin].

For freshwater benthic organisms exposed to cyhalothrin, the acute RQs exceeded the listed and non-listed LOCs for all the scenarios (acute LOCs = 0.05 and 0.5, respectively). Additionally, all the chronic RQs exceeded the LOC (chronic LOC = 1.0). The acute RQs ranged from 330 to 2830, and the chronic RQs ranged from 120 to 1032.

For the uses of cyhalothrin (*lambda*-) on rice, the EECs and RQs were of the same order of magnitude than some of the other conventional agricultural uses. The acute and chronic RQs for freshwater benthic invertebrates exceeded the listed and non-listed species LOCs (RQ $\geq$ 668 for rice).

Table 98. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to *Lambda*-Cyhalothrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0336 (0.03) per cutting	Aerial	0.0422	0.0421	113	113	**528**	**191**		**365**
FL cucumber/ Cucurbit Vegetables	0.0336 (0.03)	Aerial	0.0902	0.0900	241	241	**1128**	**409**		**777**
FL citrus/ Citrus	0.0448 (0.04)	Assume Airblast	0.0916	0.0914	246	244	**1145**	**415**		**787**
IL corn/ Corn	0.0336 (0.03)	Aerial	0.0930	0.0929	249	248	**1163**	**422**		**800**
FL sweet corn/ Sweet Corn	0.0336 (0.03)	Aerial	0.116	0.115	310	307	**1450**	**523**		**990**
MS cotton/ Cotton	0.0448 (0.04)	Aerial	0.227	0.227	607	607	**2838**	**1032**		**1958**
MS soybean/ Soybeans	0.0336 (0.03)	Aerial	0.0322	0.0322	86.1	86.1	**403**	**146**		**278**
ND wheat/ Sunflowers	0.0336 (0.03)	Aerial	0.0532	0.0531	142	142	**665**	**241**		**458**
ND wheat/ Wheat	0.0336 (0.03)	Aerial	0.0264	0.0263	70.6	70.3	**330**	**120**		**227**
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	0.0336 (0.03)	Aerial	0.191	0.190	511	508	**2388**	**864**		**1639**
CA rice (Winter flood)/ Rice	0.0448 (0.04)	Aerial	0.147	0.147	310	310	**1838**	**668**		**1000**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.00008 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.00022 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC / 0.31 µg/kg$_{dw}$ [for amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to fenpropathrin, the acute RQs exceeded the listed and non-listed LOCs for all the scenarios (LOCs = 0.05 and 0.5, respectively). Additionally, all the chronic RQs exceeded the LOC (LOC = 1.0). The acute RQs ranged from 28.8 to 99.3, and the chronic RQs ranged from >58 to >202.

Table 99. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Fenpropathrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	0.336 (0.3)	Aerial	0.146	0.145	30300	30100	**47.9**	**>97**		**>97**

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
NY grapes/ Bushberries and caneberries	0.336 (0.3)	Aerial	0.252	0.251	52300	52100	**82.6**	**>167**		**>168**
FL citrus/ Citrus	0.448 (0.4)	Assume Airblast	0.110	0.109	22800	22600	**36.0**	**>73**		**>73**
FL cucumber/ Cucurbit Vegetables	0.336 (0.3)	Aerial	0.0877	0.0873	18200	18100	**28.8**	**>58**		**>58**
PA apple/ Pome Fruits	0.448 (0.4)	Aerial	0.160	0.159	33300	33100	**52.5**	**>106**		**>107**
MS cotton/ Cotton	0.336 (0.3)	Aerial	0.303	0.301	63010	62600	**99.3**	**>201**		**>202**
MI cherries/ Stone Fruits	0.448 (0.4)	Aerial	0.295	0.293	61400	61000	**96.7**	**>195**		**>197**
GA pecan/ Tree Nuts	0.448 (0.4)	Aerial	0.150	0.148	31200	30800	**49.2**	**>99**		**>99**
NC peanuts/ Peanuts	0.336 (0.3)	Aerial	0.155	0.153	32300	31900	**50.8**	**>102**		**>103**
FL tomato/ Fruiting Vegetables	0.336 (0.3)	Aerial	0.0975	0.0968	20300	20200	**32.0**	**>65**		**>65**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0015 ppb [NOAEC <0.0015 ppb, for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 310 µg/kg$_{OC}$ [NOAEC <310 µg/kg$_{OC}$, for amphipod, *Hyalella azteca*].

For freshwater benthic organisms exposed to fenpropathrin plus the unextracted residues, the acute RQs exceeded the listed and non-listed LOCs for all the scenarios (LOCs = 0.05 and 0.5, respectively). Additionally, all the chronic RQs exceeded the LOC (LOC = 1.0). The acute RQs ranged from 40.0 to 112, and the chronic RQs ranged from >81 to >228.

Table 100. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Fenpropathrin plus Unextracted Residues

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	0.336 (0.3)	Aerial	0.204	0.204	42500	42500	**66.9**	**>136**		**>137**
NY grapes/ Bushberries and caneberries	0.336 (0.3)	Aerial	0.274	0.274	57100	57100	**89.8**	**>183**		**>184**
FL citrus/ Citrus	0.448 (0.4)	Assume Airblast	0.140	0.140	29200	29200	**45.9**	**>93**		**>94**
FL cucumber/ Cucurbit Vegetables	0.336 (0.3)	Aerial	0.122	0.121	25400	25200	**40.0**	**>81**		**>81**
PA apple/ Pome Fruits	0.448 (0.4)	Aerial	0.214	0.212	44700	44300	**70.2**	**>141**		**>143**
MS cotton/ Cotton	0.336 (0.3)	Aerial	0.333	0.331	69500	69100	**109**	**>221**		**>223**

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
MI cherries/ Stone Fruits	0.448 (0.4)	Aerial	0.341	0.339	71200	70800	**112**	**>226**		**>228**
GA pecan/ Tree Nuts	0.448 (0.4)	Aerial	0.178	0.176	37200	36800	**58.4**	**>117**		**>119**
NC peanuts/ Peanuts	0.336 (0.3)	Aerial	0.179	0.178	37400	37200	**58.7**	**>119**		**>120**
FL tomato/ Fruiting Vegetables	0.336 (0.3)	Aerial	0.128	0.126	26800	26300	**42.0**	**>84**		**>85**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific peak EEC / 0.00305 ppb [for Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0015 ppb [NOAEC <0.0015 ppb, for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 310 µg/kg$_{OC}$ [NOAEC <310 µg/kg$_{OC}$, for amphipod, *Hyalella azteca*].

7.1.4. Estuarine/Marine Benthic Invertebrates Risk Quotients

For estuarine/marine benthic organisms exposed to bifenthrin, there were exceedances of LOCs (acute listed and non-listed, and chronic). On an acute basis, all scenario RQs exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively). Given that the EECs were at the limit of solubility, the acute RQs were 3.53 in all instances. On a chronic basis (pore water based and sediment based), all scenario RQs exceeded the chronic LOC (1.0). The pore water-based chronic RQs were based on the limit of solubility and were >23 for all of the scenarios. The sediment-based chronic RQs are not limited by solubility and they ranged from >23 for the FL sweet corn scenario to >228 for the NY grapes scenario (representing blueberries). Since the chronic endpoint was non-definitive, all the chronic RQs have the potential to be even higher than indicated.

Table 101. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Bifenthrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
FL cucumber/ Cucurbit Vegetables	0.1121 (0.1)	Aerial	0.014* (0.0422)	0.014* (0.0419)	131	130	**3.53**	**>23**		**>24**
NY grapes/ Blueberries (and other Bushberries)	0.1121 (0.1)	Aerial	0.014* (0.398)	0.014* (0.397)	1234	1231	**3.53**	**>23**		**>228**
FL citrus/ Citrus[3]	0.5604 (0.5)	Ground to bare soil	0.014* (0.0919)	0.014* (0.0924)	285	287	**3.53**	**>23**		**>53**
IL corn/ Corn	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	At plant ground, foliar aerial	0.014* (0.245)	0.014* (0.243)	760	753	**3.53**	**>23**		**>139**
FL sweet corn/ Sweet Corn	0.2242 (0.2) at plant + 0.1121 (0.1) foliar	Aerial	0.014* (0.0419)	0.014* (0.0417)	130	129	**3.53**	**>23**		**>23**
MS cotton/ Cotton	0.1121 (0.1)	Aerial	0.014* (0.247)	0.014* (0.248)	768	769	**3.53**	**>23**		**>142**
MS soybean/ Soybean[3]	0.1121 (0.1)	Aerial	0.014* (0.0963)	0.014* (0.0960)	299	298	**3.53**	**>23**		**>55**
GA pecan/ Tree Nuts	1 @ 0.1121 (0.1) + 2 @ 0.2242 (0.2)	Airblast	0.014* (0.162)	0.014* (0.162)	502	502	**3.53**	**>23**		**>93**
CA cole crops/ Brassica Vegetables	0.1121 (0.1) (1 app could be at plant)	Aerial	0.014* (0.137)	0.014* (0.136)	425	422	**3.53**	**>23**		**>78**
CA lettuce/ Lettuce	0.1121 (0.1)	Aerial	0.014* (0.127)	0.014* (0.126)	394	391	**3.53**	**>23**		**>72**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.014 ppb because they exceeded the limit of solubility of bifenthrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00397 ppb [water column result for Mysid Shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / <0.0006 ppb [for amphipod, *Leptocheirus plumulosus*]. Chronic sediment RQ = use-specific sediment 21-day EEC dry weight / 5.4 µg/kg-dw [<5.4 µg/kg-dw for the amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to deltamethrin, six out of 10 of scenarios exceeded only the acute listed species LOC (listed LOC = 0.05, non-listed LOC = 0.5). The remaining four scenarios exceeded the acute listed and non-listed LOCs. The highest acute RQ was 1.9 for the MS cotton scenario. The range in acute RQs was 0.08 to 1.9. All the scenarios, except for the ND wheat (representing sunflowers), exceeded the chronic LOC (1.0). The range in chronic RQs was 0.61 to 14 (RQ = 14 for the MS cotton scenario).

Table 102. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Deltamethrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#
GA onion/ Bulb Vegetables	0.0314 (0.028)	Aerial	0.00160	0.00151	718	678	*0.43*	**3.2**
WA potato/ Tuberous and Corm Vegetables	0.0314 (0.028)	Aerial	8.95×10^{-4}	8.61×10^{-4}	402	387	*0.24*	**1.8**
GA pecan/ Tree Nuts	0.0370 (0.033)	Airblast	0.00189	0.00193	145	138	**0.51**	**4.1**
IA corn/ Corn	2 @ 0.0163 (0.0145) + 3 @ 0.0247 (0.022)	Aerial	0.00192	0.00185	862	831	**0.52**	**4.0**
FL sweet corn/ Sweet Corn	0.0314 (0.028)	Aerial	0.00217	0.00208	974	934	**0.59**	**4.4**
MS cotton/ Cotton	0.0336 (0.03)	Aerial	0.00707	0.00670	3175	3009	**1.9**	**14**
MS soybean/ Soybean	1 @ 0.0179 (0.016) + 3 @ 0.0314 (0.028)	Aerial	0.00107	0.00101	480	454	*0.29*	**2.1**
ND wheat/ Sunflowers[3]	0.0168 (0.015)[2]	Aerial	3.02×10^{-4}	2.89×10^{-4}	136	130	*0.08*	0.61
FL cucumbers/ Cucurbit Vegetables	0.0314 (0.028)	Aerial	8.56×10^{-4}	8.37×10^{-4}	384	376	*0.23*	**1.8**
FL tomatoes/ Fruiting Vegetables	0.0314 (0.028)	Aerial	0.00149	0.00145	669	651	*0.40*	**3.1**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0037 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00047 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = N/A [no study was submitted].

For estuarine/marine benthic invertebrates exposed to pyrethrins, all of the acute RQs exceeded the listed species LOC (0.05), but not the non-listed species LOC (0.5). The range in acute RQs was 0.08 to 0.40. The highest acute RQ of 0.40 was for the NY grapes scenario (representing blueberries). Of the chronic RQs, three exceeded the LOC (1.0) as follows: NY grapes (representing blueberries), IL corn and NC cotton. For these three scenarios, the range of chronic RQs was 1.4 to 2.2. For the remaining scenarios, the chronic RQs were 0.43 to 0.96.

For the uses of pyrethrins on rice, the EECs and RQs were about one order of magnitude greater than the other conventional agricultural uses. The acute and chronic RQs for estuarine/marine benthic invertebrates exceeded the listed and non-listed species LOCs (RQs ≥ 1.3 for rice).

Table 103. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Pyrethrins

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#
MN alfalfa/ Alfalfa	0.0560 (0.050)	Aerial	0.239	0.234	72.2	70.7	*0.17*	0.96
NY grapes/ Blueberries	0.0560 (0.050)	Aerial	0.563	0.553	170	167	*0.40*	**2.2**
FL citrus/ Citrus	0.0560 (0.050)	Assumed Airblast	0.111	0.108	33.5	32.6	*0.08*	0.43
IL corn/ Corn	0.0560 (0.050)	Aerial	0.359	0.354	108	107	*0.26*	**1.4**
FL sweet corn/ Sweet Corn	0.0560 (0.050)	Aerial	0.166	0.161	50.0	48.5	*0.12*	0.64
NC cotton/ Cotton	0.0560 (0.050)	Aerial	0.430	0.424	130	128	*0.31*	**1.7**
MS soybean/ Soybean	0.0560 (0.050)	Aerial	0.176	0.170	53.2	51.3	*0.13*	0.68
ND wheat/ Sunflower	0.0560 (0.050)	Aerial	0.233	0.227	70.4	68.6	*0.17*	0.91
ND wheat/ Wheat	0.0560 (0.050)	Aerial	0.233	0.227	70.4	68.6	*0.17*	0.91
FL tomato/ Fruiting Vegetables	0.0560 (0.050)	Aerial	0.179	0.174	54.0	52.5	*0.13*	0.70
CA rice (Winter flood)/ Rice	0.0560 (0.050)	Aerial	1.75	1.67	617	586	**1.3**	**6.7**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 1.4 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.25 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. No sediment toxicity study was submitted for estuarine/marine invertebrates.

For estuarine/marine benthic invertebrates exposed to permethrin all the scenarios exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively). The

range in acute RQs was 3.6 to 59. Furthermore, all the scenarios tested exceeded the chronic LOC (1.0). The pore water-based chronic RQs were higher than the sediment-based RQs. The reason is that the water column test with mysid shrimp, *Americamysis bahia*, used in pore water, yielded more sensitive endpoints than the sediment study, conducted with the amphipod, *Leptocheirus plumulosus*. The range in chronic RQs was 26 to 442 (pore water based), and 5.3 to 89 (sediment based).

Table 104. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Permethrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.2242 (0.2)/ cutting	Aerial	0.0704	0.0693	224	221	**3.9**	**29**		**5.8**
NY grapes/ Blueberries	0.3362 (0.3)	Aerial	1.07	1.06	3413	3381	**59**	**442**		**89**
GA pecans/ Tree Nuts (based on pistachios)	0.3362 (0.3)	Assume Airblast	0.177	0.175	565	558	**9.8**	**73**		**15**
IL corn/ Corn	0.1681 (0.15)	Aerial	0.114	0.113	363	360	**6.3**	**47**		**9.5**
FL sweet corn/ Sweet Corn	0.2242 (0.2)	Aerial	0.0647	0.0635	206	202	**3.6**	**26**		**5.3**
CA lettuce/ Leafy Greens (based on the rate for lettuce)	0.2242 (0.2)	Aerial	0.108	0.107	345	341	**6.0**	**45**		**9.0**
MS soybean/ Soybean	0.2242 (0.2)	Aerial	0.0747	0.0724	238	231	**4.2**	**30**		**6.1**
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	0.2242 (0.2)	Aerial	0.105	0.104	335	332	**5.8**	**43**		**8.7**
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	0.2242 (0.2)	Aerial	0.0918	0.0897	293	286	**5.1**	**37**		**7.5**
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	0.2242 (0.2)	Aerial	0.0992	0.0969	316	309	**5.5**	**40**		**8.1**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.018 ppb [water column test for the Stone crab, *Menippe mercenaria*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0024 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 38 µg/kg$_{-dw}$ [for the amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to esfenvalerate, the acute RQs for all of the scenarios exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively). The highest acute RQ was 7.02 for the NC cotton scenario. On a chronic basis, the chronic RQs for all of the scenarios exceeded the chronic LOC (LOC = 1.0). The highest chronic RQ is 11 for the NC cotton scenario. The porewater-based chronic RQs were slightly higher than the sediment-based RQs.

Table 105. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Esfenvalerate

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head & stem) Vegetables	0.0560 (0.05)	Foliar, Aerial	0.0198	0.0195	5000	4930	**4.25**	**6.5**		**5.9**
NY grapes/ Blueberries (*except CA*)	0.0560 (0.05)	Foliar, recommend Ground	0.0237	0.0232	5970	5840	**5.09**	**7.7**		**7.0**
GA pecan/ Tree Nuts (based on rate on almonds)	0.112 (0.1)	Foliar, assumed airblast	0.0226	0.0230	5690	5330	**4.85**	**7.7**		**6.4**
IL corn/ Corn	0.0560 (0.05)	At plant or Foliar, assume Aerial	0.0254	0.0249	6390	6270	**5.45**	**8.3**		**7.6**
FL sweet corn/ Sweet Corn	0.0560 (0.05)	Foliar, Aerial	0.0134	0.0131	3370	3300	**2.88**	**4.4**		**4.0**
NC cotton/ Cotton	0.0560 (0.05)	At plant or Foliar, assume Aerial	0.0327	0.0322	8230	8110	**7.02**	**11**		**9.8**
MS soybean/ Soybeans	0.0560 (0.05)	Foliar, Aerial	0.00968	0.00951	2440	2390	**2.08**	**3.2**		**2.9**
ND wheat/ Sunflowers	0.0560 (0.05)	Foliar, Aerial	0.00612	0.00588	1540	1480	**1.31**	**2.0**		**1.8**
FL cucumber/ Cucurbit Vegetables	0.0560 (0.05)	Foliar, Aerial	0.00798	0.00768	2010	1930	**1.71**	**2.6**		**2.3**
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	0.0560 (0.05)	Foliar, Aerial	0.0129	0.0126	3250	3170	**2.77**	**4.2**		**3.8**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00466 ppb [water column result for Mysid Shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / 0.003 ppb [for amphipod, *Leptocheirus plumulosus*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 830 µg/kg$_{OC}$ [for the amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to cypermethrin all the scenarios tested exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), with the exception of the ND wheat scenario representing sunflowers (RQ = 0.22). The highest acute RQ is 5.7 for the NY grapes scenario representing blueberries. Further, all the scenario RQs exceeded the chronic LOC (LOC = 1.0). The highest chronic RQ was 148 for the same scenario (blueberries). The porewater-based chronic RQs are slightly higher than the sediment-based chronic RQs.

For the uses of cypermethrin (*zeta*-) on rice, the EECs and RQs were about one order of magnitude or greater than the other conventional agricultural uses. The acute and chronic RQs for estuarine/marine benthic invertebrates exceeded the listed and non-listed species LOCs (RQs ≥ 45 for rice).

Table 106. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Cypermethrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.056 (0.05)	Aerial	0.00304	0.00285	431	404	**0.56**	**14**		**12**
NY grapes/ Blueberries:	0.056 (0.05)	Aerial	0.0309	0.0295	4380	4180	**5.7**	**148**		**123**
FL citrus/ Citrus:	0.056 (0.05)	Assume Airblast	0.00719	0.00661	1020	937	**1.3**	**33**		**28**
IL corn/ Corn	0.056 (0.05)	Aerial	0.0139	0.0131	1970	1860	**2.6**	**66**		**55**
FL sweet corn/ Sweet Corn	0.056 (0.05)	Aerial	0.00630	0.00581	893	823	**1.2**	**29**		**24**
MS cotton/ Cotton	0.056 (0.05)	Aerial	0.0227	0.0207	3220	2930	**4.2**	**104**		**86**
MS soybean/ Soybean	0.056 (0.05)	Ground	0.0167	0.0163	2370	2310	**3.1**	**82**		**68**
ND wheat/ Sunflower	0.056 (0.05)	Ground	0.00117	0.00111	166	157	*0.22*	**5.6**		**4.6**
ND wheat/ Wheat	0.056 (0.05)	Aerial	0.00766	0.00731	1090	1040	**1.4**	**37**		**31**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.056 (0.05)	Aerial	0.0103	0.00983	1460	1390	**1.9**	**49**		**41**
CA rice (Winter flood)/ Rice	0.056 (0.05)	Aerial	0.242	0.226	34300	32100	**45**	**1130**		**944**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0054 ppb [water column result for mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific 21-day EEC / 0.0002 ppb [for amphipod, *Leptocheirus plumulosus*]. Chronic sediment RQ = use-specific 21-day EEC / 34 µg/kg$_{OC}$ [for amphipod, *Leptocheirus plumulosus*].

For estuarine/marine benthic invertebrates exposed to cyfluthrin, all but two of the scenarios exceeded the listed and non-listed species LOCs (acute listed species LOC = 0.05; acute non-listed species LOC = 0.5). The two scenarios (ND wheat representing sunflowers and ND wheat) exceeded only the listed species LOC with RQs of 0.48 and 0.26, respectively. The highest acute RQ was 4.5 for the MS soybean scenario. The porewater based chronic RQs were higher than the sediment based chronic RQs. The reason is that there is a chronic water column test, conducted on the mysid shrimp,

Mysidopsis bahia, that yielded a more sensitive endpoint than the sediment study. The chronic RQs for cyfluthrin exceeded the LOC (LOC = 1.0) for all the scenarios (porewater-basis), and with the exception of the ND wheat representing sunflowers, and the ND wheat scenarios (sediment basis). The highest chronic RQ was for the NY grapes scenario (RQ = 107, porewater-based).

Table 107. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Cyfluthrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.049 (0.044)	Aerial	0.00211	0.00172	390	318	**0.96**	**25**		**>9.4**
NY grapes/ Grapes	0.056 (0.05)	Aerial	0.00906	0.00751	1680	1390	**4.1**	**107**		**>41**
FL citrus/ Citrus	0.112 (0.1)	Assume Airblast	0.00277	0.00201	512	372	**1.3**	**29**		**>11**
IL corn/ Corn	0.049 (0.044)	Aerial	0.00441	0.00380	815	703	**2.0**	**54**		**>21**
FL sweet corn/ Sweet Corn	0.049 (0.044)	Aerial	0.00279	0.00253	516	468	**1.3**	**36**		**>14**
MS cotton/ Cotton	0.056 (0.05)	Aerial	0.00964	0.00732	1780	1350	**4.4**	**105**		**>40**
MS soybean/ Soybeans	0.049 (0.044)	Aerial	0.00320	0.00292	592	540	**4.5**	**42**		**>16**
ND wheat/ Sunflowers	0.049 (0.044)	Aerial	0.00107	0.000880	271	223	*0.48*	**13**		**>6.6**
ND wheat/ Wheat	0.043 (0.038)	Aerial	0.000578	0.000481	107	88.9	*0.26*	**7**		**>2.6**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.056 (0.05)	Aerial	0.00745	0.00574	1380	1060	**3.4**	**82**		**>31**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0022 ppb [water column result for mysid shrimp, *Americamysis bahia* for *beta*-cyfluthrin]. Chronic pore water RQ = use-specific 21-day EEC / 0.00007 ppb [estimated for mysid shrimp, *Mysidopsis bahia*, for *beta*-cyfluthrin]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 34 µg/kg$_{OC}$ [<34 µg/kg$_{OC}$ for the amphipod, *Leptocheirus plumulosus* for cyfluthrin for cyfluthrin].

For estuarine/marine benthic invertebrates exposed to *lambda*-cyhalothrin, the acute RQs for all the scenarios exceeded the listed and non-listed species LOCs (acute listed species LOC = 0.05; non-listed LOC = 0.5). The highest acute RQ was 46.2, for the MS cotton scenario. On a chronic basis, the RQs based on pore water were higher than the ones based on sediment. The reason is that the chronic water column study yielded a more sensitive endpoint than the sediment study. The pore water-based RQs exceeded the chronic LOC (LOC = 1.0) for all the scenarios, showing a highest chronic RQ = 1135 for

the MS cotton scenario. As a result of a non-definitive endpoint, the sediment chronic RQs were expressed as a greater than value. The highest sediment based chronic RQ is >253 for the MS cotton scenario.

For the uses of cyhalothrin (*lambda*-) on rice, the EECs and RQs were of similar one order of magnitude than some of the other conventional agricultural uses. The acute and chronic RQs for estuarine/marine benthic invertebrates exceeded the listed and non-listed species LOCs (RQs ≥ 29.9 for rice).

Table 108. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to *Lambda*-Cyhalothrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
PA alfalfa/ Alfalfa	0.0336 (0.03) per cutting	Aerial	0.0422	0.0421	113	113	**8.59**	**211**		**>47.1**
FL cucumber/ Cucurbit Vegetables	0.0336 (0.03)	Aerial	0.0902	0.0900	241	241	**18.4**	**450**		**>100**
FL citrus/ Citrus	0.0448 (0.04)	Assume Airblast	0.0916	0.0914	246	244	**18.7**	**457**		**>102**
IL corn/ Corn	0.0336 (0.03)	Aerial	0.0930	0.0929	249	248	**18.9**	**465**		**>103**
FL sweet corn/ Sweet Corn	0.0336 (0.03)	Aerial	0.116	0.115	310	307	**23.6**	**575**		**>128**
MS cotton/ Cotton	0.0448 (0.04)	Aerial	0.227	0.227	607	607	**46.2**	**1135**		**>253**
MS soybean/ Soybeans	0.0336 (0.03)	Aerial	0.0322	0.0322	86.1	86.1	**6.56**	**161**		**>35.9**
ND wheat/ Sunflowers	0.0336 (0.03)	Aerial	0.0532	0.0531	142	142	**10.8**	**266**		**>59.2**
ND wheat/ Wheat	0.0336 (0.03)	Aerial	0.0264	0.0263	70.6	70.3	**5.38**	**132**		**>29.3**
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	0.0336 (0.03)	Aerial	0.191	0.190	511	508	**38.9**	**950**		**>213**
CA rice (Winter flood)/ Rice	0.0448 (0.04)	Aerial	0.147	0.147	310	310	**29.9**	**735**		**>129**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.00491 ppb [water column result for Mysid Shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin]. Chronic pore water RQ = use-specific 21-day EEC / 0.0002 ppb [water column result for Mysid Shrimp, *Americamysis bahia*, conducted with *lambda*-cyhalothrin]. Chronic sediment RQ = use-specific 21-day EEC / 2.40 µg ai/kg-dw [<2.40 µg ai/kg-dw, for amphipod, *Leptocheirus plumulosus*].

For freshwater benthic invertebrates exposed to fenpropathrin, the acute RQs exceeded the listed and non-listed LOCs (0.05 and 0.5, respectively) for all the scenarios tested. The acute RQs ranged from 4.2 to 14.

The chronic RQs exceeded the LOC (LOC = 1.0) in all instances as well. The highest RQs were for the MS cotton scenario. The chronic RQs ranged from 5.7 to 25. Even though the pore water based RQs were slightly higher than the sediment based RQs, the risk picture was the same in both cases. The slightly higher RQs for the pore water chronic RQs is due to the use of a more sensitive endpoint from a water column test, conducted with the mysid shrimp, compared to the sediment chronic RQ, which was derived from a test conducted on *Leptocheirus plumulosus*.

Table 109. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Fenpropathrin

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	0.336 (0.3)	Aerial	0.146	0.145	30300	30100	**7.0**	**12**		**9.5**
NY grapes/ Bushberries and caneberries	0.336 (0.3)	Aerial	0.252	0.251	52300	52100	**12**	**21**		**16**
FL citrus/ Citrus	0.448 (0.4)	Assume Airblast	0.110	0.109	22800	22600	**5.2**	**9.1**		**7.1**
FL cucumber/ Cucurbit Vegetables	0.336 (0.3)	Aerial	0.0877	0.0873	18200	18100	**4.2**	**7.3**		**5.7**
PA apple/ Pome Fruits	0.448 (0.4)	Aerial	0.160	0.159	33300	33100	**7.6**	**13**		**10**
MS cotton/ Cotton	0.336 (0.3)	Aerial	0.303	0.301	63010	62600	**14**	**25**		**20**
MI cherries/ Stone Fruits	0.448 (0.4)	Aerial	0.295	0.293	61400	61000	**14**	**24**		**19**
GA pecan/ Tree Nuts	0.448 (0.4)	Aerial	0.150	0.148	31200	30800	**7.1**	**12**		**9.6**
NC peanuts/ Peanuts	0.336 (0.3)	Aerial	0.155	0.153	32300	31900	**7.4**	**13**		**10**
FL tomato/ Fruiting Vegetables	0.336 (0.3)	Aerial	0.0975	0.0968	20300	20200	**4.6**	**8.1**		**6.3**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For estuarine/marine benthic invertebrates, Acute pore water RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.012 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 3200 µg/kg$_{OC}$ [for Amphipod, *Leptocheirus plumulosus*].

For freshwater benthic invertebrates exposed to fenpropathrin plus the unextracted residues, the acute RQs exceeded the listed and non-listed LOCs (0.05 and 0.5, respectively) for all the scenarios tested. The acute RQs ranged from 5.8 to 16.

The chronic RQs (sediment based) exceeded the LOC (LOC = 1.0) in all instances as well. The highest RQs were for the MS cotton and MI cherries scenarios. The chronic RQs ranged from 7.9 to 28. The pore water based RQs were slightly higher than the sediment based RQs as a result of a more sensitive endpoint from a water column test with the mysid shrimp, compared to the sediment chronic RQ, which was derived from a test conducted on *Leptocheirus plumulosus*.

Table 110. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Fenpropathrin plus Unextracted Residues

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA cole crops/ Brassica (head and stem) Vegetables	0.336 (0.3)	Aerial	0.204	0.204	42500	42500	**9.7**	**17**		**13**
NY grapes/ Bushberries and caneberries	0.336 (0.3)	Aerial	0.274	0.274	57100	57100	**13**	**23**		**18**
FL citrus/ Citrus	0.448 (0.4)	Assume Airblast	0.140	0.140	29200	29200	**6.7**	**12**		**9.1**
FL cucumber/ Cucurbit Vegetables	0.336 (0.3)	Aerial	0.122	0.121	25400	25200	**5.8**	**10**		**7.9**
PA apple/ Pome Fruits	0.448 (0.4)	Aerial	0.214	0.212	44700	44300	**10**	**18**		**14**
MS cotton/ Cotton	0.336 (0.3)	Aerial	0.333	0.331	69500	69100	**16**	**28**		**22**
MI cherries/ Stone Fruits	0.448 (0.4)	Aerial	0.341	0.339	71200	70800	**16**	**28**		**22**
GA pecan/ Tree Nuts	0.448 (0.4)	Aerial	0.178	0.176	37200	36800	**8.5**	**15**		**12**
NC peanuts/ Peanuts	0.336 (0.3)	Aerial	0.179	0.178	37400	37200	**8.5**	**15**		**12**
FL tomato/ Fruiting Vegetables	0.336 (0.3)	Aerial	0.128	0.126	26800	26300	**6.1**	**11**		**8.2**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For estuarine/marine benthic invertebrates, Acute pore water RQ = use-specific peak EEC / 0.021 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.012 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 3200 µg/kg$_{OC}$ [for Amphipod, *Leptocheirus plumulosus*].

7.1.5. Vascular and Non-Vascular Aquatic Plants Risk Quotients

For vascular plants exposed to bifenthrin there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). For vascular and non-vascular plants, the RQ values were very low in all instances (<0.01 for all the scenarios).

Table 111. Acute RQs for Vascular and Non-vascular Plants Exposed to Bifenthrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
FL cucumber/ Cucurbit Vegetables	0.014* (0.231)	<0.01	<0.01	<0.01	<0.01
NY grapes/ Blueberries (and other Bushberries)	0.014* (2.51)	<0.01	<0.01	<0.01	<0.01
FL citrus/ Citrus[3]	0.014* (0.798)	<0.01	<0.01	<0.01	<0.01
IL corn/ Corn	0.014* (1.74)	<0.01	<0.01	<0.01	<0.01
FL sweet corn/ Sweet Corn	0.014* (0.296)	<0.01	<0.01	<0.01	<0.01
MS cotton/ Cotton	0.014* (1.86)	<0.01	<0.01	<0.01	<0.01
MS soybean/ Soybean[3]	0.014* (0.513)	<0.01	<0.01	<0.01	<0.01
GA pecan/ Tree Nuts	0.014* (1.20)	<0.01	<0.01	<0.01	<0.01
CA cole crops/ Brassica Vegetables	0.014* (0.540)	<0.01	<0.01	<0.01	<0.01
CA lettuce/ Lettuce	0.014* (0.614)	<0.01	<0.01	<0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 330 ppb [NOAEC = 330 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 330 ppb [IC_{50} of >330 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 290 ppb [NOAEC = 290 ppb for marine diatom, *Skeletonema costatum*]; the non-listed species acute RQ = use-specific peak EEC / 290 ppb [IC_{50} > 290 ppb, for marine diatom, *Skeletonema costatum*].

For vascular plants exposed to deltamethrin there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). For vascular plants, the highest RQs were 0.28 and <0.28, respectively, for listed and non-listed plants, for the MS cotton scenario. For non-vascular plants exposed to deltamethrin, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to 0.03.

Table 112. Acute RQs for Vascular and Non-vascular Plants Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
GA onion/ Bulb Vegetables	0.0639	<0.01	<0.01	0.02	<0.02
WA potato/ Tuberous and Corm Vegetables	0.0408	<0.01	<0.01	0.01	<0.01
GA pecan/ Tree Nuts	0.108	<0.01	<0.01	0.03	<0.03
IA corn/ Corn	0.0835	<0.01	<0.01	0.03	<0.03
FL sweet corn/ Sweet Corn	0.0840	<0.01	<0.01	0.03	<0.03
MS cotton/ Cotton	0.200* (0.434)	<0.01	<0.01	0.06	<0.06
MS soybean/ Soybean	0.0544	<0.01	<0.01	0.02	<0.02
ND wheat/ Sunflowers[3]	0.0120	<0.01	<0.01	<0.01	<0.01
FL cucumbers/ Cucurbit Vegetables	0.0309	<0.01	<0.01	0.01	<0.01
FL tomatoes/ Fruiting Vegetables	0.0651	<0.01	<0.01	0.02	<0.02

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 779 ppb [NOAEC = 779 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 779 ppb [EC_{50} of >779 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 3.1 ppb [NOAEC = 3.1 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC / 3.1 ppb [EC_{50} >3.1 ppb for green algae, *Pseudo-kirchneriella subcapitata*].

For pyrethrins the vascular plant RQs were below the LOCs for all uses. The RQs were low and they ranged from <0.01 to 0.11. For listed non-vascular plants, the RQ exceeded the LOC for only the rice use (listed species RQ = 1.9). For all the remaining uses, the RQs were 0.02 to 0.06. For non-listed non-vascular plants exposed to permethrin, the RQs did not exceed the LOC (1.0) for any of the scenarios. The range in RQs was <0.01 to 0.54.

Table 113. Acute RQs for Vascular and Non-vascular Plants Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
MN alfalfa/ Alfalfa	0.663	<0.01	<0.01	0.02	0.01
NY grapes/ Blueberries	1.64	<0.01	<0.01	0.06	0.02
FL citrus/ Citrus	0.515	<0.01	<0.01	0.02	<0.01
IL corn/ Corn	1.22	<0.01	<0.01	0.04	0.01
FL sweet corn/ Sweet Corn	0.591	<0.01	<0.01	0.02	0.01

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
NC cotton/ Cotton	1.54	<0.01	<0.01	0.05	0.01
MS soybean/ Soybean	0.725	<0.01	<0.01	0.03	0.01
ND wheat/ Sunflower	0.690	<0.01	<0.01	0.02	0.01
ND wheat/ Wheat	0.690	<0.01	<0.01	0.02	0.01
FL tomato/ Fruiting Vegetables	0.782	<0.01	<0.01	0.03	0.01
CA rice (Winter flood)/ Rice	56.5	0.11	0.05	*1.9*	0.54

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1. A light shaded and italics "*RQ*" means the listed species LOC of 1 was exceeded. A dark shaded and bolded "**RQ**" represents LOC exceedances (LOC = l) for non-listed species LOCs.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 480 ppb [NOAEC = 480 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1230 ppb [IC_{50} = 1230 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 29 ppb [NOAEC = 29 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC/ 105 ppb [IC_{50} =105 ppb, for green algae, *Pseudo-kirchneriella subcapitata*].

For permethrin the vascular plant RQs were below the LOCs for all uses except for blueberries (represented by NY grapes). The RQs ranged from <0.18 to 1.7. For listed non-vascular plants, the RQs exceeded the LOC for all uses except for PA alfalfa. The RQs were 0.88 to 8.5 overall for all uses. For non-listed non-vascular plants exposed to permethrin, the RQs did not exceed the LOC (1.0) for any of the scenarios, except for the blueberries (represented by NY grapes). The range in RQs was <0.13 to <1.3.

Table 114. Acute RQs for Vascular and Non-vascular Plants Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
PA alfalfa/ Alfalfa	0.574	0.18	<0.18	0.88	<0.13
NY grapes/ Blueberries	5.50* (10.3)	*1.7*	**<1.7**	*8.5*	**<1.3**
GA pecans/ Tree Nuts (based on pistachios)	2.20	0.69	<0.69	*3.4*	<0.50
IL corn/ Corn	1.07	0.33	<0.33	*1.6*	<0.24
FL sweet corn/ Sweet Corn	0.670	0.21	<0.21	*1.0*	<0.15
CA lettuce/ Leafy Greens (based on the rate for lettuce)	1.10	0.34	<0.34	*1.7*	<0.25
MS soybean/ Soybean	0.724	0.23	<0.23	*1.1*	<0.16
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	0.831	0.26	<0.26	*1.3*	<0.19
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	0.924	0.29	<0.29	*1.4*	<0.21

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	1.04	0.33	<0.33	*1.6*	<0.24

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1. A light shaded and italics "*RQ*" means the listed species LOC of 1 was exceeded. A dark shaded and bolded "**RQ**" represents LOC exceedances (LOC = l) for non-listed species LOCs.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 3.2 ppb [NOAEC = 3.2 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 3.2 ppb [IC_{50} of >3.2 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 0.65 ppb [NOAEC = 0.65 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC / 4.4 ppb [IC_{50} > 4.4 ppb, for green algae, *Pseudo-kirchneriella subcapitata*].

For vascular plants exposed to esfenvalerate there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). The highest RQs were 0.15 and <0.15, respectively, for the NC cotton scenario. For non-vascular plants exposed to esfenvalerate, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from 0.03 to 0.22.

Table 115. Acute RQs for Vascular and Non-vascular Plants Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
CA cole crops/ Brassica (head & stem) Vegetables	0.369	0.04	<0.04	0.07	<0.07
NY grapes/ Blueberries (*except CA*)	0.900	0.10	<0.10	0.16	<0.16
GA pecan/ Tree Nuts (based on rate on almonds)	0.899	0.10	<0.10	0.16	<0.16
IL corn/ Corn	0.851	0.10	<0.10	0.15	<0.15
FL sweet corn/ Sweet Corn	0.422	0.05	<0.05	0.08	<0.08
NC cotton/ Cotton	1.25	0.15	<0.15	0.22	<0.22
MS soybean/ Soybeans	0.303	0.04	<0.04	0.05	<0.05
ND wheat/ Sunflowers	0.165	0.02	<0.02	0.03	<0.03
FL cucumber/ Cucurbit Vegetables	0.241	0.03	<0.03	0.04	<0.04
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	0.443	0.05	<0.05	0.08	<0.08

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 8.6 ppb [NOAEC = 8.6 for Duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 8.6 ppb [EC_{50} of >8.6 for Duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 5.6 ppb [NOAEC = 5.6 ppb for freshwater algae, *Pseudokirchneriella subcapita*]; the non-listed species acute RQ = use-specific peak EEC / 5.6 ppb [EC_{50} >5.6 ppb for freshwater algae, *Pseudokirchneriella subcapita*].

For vascular plants exposed to cypermethrin, all the listed and non-listed RQs were below the LOC (LOC = 1.0). The RQ values ranged from <0.02 to 0.58. For non-vascular plants exposed to cypermethrin, all the listed and non-listed RQs were well below the LOC (1.0). The RQ values ranged from <0.01 to 0.02.

For the uses of cypermethrin (*zeta*-) on rice, the EECs and RQs were about one order of magnitude greater than the other conventional agricultural uses. The RQs exceeded the listed and non-listed species LOCs for vascular plants (RQs of 2.45 and <2.45, respectively); however, the RQs did not exceed the LOCs for non-vascular plants.

Table 116. Acute RQs for Vascular and Non-vascular Plants Exposed to Cypermethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
PA alfalfa/ Alfalfa	0.0847	0.05	<0.05	<0.01	<0.01
NY grapes/ Blueberries:	0.938	0.58	<0.58	0.02	<0.01
FL citrus/ Citrus:	0.270	0.17	<0.17	<0.01	<0.01
IL corn/ Corn	0.461	0.28	<0.28	0.01	<0.01
FL sweet corn/ Sweet Corn	0.193	0.12	<0.12	<0.01	<0.01
MS cotton/ Cotton	0.908	0.56	<0.56	0.02	<0.01
MS soybean/ Soybean	0.480	0.30	<0.30	0.01	<0.01
ND wheat/ Sunflower	0.0403	0.02	<0.02	<0.01	<0.01
ND wheat/ Wheat	0.221	0.14	<0.14	<0.01	<0.01
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.318	0.20	<0.20	0.01	<0.01
CA rice (Winter flood)/ Rice	3.97* (55.4)	**2.45**	**<2.45**	0.07	<0.01

* EECs marked with an asterisk were set to 3.97 ppb because they exceeded the limit of solubility of cypermethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

Generally, numbers were rounded to three significant figures; for the RQs no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 1.62 ppb [NOAEC = 1.62 for Duckweed, *Lemna gibba*, conducted on *alpha*-cypermethrin]; the non-listed species acute RQ = use-specific peak EEC / 1.62 ppb [EC_{50} of >1.62 for Duckweed, *Lemna gibba*, conducted on *alpha*-cypermethrin].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 60 ppb [NOAEC = 60 ppb for freshwater algae, *Pseudokirchneriella subcapitata*, conducted on *alpha*-cypermethrin]; the non-listed species acute RQ = use-specific peak EEC / 25,000 ppb [EC_{50} of 25,000 ppb for freshwater algae, *Pseudokirchneriella subcapitata*, conducted on *alpha*-cypermethrin].

For the cyfluthrin there is no vascular plants data available. Therefore, no RQs could be calculated. For non-vascular plants exposed to cyfluthrin, all non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.02 to <0.36. There was no endpoint available to calculate the listed species RQ.

Table 117. Acute RQs for Non-Vascular Plants Exposed to Cyfluthrin

Scenario/Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Peak EEC (µg/L)	Non-Listed Acute RQ+	Non-Listed Acute RQ#
PA alfalfa/ Alfalfa	0.049 (0.044)	Aerial	0.0865	NC	<0.04
NY grapes/ Grapes	0.056 (0.05)	Aerial	0.535	NC	<0.27
FL citrus/ Citrus	0.112 (0.1)	Assume Airblast	0.197	NC	<0.10
IL corn/ Corn	0.049 (0.044)	Aerial	0.246	NC	<0.12
FL sweet corn/ Sweet Corn	0.049 (0.044)	Aerial	0.127	NC	<0.06
MS cotton/ Cotton	0.056 (0.05)	Aerial	0.728	NC	<0.36
MS soybean/ Soybeans	0.049 (0.044)	Aerial	0.147	NC	<0.07
ND wheat/ Sunflowers	0.049 (0.044)	Aerial	0.0523	NC	<0.03
ND wheat/ Wheat	0.043 (0.038)	Aerial	0.0434	NC	<0.02
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	0.056 (0.05)	Aerial	0.358	NC	<0.18

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. NC=not calculated since there is no suitable endpoint.
= LOC for acute risk 1, and acute endangered species 1.
For non-vascular plants, the non-listed species acute RQ = use-specific peak EEC / 2 ppb [EC_{50} >2 for algae, *Scenedesmus subspicatus*, conducted with cyfluthrin].

For vascular plants exposed to *lambda*-cyhalothrin, all the listed and non-listed RQs were below the LOC (1.0), with the exception of the MS cotton scenario, which slightly exceeded the LOC. The RQ values were very low in all instances, ranging from <0.01 to <0.02 for non-vascular plants.

For the uses of cyhalothrin (*lambda*-) on rice, the EECs and RQs were about one order of magnitude greater than the other conventional agricultural uses. The RQs exceeded the listed and non-listed species LOCs for vascular plants (RQs of ≤9.8); however, the RQs did not exceed the LOCs for non-vascular plants.

Table 118. Acute RQs for Vascular and Non-vascular Plants Exposed to *Lambda*-Cyhalothrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
PA alfalfa/ Alfalfa	0.0884	0.17	<0.17	≤0.01	<0.01
FL cucumber/ Cucurbit Vegetables	0.186	0.37	<0.37	≤0.01	<0.01

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
FL citrus/ Citrus	0.273	0.54	<0.54	≤0.01	<0.01
IL corn/ Corn	0.279	0.55	<0.55	≤0.01	<0.01
FL sweet corn/ Sweet Corn	0.230	0.45	<0.45	≤0.01	<0.01
MS cotton/ Cotton	0.740	**1.5**	**<1.5**	≤0.01	<0.01
MS soybean/ Soybeans	0.0768	0.15	<0.15	≤0.01	<0.01
ND wheat/ Sunflowers	0.0964	0.19	<0.19	≤0.01	<0.01
ND wheat/ Wheat	0.0674	0.13	<0.13	≤0.01	<0.01
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	0.361	0.71	<0.71	≤0.01	<0.01
CA rice (Winter flood)/ Rice	5.00* (44.3)	**9.8**	**<9.8**	≤0.02	<0.02

* EECs marked with an asterisk were set to 5.00 ppb because they exceeded the limit of solubility of *lambda*-cyhalothrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 0.508 ppb [NOAEC = 5.4 for Duckweed, *Lemna gibba*, conducted with *gamma*-cyhalothrin]; the non-listed species acute RQ = use-specific peak EEC / 0.508 ppb [EC_{50} of >0.508 for Duckweed, *Lemna gibba*, conducted with *gamma*-cyhalothrin].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 310 ppb [NOAEC ≥310 ppb for green algae, *Selenastrum capricornutum*]; the non-listed species acute RQ = use-specific peak EEC / 310 ppb [EC_{50} >310 for green algae, *Selenastrum capricornutum*].

For vascular plants exposed to fenpropathrin, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances (RQs <0.01).

For non-vascular plants exposed to fenpropathrin, none of the listed species or non-listed species RQs exceeded the LOCs (LOC = 1.0) for any of the scenarios tested. The highest RQs were for the MS cotton scenario, for which the RQs were only 0.15 and 0.06 for listed and non-listed species, respectively.

Table 119. Acute RQs for Vascular and Non-vascular Plants Exposed to Fenpropathrin

Scenario/Uses	App Rate kg a.i./ha (lb a.i./A)	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
CA cole crops/ Brassica (head and stem) Vegetables	0.336 (0.3)	1.02	<0.01	<0.01	0.04	0.02
NY grapes/ Bushberries and caneberries	0.336 (0.3)	3.35	<0.01	<0.01	0.14	0.05

Scenario/Uses	App Rate kg a.i./ha (lb a.i./A)	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
FL citrus/ Citrus	0.448 (0.4)	1.30	<0.01	<0.01	0.05	0.02
FL cucumber/ Cucurbit Vegetables	0.336 (0.3)	0.970	<0.01	<0.01	0.04	0.02
PA apple/ Pome Fruits	0.448 (0.4)	2.08	<0.01	<0.01	0.09	0.03
MS cotton/ Cotton	0.336 (0.3)	3.70	<0.01	<0.01	0.15	0.06
MI cherries/ Stone Fruits	0.448 (0.4)	3.18	<0.01	<0.01	0.13	0.05
GA pecan/ Tree Nuts	0.448 (0.4)	2.02	<0.01	<0.01	0.08	0.03
NC peanuts/ Peanuts	0.336 (0.3)	2.72	<0.01	<0.01	0.11	0.04
FL tomato/ Fruiting Vegetables	0.336 (0.3)	1.10	<0.01	<0.01	0.05	0.02

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute endangered species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 1000 ppb [NOAEC for Duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1000 ppb [EC_{50} >1000 µg/L for Duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 24 ppb [NOAEC for marine diatom, *Skeletonema costatum*]; the non-listed species acute RQ = use-specific peak EEC / 63 ppb [EC_{50} for marine diatom, *Skeletonema costatum*].

For vascular plants exposed to fenpropathrin, all the listed and non-listed RQs were well below the LOC (1.0). The RQ values were very low in all instances (RQs <0.01).

For non-vascular plants exposed to fenpropathrin, none of the listed species or non-listed species RQs exceeded the LOCs (LOC = 1.0) for any of the scenarios tested. The highest RQs were for the MS cotton scenario, for which the RQs were only 0.16 and 0.06 for listed and non-listed species, respectively.

Table 120. Acute RQs for Vascular and Non-vascular Plants Exposed to Fenpropathrin plus Unextracted Residues

Scenario/Uses	App Rate kg a.i./ha (lb a.i./A)	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
CA cole crops/ Brassica (head and stem) Vegetables	0.336 (0.3)	1.44	<0.01	<0.01	0.06	0.02
NY grapes/ Bushberries and caneberries	0.336 (0.3)	3.44	<0.01	<0.01	0.14	0.05
FL citrus/ Citrus	0.448 (0.4)	1.63	<0.01	<0.01	0.07	0.03
FL cucumber/ Cucurbit Vegetables	0.336 (0.3)	1.43	<0.01	<0.01	0.06	0.02
PA apple/ Pome Fruits	0.448 (0.4)	3.01	<0.01	<0.01	0.13	0.05
MS cotton/ Cotton	0.336 (0.3)	3.95	<0.01	<0.01	0.16	0.06
MI cherries/ Stone Fruits	0.448 (0.4)	3.56	<0.01	<0.01	0.15	0.06

Scenario/Uses	App Rate kg a.i./ha (lb a.i./A)	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
			Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
GA pecan/ Tree Nuts	0.448 (0.4)	2.41	<0.01	<0.01	0.10	0.04
NC peanuts/ Peanuts	0.336 (0.3)	2.94	<0.01	<0.01	0.12	0.05
FL tomato/ Fruiting Vegetables	0.336 (0.3)	1.47	<0.01	<0.01	0.06	0.02

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute endangered species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 1000 ppb [NOAEC for Duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1000 ppb [EC_{50} >1000 µg/L for Duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 24 ppb [NOAEC for marine diatom, *Skeletonema costatum*]; the non-listed species acute RQ = use-specific peak EEC / 63 ppb [EC_{50} for marine diatom, *Skeletonema costatum*].

7.2. Risk Description

7.2.1. Main Factors Affecting the Risk Quotients

One of the major factors that affect the risk quotients for the synthetic pyrethroids and pyrethrins is their toxicity to aquatic animals. As indicated earlier, previous assessments had shown the potential for hazard of these chemicals to aquatic animals, and for risk concerns in agricultural settings.

Pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} <0.1 mg/L). Freshwater fish are generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates are more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis. On a chronic basis, a trend is not clear for freshwater invertebrates, when compared to estuarine/marine invertebrates. Freshwater and estuarine/marine invertebrates are orders of magnitude more sensitive to pyrethroids and pyrethrins than freshwater and estuarine/marine fish. Vascular and non-vascular plants endpoints for the pyrethroids for which data are available indicate that these organisms are much less sensitive than aquatic animals.

The use information utilized in the risk assessment is another factor that could affect the risk quotients. In order to simulate applications to agricultural crops, and given the large number of uses per chemical, EFED focused its attention on those crops that represent the highest usage for pyrethroids. There were around seven to eight major field crops for pyrethroids overall in terms of usage, according to BEAD: alfalfa, corn, sweet corn, cotton, soybean, sunflowers, wheat and rice (this particular use applies to only some of the chemicals). Besides these crops, EFED modelled one or two vegetable crops (selecting from brassica, fruiting and cucurbit vegetables), a tree (citrus or tree nuts), and a specialty crop (blueberries). About 10 to 11 crops or crop groups were selected per chemical. For each crop or use, a batch run file was prepared and multiple runs were performed simultaneously in the PWC, using all the available representative crops. Then the scenario yielding the highest EECs was presented in the EEC tables and the RQ tables. For example, corn was one of the major uses for pyrethroids, according to BEAD's supplied information. For corn, there are thirteen PRZM scenarios across the U.S. as follows: CA, IA, IN, IL KS, MN, MS, NC, ND, NE, OH, PA, and TX corn. Note that all these scenarios were run in batch mode in the PWC. Then from these thirteen locations, BEAD indicated the states of major pyrethroid use. The maximum EECs presented in this assessment represent a combination of major use patterns for pyrethroids, locations of major usage within the U.S. and highest EECs.

7.2.2. Summary of Risk Quotients

Tables 71 to **120** (above), provided detailed RQ tables including EECs and endpoints used for each pyrethroid (see footnotes in those tables). **Tables 121** to **130** provide overall

summaries of all the risk quotients for freshwater and estuarine/marine animals for eight pyrethroids and pyrethrins, for the uses assessed. The summary tables below are presented to show trends for each chemical and across chemicals.

Acute and chronic risks quotients (RQs) for freshwater and estuarine/marine fish were generally orders of magnitude lower than for freshwater and estuarine/marine invertebrates. For freshwater fish, there were a fewer exceedances of the acute and chronic LOCs, compared to invertebrates, and further, for estuarine/marine fish there were even fewer exceedances of acute and chronic LOCs. For deltamethrin, permethrin and bifenthrin, some of the peak EECs were limited by the solubility of each compound. Refer to the EEC or RQ tables for the particular runs for which this occurred. In these tables, when the EEC exceeded the limit of solubility, the EEC from the run was added in a (parenthesis) for informative purposes. The pyrethroids are highly hydrophobic, and should not be bioavailable above the limit of solubility.

For one chemical, fenpropathrin, inspection of the unextracted residues was performed. Inspection of the RQ results for fenpropathrin and fenpropathrin plus the unextracted residues, in **Tables 129** and **130**, respectively, shows the following trends:

- RQs for invertebrates (freshwater and estuarine/marine) are higher than for fish (freshwater and estuarine/marine). This is common across all the chemicals tested, for which invertebrates are more susceptible than fish to pyrethroid exposure.
- Benthic acute and chronic RQs are lower than water column RQs, which is expected, since the pore water EECs are lower than water column EECs.
- The overall risk picture for parent only and parent plus unextracted residues are similar. It appears that additional runs including the unextracted residues will not change the overall conclusions of the risk assessment for the other chemicals.

No RQ *summary tables* were presented for vascular and non-vascular plants, since for these species there were no exceedances of the listed and/or non-listed species LOC (LOC = 1.0) for any of the pyrethroids for which aquatic plant data were available (aquatic plant toxicity data were available for around 6 out of 9 chemicals). Based on the above information, and in the absence of further data, it is presumed that no risks of concern are present for the remaining chemicals for aquatic plants.

Table 121. Summary of Risk Quotients for Certain Agricultural Uses of Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
MN alfalfa/ Alfalfa	*0.13*	0.17	0.04	0.47	**0.87**	**12**	*0.31*	**5.9**	*0.35*	**2.0**	*0.17*	0.96
NY grapes/ Blueberries	*0.32*	0.33	*0.10*	0.89	**2.2**	**24**	**0.74**	**14**	**0.68**	**3.8**	*0.40*	**2.2**
FL citrus/ Citrus	*0.10*	0.08	0.03	0.21	**0.68**	**5.9**	*0.15*	**2.7**	*0.37*	0.94	*0.08*	0.43
IL corn/ Corn	*0.24*	0.24	*0.08*	0.64	**1.6**	**17**	*0.47*	**8.9**	*0.49*	**2.7**	*0.26*	**1.4**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
FL sweet corn/ Sweet Corn	*0.12*	0.14	0.04	0.37	**0.78**	**10**	*0.22*	**4.0**	*0.29*	**1.6**	*0.12*	0.64
NC cotton/ Cotton	*0.30*	0.27	*0.10*	0.73	**2.0**	**18**	**0.57**	**11**	**0.53**	**3.0**	*0.31*	**1.7**
MS soybean/ Soybean	*0.14*	0.13	*0.05*	0.36	**0.95**	**10**	*0.23*	**4.3**	*0.29*	**1.6**	*0.13*	0.68
ND wheat/ Sunflower	*0.14*	0.17	0.04	0.45	**0.91**	**12**	*0.31*	**5.7**	*0.34*	**1.9**	*0.17*	0.91
ND wheat/ Wheat	*0.14*	0.17	0.04	0.45	**0.91**	**12**	*0.31*	**5.7**	*0.34*	**1.9**	*0.17*	0.91
FL tomato/ Fruiting Vegetables	*0.15*	0.14	*0.05*	0.37	**1.0**	**11**	*0.24*	**4.4**	*0.30*	**1.7**	*0.13*	0.70
CA rice/ Rice	**11**	**1.5**	**3.5**	**4.0**	**74**	**115**	**2.3**	**42**	**40**	**18**	**1.3**	**6.7**

RQs with *italics* font and shaded light grey exceed only the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 122. Summary of Risk Quotients for Certain Agricultural Uses of Bifenthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
FL cucumber/ Cucurbit Vegetables	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**520**	**3.5**	**>23**	**3.53**	**>24**
NY grapes/ Blueberries (and other Bushberries)	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**4920**	**3.5**	**>23**	**3.53**	**>228**
FL citrus/ Citrus[3]	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**1150**	**3.5**	**>23**	**3.53**	**>53**
IL corn/ Corn	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**3010**	**3.5**	**>23**	**3.53**	**>139**
FL sweet corn/ Sweet Corn	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**516**	**3.5**	**>23**	**3.53**	**>23**
MS cotton/ Cotton	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**3080**	**3.5**	**>23**	**3.53**	**>142**
MS soybean/ Soybean	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**1190**	**3.5**	**>23**	**3.53**	**>55**
GA pecan/ Tree Nuts	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**2010**	**3.5**	**>23**	**3.53**	**>93**
CA cole crops/ Brassica Vegetables	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**1690**	**3.5**	**>23**	**3.53**	**>78**
CA lettuce/ Lettuce	*0.09*	**3.5**	<0.01	0.14	**28.4**	**280**	**28.4**	**1560**	**3.5**	**>23**	**3.53**	**>72**

RQs with *italics* font and shaded light grey exceed only the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 123. Summary of Risk Quotients for Certain Agricultural Uses of Deltamethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
GA onion/ Bulb Vegetables	**1.6**	0.11	*0.11*	0.08	**320**	**110**	**8.0**	**58**	**17**	**6.0**	*0.43*	**3.2**
WA potato/ Tuberous and Corm Vegetables	**1.0**	0.07	*0.07*	0.05	**200**	**68**	**4.5**	**33**	**11**	**3.8**	*0.24*	**1.8**
GA pecan/ Tree Nuts	**2.7**	0.13	*0.19*	0.09	**540**	**110**	**9.4**	**74**	**29**	**6.1**	**0.51**	**4.1**
IA corn/ Corn	**2.1**	0.13	*0.14*	0.09	**420**	**120**	**9.6**	**71**	**23**	**6.6**	**0.52**	**4.0**
FL sweet corn/ Sweet Corn	**2.1**	0.19	*0.14*	0.13	**420**	**190**	**11**	**80**	**23**	**10**	**0.59**	**4.4**
MS cotton/ Cotton	**5.0**	0.50	*0.34*	0.35	**1000**	**490**	**35**	**260**	**54**	**27**	**1.9**	**14**
MS soybean/ Soybean	**1.4**	0.08	*0.09*	0.05	**270**	**65**	**5.4**	**39**	**15**	**3.6**	*0.29*	**2.1**
ND wheat/ Sunflowers	*0.30*	0.02	0.02	0.02	**60**	**24**	**1.5**	**11**	**3.2**	**1.3**	*0.08*	0.61
FL cucumbers/ Cucurbit Vegetables	**0.77**	0.08	*0.05*	0.05	**150**	**75**	**4.3**	**32**	**8.4**	**4.1**	*0.23*	**1.8**
FL tomatoes/ Fruiting Vegetables	**1.6**	0.11	*0.11*	0.08	**330**	**87**	**7.5**	**56**	**18**	**4.8**	*0.40*	**3.1**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 124. Summary of Risk Quotients for Certain Agricultural Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	**0.73**	**1.5**	*0.26*	0.55	**87**	**20**	**11**	**30**	**32**	**36**	**3.9**	**29**
NY grapes/ Blueberries	**7.0**	**23**	**2.5**	**8.53**	**830**	**329**	**162**	**457**	**310**	**580**	**59**	**442**
GA pecans/ Tree Nuts (based on pistachios)	**2.8**	**3.8**	**1.0**	**1.38**	**330**	**60**	**27**	**75**	**120**	**100**	**9.8**	**73**
IL corn/ Corn	**1.4**	**2.2**	*0.49*	0.80	**160**	**31**	**17**	**49**	**59**	**54**	**6.3**	**47**
FL sweet corn/ Sweet Corn	**0.85**	**1.4**	*0.30*	0.52	**100**	**20**	**9.8**	**27**	**37**	**35**	**3.6**	**26**
CA lettuce/ Leafy Greens (based on the rate for lettuce)	**1.4**	**2.3**	**0.50**	0.85	**170**	**34**	**16**	**46**	**61**	**60**	**6.0**	**45**
MS soybean/ Soybean	**0.92**	**1.6**	*0.33*	0.56	**110**	**23**	**11**	**31**	**40**	**40**	**4.2**	**30**
CA cole crops/ Brassica Vegetables (based on maximum rate on broccoli)	**1.1**	**2.4**	*0.38*	0.87	**130**	**35**	**16**	**45**	**46**	**61**	**5.8**	**43**
FL tomatoes/ Fruiting Vegetables (based on the rate for bell peppers)	**1.2**	**2.1**	*0.42*	0.76	**140**	**30**	**14**	**39**	**51**	**53**	**5.1**	**37**
FL cucumbers/ Cucurbit Vegetables (based on rate for watermelons)	**1.3**	**2.2**	*0.47*	0.80	**160**	**30**	**15**	**42**	**58**	**53**	**5.5**	**40**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 125. Summary of Risk Quotients for Certain Agricultural Uses of Esfenvalerate for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA cole crops/ Brassica (head & stem) Vegetables	**2.60**	**1.3**	<0.02	0.04	**435**	**890**	**23.3**	**27.9**	**79.2**	**162**	**4.25**	**6.5**
NY grapes/ Blueberries (*except CA*)	**6.34**	**1.7**	*<0.05*	0.05	**1060**	**1380**	**27.9**	**33.1**	**193**	**251**	**5.09**	**7.7**
GA pecan/ Tree Nuts (based on rate on almonds)	**6.33**	**1.6**	*<0.05*	0.04	**1060**	**1100**	**26.7**	**33**	**193**	**200**	**4.85**	**7.7**
IL corn/ Corn	**5.99**	**1.6**	<0.04	0.04	**1004**	**1240**	**30.0**	**36**	**183**	**226**	**5.45**	**8.3**
FL sweet corn/ Sweet Corn	**2.97**	0.99	<0.02	0.03	**498**	**683**	**15.8**	**19**	**90.6**	**124**	**2.88**	**4.4**
NC cotton/ Cotton	**8.80**	**2.2**	*<0.06*	0.06	**1470**	**1420**	**38.6**	**46**	**268**	**258**	**7.02**	**11**
MS soybean/ Soybeans	**2.13**	0.65	<0.02	0.02	**357**	**450**	**11.4**	**14**	**65.0**	**81.8**	**2.08**	**3.2**
ND wheat/ Sunflowers	**1.16**	0.42	<0.01	0.01	**195**	**315**	**7.22**	**8.4**	**35.4**	**57.2**	**1.31**	**2.0**
FL cucumber/ Cucurbit Vegetables	**1.70**	0.59	<0.01	0.02	**284**	**372**	**9.41**	**11**	**51.7**	**67.6**	**1.71**	**2.6**
FL tomato/ Fruiting Vegetables (based on the rate for tomatoes)	**3.12**	0.99	<0.02	0.03	**522**	**650**	**15.2**	**18**	**95.1**	**118**	**2.77**	**4.2**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 126. Summary of Risk Quotients for Certain Agricultural Uses of for Cypermethrin Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	*0.22*	0.08	*0.09*	0.03	**151**	**>135**	**5.4**	**>57**	**16**	**34**	**0.56**	**14**
NY grapes/ Blueberries:	**2.4**	0.77	**0.99**	0.32	**1675**	**>1124**	**55**	**>590**	**174**	**281**	**5.7**	**148**
FL citrus/ Citrus:	**0.69**	0.18	*0.28*	0.07	**482**	**>300**	**13**	**>132**	**50**	**75**	**1.3**	**33**
IL corn/ Corn	**1.2**	0.34	*0.49*	0.14	**823**	**>530**	**25**	**>262**	**85**	**133**	**2.6**	**66**
FL sweet corn/ Sweet Corn	*0.49*	0.17	*0.20*	0.07	**345**	**>234**	**11**	**>116**	**36**	**59**	**1.2**	**29**
MS cotton/ Cotton	**2.3**	0.57	**0.96**	0.23	**1620**	**>706**	**41**	**>414**	**168**	**177**	**4.2**	**104**
MS soybean/ Soybean	**1.2**	0.39	**0.51**	0.16	**857**	**>508**	**30**	**>326**	**89**	**127**	**3.1**	**82**
ND wheat/ Sunflower	*0.10*	0.03	0.04	0.01	**72**	**>40**	**2.1**	**>22**	**7.5**	**10**	*0.22*	**5.6**
ND wheat/ Wheat	**0.57**	0.18	*0.23*	0.07	**395**	**>256**	**14**	**>146**	**41**	**64**	**1.4**	**37**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	**0.82**	0.28	*0.33*	0.11	**568**	**>354**	**18**	**>197**	**59**	**89**	**1.9**	**49**
CA rice/ Rice	**10**	**8.0**	**4.2**	**3.3**	**7090**	**>13440**	**432**	**>4520**	**735**	**3360**	**45**	**1130**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 127. Summary of Risk Quotients for Agricultural Uses of Cyfluthrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	**1.3**	0.96	0.02	0.16	**3.5**	**50**	*0.08*	**14**	**39**	**86**	**0.96**	**25**
NY grapes/ Grapes	**7.9**	**3.0**	*0.13*	0.51	**21**	**177**	*0.36*	**63**	**243**	**303**	**4.1**	**107**
FL citrus/ Citrus	**2.9**	**1.0**	*0.05*	0.17	**7.9**	**60**	*0.11*	**17**	**90**	**102**	**1.3**	**29**
IL corn/ Corn	**3.6**	**1.4**	*0.06*	0.23	**9.8**	**85**	*0.18*	**32**	**112**	**146**	**2.0**	**54**
FL sweet corn/ Sweet Corn	**1.9**	**1.3**	0.03	0.22	**5.1**	**81**	*0.11*	**21**	**58**	**139**	**1.3**	**36**
MS cotton/ Cotton	**10.1**	**3.3**	*0.18*	0.56	**29**	**194**	*0.39*	**61**	**331**	**333**	**4.4**	**105**
MS soybean/ Soybeans	**2.2**	**1.0**	0.04	0.17	**5.9**	**55**	*0.13*	**24**	**67**	**95**	**4.5**	**42**
ND wheat/ Sunflowers	**0.77**	0.43	0.01	0.07	**2.1**	**26**	0.04	**7.3**	**24**	**45**	*0.48*	**13**
ND wheat/ Wheat	**0.64**	0.25	0.01	0.04	**1.7**	**16**	0.02	**4.0**	**20**	**28**	*0.26*	**7**
FL tomato/ Brassica, Fruiting and Cucurbit Vegetables	**5.2**	**2.7**	*0.09*	0.46	**14**	**140**	*0.30*	**48**	**163**	**240**	**3.4**	**82**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 128. Summary of Risk Quotients for Certain Agricultural Uses of *Lambda*-Cyhalothrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
PA alfalfa/ Alfalfa	**3.0**	**1.4**	*0.11*	0.17	**1105**	**214**	**528**	**365**	**18.0**	**236**	**8.59**	**211**
FL cucumber/ Cucurbit Vegetables	**6.4**	**3.0**	*0.23*	0.37	**2325**	**434**	**1128**	**777**	**37.9**	**478**	**18.4**	**450**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
FL citrus/ Citrus	**9.4**	**3.0**	*0.34*	0.37	**3413**	**441**	**1149**	**787**	**55.6**	**485**	**18.7**	**457**
IL corn/ Corn	**9.6**	**3.0**	*0.35*	0.37	**3488**	**442**	**1163**	**800**	**56.8**	**486**	**18.9**	**465**
FL sweet corn/ Sweet Corn	**7.9**	**3.8**	*0.29*	0.48	**2875**	**559**	**1450**	**990**	**46.8**	**615**	**23.6**	**575**
MS cotton/ Cotton	**26**	**7.3**	**0.92**	0.91	**9250**	**1082**	**2838**	**1958**	**151**	**1190**	**46.2**	**1135**
MS soybean/ Soybeans	**2.6**	**1.1**	*0.10*	0.13	**960**	**154**	**403**	**278**	**15.6**	**170**	**6.56**	**161**
ND wheat/ Sunflowers	**3.3**	**1.9**	*0.12*	0.23	**1205**	**268**	**665**	**458**	**19.6**	**289**	**10.8**	**266**
ND wheat/ Wheat	**2.3**	0.88	*0.08*	0.11	**843**	**135**	**330**	**227**	**13.7**	**145**	**5.38**	**132**
CA cole crops/ Brassica (head and stem) and Fruiting Vegetables	**12**	**6.2**	*0.45*	0.77	**4513**	**886**	**2388**	**1639**	**73.5**	**975**	**38.9**	**950**
CA rice/ Rice	**172**	**7.4**	**6.20**	0.92	**62500**	**1750**	**1838**	**1000**	**1020**	**1930**	**29.9**	**735**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 129. Summary of Risk Quotients for Certain Agricultural Uses of Fenpropathrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA cole crops/ Brassica (head and stem) Vegetables	*0.46*	**2.6**	*0.33*	0.19	**334**	**>107**	**47.9**	**>97**	**49**	**13**	**7.0**	**12**
NY grapes/ Bushberries and caneberries	**1.5**	**4.4**	**1.1**	0.33	**1098**	**>202**	**82.6**	**>168**	**160**	**25**	**12**	**21**
FL citrus/ Citrus	**0.59**	**1.9**	*0.42*	0.14	**426**	**>87**	**36.0**	**>73**	**62**	**11**	**5.2**	**9.1**
FL cucumber/ Cucurbit Vegetables	*0.44*	**1.5**	*0.31*	0.11	**318**	**>65**	**28.8**	**>58**	**46**	**8.2**	**4.2**	**7.3**
PA apple/ Pome Fruits	**0.95**	**2.8**	**0.67**	0.21	**682**	**>119**	**52.5**	**>107**	**99**	**15**	**7.6**	**13**
MS cotton/ Cotton	**1.7**	**5.2**	**1.2**	0.38	**1213**	**>229**	**99.3**	**>202**	**176**	**29**	**14**	**25**
MI cherries/ Stone Fruits	**1.4**	**5.1**	**1.0**	0.38	**1043**	**>226**	**96.7**	**>197**	**151**	**28**	**14**	**24**
GA pecan/ Tree Nuts	**0.92**	**2.6**	**0.65**	0.19	**662**	**>115**	**49.2**	**>99**	**96**	**14**	**7.1**	**12**
NC peanuts/ Peanuts	**1.2**	**2.7**	**0.88**	0.20	**892**	**>127**	**50.8**	**>103**	**130**	**16**	**7.4**	**13**
FL tomato/ Fruiting Vegetables	**0.50**	**1.7**	*0.35*	0.13	**361**	**>75**	**32.0**	**>65**	**52**	**9.3**	**4.6**	**8.1**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 130. Summary of Risk Quotients for Certain Agricultural Uses of Fenpropathrin plus Unextracted Residues for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA cole crops/ Brassica (head and stem) Vegetables	**0.65**	**3.5**	*0.46*	0.26	**472**	**>146**	**66.9**	**>137**	**69**	**18**	**9.7**	**17**
NY grapes/ Bushberries and caneberries	**1.6**	**4.8**	**1.1**	0.35	**1128**	**>215**	**89.8**	**>184**	**164**	**27**	**13**	**23**
FL citrus/ Citrus	**0.74**	**2.5**	**0.53**	0.18	**534**	**>113**	**45.9**	**>94**	**78**	**14**	**6.7**	**12**
FL cucumber/ Cucurbit Vegetables	**0.65**	**2.1**	*0.46*	0.16	**469**	**>91**	**40.0**	**>81**	**68**	**11**	**5.8**	**10**
PA apple/ Pome Fruits	**1.4**	**3.7**	**0.97**	0.28	**987**	**>161**	**70.2**	**>143**	**143**	**20**	**10**	**18**
MS cotton/ Cotton	**1.8**	**5.7**	**1.3**	0.42	**1295**	**>251**	**109**	**>223**	**188**	**31**	**16**	**28**
MI cherries/ Stone Fruits	**1.6**	**5.9**	**1.1**	0.44	**1167**	**>257**	**112**	**>228**	**170**	**32**	**16**	**28**
GA pecan/ Tree Nuts	**1.1**	**3.1**	**0.78**	0.23	**790**	**>139**	**58.4**	**>119**	**115**	**17**	**8.5**	**15**
NC peanuts/ Peanuts	**1.3**	**3.1**	**0.95**	0.23	**964**	**>143**	**58.7**	**>120**	**140**	**18**	**8.5**	**15**
FL tomato/ Fruiting Vegetables	**0.67**	**2.3**	*0.47*	0.17	**482**	**>99**	**42.0**	**>85**	**70**	**12**	**6.1**	**11**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

7.2.3. Comparison of Risk Quotients Based on Monitored Concentrations

Another line of evidence is the monitoring of pyrethroids. Monitoring data from water and sediment in California and the rest of the U.S. corroborate the presence of synthetic pyrethroids in agricultrural environments. Even though it is apparent that the pyrethroids are present in agricultural waters, the vast majority of the water concentrations available are for whole (unfiltered) water, as opposed to filtered water. Whole water may contain suspended soil, sediment or particulate that could sorb pyrethroids, while the calculated EECs in the water column are freely dissolved pyrethroid concentrations.

Given that the sediment concentrations are organic carbon normalized, they appear to be more suitable for comparison with modeled EECs, and to calculate risk quotients. The following table shows the chronic risk quotients, based on monitored and modeled sediment concentrations (excluding the rice use).

Table 131. Summary of Risk Quotients for Pyrethroids for Freshwater and Estuarine/ Marine Invertebrates, Based on the Maximum Sediment Monitored Concentration in Agricultural Environments

Chemical	90th Percentile Sediment Monitored Conc.[1] (µg/kgOC)	Maximum Sediment Monitored Conc.[1] (µg/kgOC)	Maximum Sediment Modeled EEC[2] (µg/kgOC)	Chronic Risk Quotient (based on Max. Conc.)[3]			
				FW Inverts		E/M Inverts	
				Monitored	Modeled	Monitored	Modeled
Bifenthrin	300	8,800	30,850	**1408**	**4936**	**>65**	**>229**
Cyfluthrin	<RL	630	1,780	**29**	**81**	**19**	**52**
L-Cyhalothrin	<RL	35,000	15,175	**4516**	**1958**	**>583**	**>253**
Cypermethrin	<RL	75,000	4,380	**9740**	**569**	**2206**	**129**
Deltamethrin	<RL	130	3,175	**>10.8**	**>265**	NA	NA
Esfenvalerate	30	7,000	8,230	**40**	**47**	**8.4**	**9.9**
Fenpropathrin	<RL	11,000	63,010	**>35**	**>203**	**3.4**	**20**
Permethrin	780	47,000	85,325	**254**	**461**	**49**	**90**

NA = no available suitable chronic endpoint.

[1] Based on sediment samples from agricultural flowing water use sites, see **Table 43**.

[2] When the sediment EEC was expressed in µg/kg-dw, the OC normalized EEC was estimated by dividing by 0.04, which is the fraction of OC in the standard pond sediment.

[3] RQs presented are as follows: monitored based maximum sediment OC normalized concentration / sediment toxicity endpoint or maximum sediment modelled EEC / sediment toxicity endpoint. For bifenthrin, permethrin and *lambda*-cyhalothrin, the estimated endpoint was calculated by dividing ug/kg-dw by 0.04, which is the fraction of OC in the standard pond sediment.

It should be noted that the RQs in **Table 130** are derived for the maximum EEC and therefore are not exactly the same than the ones provided in the RQ tables (for which the chronic RQs are derived from 21-day values); however, they should be similar.

Comparison of RQs derived based on the maximum monitored concentration against the acute and chronic endpoints yields the following findings and are detailed in **Table 131**:

- All RQs based on monitoring, with the exception of *lambda*-cyhalothrin and cypermethrin, were less than the RQs based on modeling.
- All RQ values based on maximum monitored concentrations, without exceptions exceeded the chronic LOC (1.0). All the RQs based on maximum modeled concentrations, without exceptions, exceeded the chronic LOC.
- As established in **Table 65**, "[c]omparison of the modeled and the maximum monitored sediment concentration shows that for six out of eight of the chemicals, the monitored concentrations were below the modeled concentrations (for deltamethrin, by a factor of greater than 10). The exceptions were *lambda*-cyhalothrin (which was within a factor of 10) and cypermethrin (which was 17 times lower)." It is unclear why the *lambda*-cyhalothrin EECs is lower. For freshwater benthic organisms, the overall risk picture is the same for every pyrethroid, whith RQs exceeding the chronic LOC in all cases.

- No RQs could be derived for pyrethrins based on monitoring, since there is no readily available monitoring data for this chemical.

7.2.4. Foliar Dissipation Half-life

The modelling in this report was based on a foliar dissipation half-life of 35 days (35 days is the default for terrestrial modelling). Instead, for aquatic modelling, a value of 0 (zero) should be entered, which means no foliar dissipation. In order to investigate whether the model results were substantially different using a value of 0, EFED conducted additional modelling of two chemicals, and compared the modelling results. The chemicals were deltamethrin and esfenvalerate and results are summarized in **Tables 132 and 133**, respectively.

Water column and pore water EEC results using the two values of foliar dissipation were very similar. The maximum percent difference *in the peak EECs* was found to be 14%, for deltamethrin on FL sweet corn. A general trend was apparent, that the difference was greater the higher the number of applications. Given that the difference is not substantial, it appears that conducting a full set of runs, using 0 (zero) for foliar dissipation (meaning no foliar dissipation), would not change the overall risk picture of this assessment. Exceedances of LOCs for aquatic animals were generally observed, which is expected behaviour for pyrethroids.

Table 132. Water Column, Pore Water, and Sediment EECs for Deltamethrin, for Runs Using Foliar Dissipation $t_{1/2}$ = 35 days vs. No Foliar Dissipation[1,2]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
MS cotton/ Cotton ***Foliar dissipation = 35 days***	Aerial	0.0336 (0.03)	70	10	5	0.200* (0.434)	0.0128	0.00846	0.00707	0.00670	3175	3009
GA pecan/ Tree Nuts ***Foliar dissipation = 35 days***	Airblast	0.0370 (0.033)	110	5	7	0.108	0.00286	0.00223	0.00189	0.00193	849	867
FL sweet corn/ Sweet Corn ***Foliar dissipation = 35 days***	Aerial	0.0314 (0.028)	65	16	1	0.0840	0.00482	0.00319	0.00217	0.00208	974	934
MS cotton/ Cotton ***Foliar dissipation = 0***	Aerial	0.0336 (0.03)	70	10	5	0.200* (0.460) ***(5.7%)***	0.0138	0.00946	0.00753	0.00713	3381	3201
GA pecan/ Tree Nuts ***Foliar dissipation = 0***	Airblast	0.0370 (0.033)	110	5	7	0.111 ***(2.7%)***	0.00294	0.00232	0.00199	0.00203	894	911
FL sweet corn/ Sweet Corn ***Foliar dissipation = 0***	Aerial	0.0314 (0.028)	65	16	1	0.0977 ***(14.0%)***	0.00490	0.00348	0.00237	0.00230	1064	1033

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only. The percent difference is based upon the peak EECs from the model, instead of the limit of solubility.

[1] EECs were generally rounded to three significant figures.

[2] **Bolded** value in (parenthesis) and *italics* is the percent difference between the peak EECs.

Table 133. Water Column, Pore Water, and Sediment EECs for Esfenvalerate, for Runs Using Foliar Dissipation $t_{1/2}$ = 35 days vs. No Foliar Dissipation[1,2]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
NC cotton/ Cotton ***Foliar dissipation = 35 days***	Foliar, assume Aerial	0.0560 (0.05)	130	10	3	1.25	0.0439	0.0374	0.0327	0.0322	8230	8110
NY grapes/ Blueberries (*except CA*) ***Foliar dissipation = 35 days***	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.900	0.0427	0.0288	0.0237	0.0232	5970	5840
GA pecan/ Tree Nuts (based on rate on almonds) ***Foliar dissipation = 35 days***	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.899	0.0340	0.0269	0.0226	0.0230	5690	5790
NC cotton/ Cotton ***Foliar dissipation = 0***	Foliar, assume Aerial	0.0560 (0.05)	130	10	3	1.43 ***(12.5%)***	0.0501	0.0420	0.0355	0.0351	8940	8840
NY grapes/ Blueberries (*except CA*) ***Foliar dissipation = 0***	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.973 ***(7.5%)***	0.0453	0.0313	0.0256	0.0250	6440	6290
GA pecan/ Tree Nuts (based on rate on almonds) ***Foliar dissipation = 0***	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.899 ***(0%)***	0.0340	0.0269	0.0226	0.0230	5690	5790

[1] EECs were generally rounded to three significant figures.
[2] **Bolded** value in (parenthesis) and *italics* is the percent difference between the peak EECs.

7.2.5. Alternative K_{OC} Values, Use of $K_{OC\ SPME\ free}$

As part of the ongoing efforts by PWG to address certain uncertainties related to the environmental fate studies for pyrethroids, two non-guideline studies were submitted to the Agency that provided alternative K_{OC} values (MRIDs 49410301 and 49544001, supplemental). Three types of K_{OC} values were available from the studies: liquid-liquid extraction (LLE), solid phase micro-extraction (SPME free) and SPME total. LLE values are conventional batch equilibrium studies derived using liquid-liquid extractions. The water concentrations derived using this methodology are the total pyrethroid concentrations (*i.e.*, freely dissolved plus the amount of chemical associated with dissolved organic carbon or DOC). SPME free values are derived using solid phase micro-extractions, in which the obtained water concentration is the freely dissolved pyrethroid concentration. Finally, SPME total, in which the concentrations of the pyrethroid and its deuterated analog internal standard (pyrethroid-d_6) are compared and the ratio is proportional to the total pyrethroid concentration. The $K_{OC\ SPME\ total}$ is equivalent to the $K_{OC\ LLE}$. The K_{OC} values obtained varied across pyrethroids, but it was noted that they were higher than previously reported (*e.g.*, Laskowski 2002). No desorption was studied in this experiment and only a single concentration was evaluated.

The focus of this section is on the $K_{OC\ SPME\ free}$, which are the sorption coefficients derived for the freely dissolved pyrethroid concentrations, and two example chemicals were analysed: deltamethrin and esfenvalerate. For deltamethrin, the standard or previously reported mean K_{OC} is 449,000 mL/g_{OC}; meanwhile, the mean $K_{OC\ SPME\ free}$ (from two sediments tested), is 3,661,709 mL/g_{OC}. Therefore the $K_{OC\ SPME\ free}$ for deltamethrin is 816% higher than the standard K_{OC}. For esfenvalerate, the previously reported K_{OC} value is 251,717 mL/g_{OC}, and the $K_{OC\ SPME\ free}$ is 5,810,619 mL/g_{OC}. The $K_{OC\ SPME\ free}$ for esfenvalerate is 2,308% higher than the standard K_{OC}.

EFED conducted additional runs for selected scenarios for these two chemicals, using the $K_{OC\ SPME\ free}$ instead of the standard K_{OC}. Results are summarized in the following tables.

Table 134. Water Column, Pore Water, and Sediment EECs for Deltamethrin, for Runs Using Standard $K_{OC\ LLE}$ against $K_{OC\ SPME\ free}$[1,2,3]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
MS cotton/ Cotton ***Standard $K_{OC\ LLE}$***	Aerial	0.0336 (0.03)	70	10	5	0.200* (0.434)	0.0128	0.00846	0.00707	0.00670	3175	3009
GA pecan/ Tree Nuts ***Standard $K_{OC\ LLE}$***	Airblast	0.0370 (0.033)	110	5	7	0.108	0.00286	0.00223	0.00189	0.00193	849	867
FL sweet corn/ Sweet Corn ***Standard $K_{OC\ LLE}$***	Aerial	0.0314 (0.028)	65	16	1	0.0840	0.00482	0.00319	0.00217	0.00208	974	934
MS cotton/ Cotton ***$K_{OC\ SPME\ free}$***	Aerial	0.0336 (0.03)	70	10	5	0.0926	0.00329	0.00158	0.000873	0.000827	3197	3028
GA pecan/ Tree Nuts ***$K_{OC\ SPME\ free}$***	Airblast	0.0370 (0.033)	110	5	7	0.0229	0.00110	0.000353	0.000236	0.000242	864	886
FL sweet corn/ Sweet Corn ***$K_{OC\ SPME\ free}$***	Aerial	0.0314 (0.028)	65	16	1	0.0170	0.000958	0.000589	0.000264	0.000253	967	926

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were generally rounded to three significant figures.

[2] Standard $K_{OC\ LLE}$ = 449,000 mL/g$_{OC}$; $K_{OC\ SPME\ free}$ = 3,661,709 mL/g$_{OC}$.

Table 135. Water Column, Pore Water, and Sediment EECs for Esfenvalerate, for Runs Using Standard $K_{OC\ LLE}$ against $K_{OC\ SPME\ free}$[1,2]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate kg a.i./ha (lb a.i./A)**	**Date of First Application (days since emergence)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
NC cotton/ Cotton ***Standard $K_{OC\ LLE}$***	Foliar, assume Aerial	0.0560 (0.05)	130	10	3	1.25	0.0439	0.0374	0.0327	0.0322	8230	8110
NY grapes/ Blueberries (*except CA*) ***Standard $K_{OC\ LLE}$***	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.900	0.0427	0.0288	0.0237	0.0232	5970	5840
GA pecan/ Tree Nuts (based on rate on almonds) ***Standard $K_{OC\ LLE}$***	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.899	0.0340	0.0269	0.0226	0.0230	5690	5800
NC cotton/ Cotton ***$K_{OC\ SPME\ free}$***	Foliar, assume Aerial	0.0560 (0.05)	130	10	3	0.134	0.00192	0.00163	0.00143	0.00141	8310	8190
NY grapes/ Blueberries (*except CA*) ***$K_{OC\ SPME\ free}$***	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.0979	0.00187	0.00126	0.00104	0.00102	6040	5927
GA pecan/ Tree Nuts (based on rate on almonds) ***$K_{OC\ SPME\ free}$***	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.0983	0.00153	0.00123	0.00104	0.00105	6040	6100

[1] EECs were generally rounded to three significant figures.
[2] Standard $K_{OC\ LLE}$ = 251,717 mL/g_{OC}; $K_{OC\ SPME\ free}$ = 5,810,619 mL/g_{OC}.

Water column and pore water EEC results using the $K_{OC\ SPME\ free}$ were invariably much lower than using the standard K_{OC}. However, the sediment concentrations were similar using both the standard $K_{OC\ LLE}$ and $K_{OC\ SPME\ free}$, with minor differences. Based on a higher $K_{OC\ SPME\ free}$ value, the chemical is likely redistributed in the standard pond and more pyrethroid may move towards the sediment than to the water (*i.e.*, equilibrium is established based on the set K_{OC} value).

Tables 135 and 136 summarize the freshwater benthic invertebrates RQs, which in general, appear to be the most sensitive species to the pyrethroids. Furthermore, it appears that the $K_{OC\ SPME\ free}$ is more suitable to represent what occurs in sediments. The *acute* RQs are lower using the $K_{OC\ SPME\ free}$, due to the use of the same endpoint based on a water column acute test; however, the risk conclusions are the same. ***In order to obtain applicable chronic RQs, the pore water endpoints were recalculated, based on the sediment endpoint and the corresponding K_{OC} (standard LLE or SPME free).*** For example, the pore water chronic endpoint for deltamethrin for the runs using the standard LLE K_{OC} is 12 µg/kg$_{OC}$/449,000 L/kg$_{OC}$ = 0.000026 µg/L. Meanwhile, for the runs using the $K_{OC_SPME_free}$, the endpoint is 12 µg/kg$_{OC}$/3,661,709 L/kg$_{OC}$ = 3.19×10^{-6} µg/L. It turns out that ***the chronic RQs, calculated using the adjusted endpoints are similar using both K_{OC} values***.

Table 135. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Deltamethrin, Using an Alternative $K_{OC\ SPME\ free}$ value

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
MS cotton/ Cotton ***Standard $K_{OC\ LLE}$***	0.0336 (0.03)	Aerial	0.00707	0.00670	3175	3009	**35**	**>258**		**>251**
GA pecan/ Tree Nuts ***Standard $K_{OC\ LLE}$***	0.0370 (0.033)	Airblast	0.00189	0.00193	849	867	**9.5**	**>74**		**>72**
FL sweet corn/ Sweet Corn ***Standard $K_{OC\ LLE}$***	0.0314 (0.028)	Aerial	0.00217	0.00208	974	934	**11**	**>80**		**>78**
MS cotton/ Cotton ***$K_{OC\ SPME\ free}$***	0.0336 (0.03)	Aerial	0.000873	0.000827	3197	3028	**4.4**	**>259**		**>252**
GA pecan/ Tree Nuts ***$K_{OC\ SPME\ free}$***	0.0370 (0.033)	Airblast	0.000236	0.000242	864	886	**1.2**	**>76**		**>74**
FL sweet corn/ Sweet Corn ***$K_{OC\ SPME\ free}$***	0.0314 (0.028)	Aerial	0.000264	0.000253	967	926	**1.3**	**>79**		**>77**

Generally, EECs were rounded to three significant figures; for the RQs no more than two decimal places were used.

Standard $K_{OC\ LLE}$ = 449,000 mL/g$_{OC}$; $K_{OC\ SPME\ free}$ = 3,661,709 mL/g$_{OC}$.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Using ***standard LLE K_{OC}*** values, the acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000026 ppb [estimated for *Hyalella azteca* <0.000026 ppb]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg$_{OC}$ [for *Hyalella azteca* <12 µg/kg$_{OC}$].

Using ***$K_{OC\ SPME\ free}$***, the acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00000319 ppb = 3.19×10^{-6} ppb [estimated for *Hyalella azteca* <0.00000319 ppb]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg_{OC} [for *Hyalella azteca* <12 µg/kg_{OC}].

Table 136. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Esfenvalerate, Using an Alternative $K_{OC\ SPME\ free}$ value

Uses	App Rate kg a.i./ha (lb a.i./A)	App Method	Pore Water		Sediment		Pore Water		Sediment	
			Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg_{oc})	21-day EEC (µg/kg_{oc})	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
NC cotton/ Cotton ***Standard $K_{OC\ LLE}$***	0.0560 (0.05)	Foliar, assume Aerial	0.0327	0.0322	8230	8110	**38.6**	**46**		**46**
NY grapes/ Blueberries ***Standard $K_{OC\ LLE}$***	0.0560 (0.05)	Foliar, recommend Ground	0.0237	0.0232	5970	5840	**27.9**	**34**		**33**
GA pecan/ Tree Nuts ***Standard $K_{OC\ LLE}$***	0.112 (0.1)	Foliar, assumed airblast	0.0226	0.0230	5690	5800	**26.7**	**33**		**33**
NC cotton/ Cotton ***$K_{OC\ SPME\ free}$***	0.0560 (0.05)	Foliar, assume Aerial	0.00143	0.00141	8310	8190	**1.69**	**47**		**47**
NY grapes/ Blueberries ***$K_{OC\ SPME\ free}$***	0.0560 (0.05)	Foliar, recommend Ground	0.00104	0.00102	6040	5927	**1.23**	**34**		**34**
GA pecan/ Tree Nuts ***$K_{OC\ SPME\ free}$***	0.112 (0.1)	Foliar, assumed airblast	0.00104	0.00105	6040	6100	**1.23**	**35**		**35**

Generally, EECs were rounded to three significant figures; for the RQs no more than two decimal places were used.

Standard $K_{OC\ LLE}$ = 251,717 mL/g_{OC}; $K_{OC\ SPME\ free}$ = 5,810,619 mL/g_{OC}.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Using ***standard LLE K_{OC}*** values, the acute pore water RQ = use-specific pore water peak EEC / 0.000848 [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00070 ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 176 µg/kg_{OC} [for amphipod, *Hyalella azteca*].

Using ***$K_{OC\ SPME\ free}$***, the acute pore water RQ = use-specific pore water peak EEC / 0.000848 [water column test for the amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0000303 ppb = 3.03×10^{-5} ppb [for amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 176 µg/kg_{OC} [for amphipod, *Hyalella azteca*].

EFED believes that the issues raised in the Data Evaluation Record (DER) for the SPME studies are important and cannot be disregarded at this time. These issues constitute uncertainties in the study: the fact that the tested concentrations in the study using SPME were above the limit of solubility for four of the chemicals tested (although the equilibrium concentrations were below the limit), the testing involved sediments instead of soils (while usually four soils and one sediment are requested, the reader is reminded that the K_{OC} describes the partitioning of the chemical between the soil and water in PRZM and between

the sediment and water in the VVWM), and more importantly, that it is a good practice to test multiple concentrations to verify that the chemicals behave as expected in a given soil or sediment at the range of concentrations tested (*i.e.*, whether the K_{OC} is concentration independent). Furthermore, since the K_{OC}s derived from these studies were orders of magnitude higher than previously reported values, which were based on conventional batch equilibrium studies that used LLE, *it was very important to verify whether these higher K_{OC} values were applicable at an appropriate range of concentrations and a range of soils/ sediments*.

7.2.6. Use of K_d instead of K_{OC} in the PWC

Four of the chemicals in this assessment were modeled using the K_d instead of the K_{OC} as the representative input for the mobility of the compounds: permethrin, pyrethrins, bifenthrin and *lambda*-cyhalothrin. The reason is that, per the current input parameter guidance, one or the other is selected according to the coefficient of variation (CV) for each parameter. For an analysis of this issue, refer to **Section 7.2.5** of **Part II** of the PRA. Based on the example chemicals (bifenthrin and permethrin), it appears that the K_d model is more suitable for modelling these two pyrethroids than the K_{OC} model. However, to calculate the pore water concentrations associated with each endpoint in the sediment toxicity studies, the K_{OC} was used as it has been the use and practice in EFED and widely in the open literature.

7.2.7. EPA's Experimental PWC v.1.53, Calculated PRBEN

PWG has provided feedback and comments on the PRBEN function of the PWC, which represents the initial distribution of eroded phase pesticide between the sediment (benthic zone) and the water column. The PWG had argued that setting a value of 0.5 for all chemicals was not appropriate, especially for the pyrethroids, which have high K_{OC} values and are transported preferentially by soil erosion rather than by runoff. In such cases, the PWG reasoned that the pyrethroids would be quickly transported to the benthic zone in proportions greater than suggested by the default PRBEN value of 0.5 and acute water column concentrations should be lower. Following up on these PWG concerns, EFED issued an experimental version of the PWC (v1.53, dated 03/17/2016). This version of the model incorporates an alternative to the fixed PRBEN function. For this new version, during a runoff-erosion event, incoming pesticide (whether entering by runoff, erosion, or drift) equilibrates instantaneously with the water column which includes any eroded solids that may have entered during the event. After equilibrations calculations are performed, any pesticide that remains sorbed to the suspended solids is distributed to the benthic zone instantaneously and does not contribute to peak water column concentrations. Any pesticide that remains in the aqueous phase remains in the water column and does contribute to peak concentrations. This conceptualization is more in line with the equilibrium concept upon which the PWC components are built, is not overly mechanistic nor overly parameterized like sedimentation models, and was endorsed by the SAP in 2008.

EFED selected a number of scenarios for two chemicals (deltamethrin and esfenvalerate). The three scenarios that had previously yielded the highest EECs were run both ways (constant PRBEN = 0.5 and calculated PRBEN). Comparing the sediment and pore water EECs, they were the same for the default PRBEN *vs.* the alternative calculation of PRBEN for deltamethrin and esfenvalerate. However, the water column EECs were lower when using the calculated PRBEN in all instances.

Table 138. Comparison of Water Column, Pore Water, and Sediment EECs for Deltamethrin, for Runs Using PRBEN = 0.5 and the PWC against Variable/ Calculated PRBEN and the Experimental PWC v.1.53[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
MS cotton/ Cotton ***Constant PRBEN = 0.5***	Aerial	0.0336 (0.03)	70	10	5	0.200* (0.434)	0.0128	0.00846	0.00707	0.00670	3175	3009
GA pecan/ Tree Nuts ***Constant PRBEN = 0.5***	Airblast	0.0370 (0.033)	110	5	7	0.108	0.00286	0.00223	0.00189	0.00193	849	867
FL sweet corn/ Sweet Corn ***Constant PRBEN = 0.5***	Aerial	0.0314 (0.028)	65	16	1	0.0840	0.00482	0.00319	0.00217	0.00208	974	934
MS cotton/ Cotton ***Variable PRBEN***	Aerial	0.0336 (0.03)	70	10	5	0.0542	0.00719	0.00622	0.00708	0.00671	3179	3013
GA pecan/ Tree Nuts ***Variable PRBEN***	Airblast	0.0370 (0.033)	110	5	7	0.0293	0.00204	0.00181	0.00189	0.00193	849	867
FL sweet corn/ Sweet Corn ***Variable PRBEN***	Aerial	0.0314 (0.028)	65	16	1	0.0638	0.00485	0.00313	0.00217	0.00208	974	934

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1] EECs were rounded to three significant figures.

Table 139. Comparison of Water Column, Pore Water, and Sediment EECs for Esfenvalerate, for Runs Using PRBEN = 0.5 and the PWC against Variable/ Calculated PRBEN and the Experimental PWC v.1.53[1]

Scenario (bold font)/ Crops/Uses Represented	App Method	App Rate (lb a.i./A)	Date of First Application (dd-mm)	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
NC cotton/ Cotton ***Constant PRBEN = 0.5***	Foliar, assume Aerial	0.0560 (0.05)	130	10	3	1.25	0.0439	0.0374	0.0327	0.0322	8230	8110
NY grapes/ Blueberries (*except CA*) ***Constant PRBEN = 0.5***	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.900	0.0427	0.0288	0.0237	0.0232	5970	5840
GA pecan/ Tree Nuts (based on rate on almonds) ***Constant PRBEN = 0.5***	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.899	0.0340	0.0269	0.0226	0.0230	5690	5800
NC cotton/ Cotton ***Variable PRBEN***	Foliar, assume Aerial	0.0560 (0.05)	130	10	3	0.173	0.0333	0.0325	0.0327	0.0323	8230	8140
NY grapes/ Blueberries (*except CA*) ***Variable PRBEN***	Foliar, recommend Ground	0.0560 (0.05)	90	5	5	0.108	0.0237	0.0223	0.0238	0.0232	6000	5840
GA pecan/ Tree Nuts (based on rate on almonds) ***Variable PRBEN***	Foliar, assumed airblast	0.112 (0.1)	180	4	5	0.175	0.0245	0.0226	0.0227	0.0231	5720	5820

[1] EECs were rounded to three significant figures.

Consultation with the model developer (Dr. Dirk Young) provided additional insights: These results are reasonable. For the agricultural scenarios, the actual eroded material (*i.e.*, soil) appears to be high so that it radically affects the suspended solids concentration. In these instances, the actual effective (calculated) PRBEN may actually be higher than the standard default value of 0.5. Hence the concentrations are lower for those scenarios with high amounts of eroded material (*i.e.*, typical agricultural field). Additionally, spray drift is a contributor to the EEC values and inputs from spray drift occur independently of erosion events and thus will tend to temper differences in the results of the two PRBEN methods.

The PRBEN parameter has the greatest impact on water column acute (peak) EECs, while chronic and benthic EECs are impacted much less. The reason for this is that PRBEN controls the instantaneous distribution of incoming pesticide mass and the peak water column acute concentration~~s~~ based on the instantaneous amount of mass in the water column. Benthic acute (peak) EECs are less affected than acute (peak) water column EECs because benthic peak EEC is based on a daily average rather than instantaneous concentration. For high K_{OC} compounds, PRBEN has little impact on concentrations averaged over a day or longer; it only dramatically impacts short-term concentration like the instantaneous value. This is because equilibration is rapid for high K_{OC} compounds, and the longer-term equilibrium-oriented concentrations (*i.e.*, 1 day or longer) are the same regardless of how mass is initially distributed (as controlled by PRBEN).

Tables 140 and 141 summarize the freshwater invertebrates RQs, which are among the most sensitive species to the pyrethroids. The *acute* RQs are lower using the variable PRBEN; however, when calculating the RQs, it was found that the overall risk picture is the same. Similarly, for the *chronic* RQs, the overall risk picture does not change when comparing the RQs using constant PRBEN against the RQs using the variable PRBEN. It is acknowledged that the magnitude of the RQs is lower when using the variable PRBEN.

Table 140. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Deltamethrin, Using Constant PRBEN = 0.5 and Calculated PRBEN

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Inverts		E/M Inverts	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
MS cotton/ Cotton ***Constant PRBEN = 0.5***	0.200* (0.434)	0.0128	**1000**	**492**	**54**	**18**
GA pecan/ Tree Nuts ***Constant PRBEN = 0.5***	0.108	0.00286	**540**	**110**	**29**	**3.9**
FL sweet corn/ Sweet Corn ***Constant PRBEN = 0.5***	0.0840	0.00482	**420**	**185**	**23**	**6.6**
MS cotton/ Cotton ***Variable PRBEN***	0.0542	0.00719	**271**	**277**	**15**	**9.8**
GA pecan/ Tree Nuts ***Variable PRBEN***	0.0293	0.00204	**147**	**78**	**7.9**	**2.8**
FL sweet corn/ Sweet Corn ***Variable PRBEN***	0.0638	0.00485	**319**	**186**	**17**	**6.6**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0002 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for Amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0037 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00073 ppb [for Mysid shrimp, *Americamysis bahia*].

Table 141. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Esfenvalerate

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
NC cotton/ Cotton ***Constant PRBEN = 0.5***	1.25	0.0439	**1470**	**1420**	**268**	**258**
NY grapes/ Blueberries (*except CA*) ***Constant PRBEN = 0.5***	0.900	0.0427	**1060**	**1380**	**193**	**251**
GA pecan/ Tree Nuts (based on rate on almonds) ***Constant PRBEN = 0.5***	0.899	0.0340	**1060**	**1100**	**193**	**200**
NC cotton/ Cotton ***Variable PRBEN***	0.173	0.0333	**204**	**1080**	**37.1**	**196**
NY grapes/ Blueberries (*except CA*) ***Variable PRBEN***	0.108	0.0237	**127**	**767**	**23.2**	**139**
GA pecan/ Tree Nuts (based on rate on almonds) ***Variable PRBEN***	0.175	0.0245	**206**	**793**	**37.6**	**144**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.000848 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0000309 ppb [for the amphipod, *Hyalella azteca* acute data and ACR of 27 from mysid studies].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.00466 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00017 ppb [for Mysid shrimp, *Americamysis bahia*].

7.2.8. Co-Applied Synergists

Background

Synergists are often co-applied with pyrethrins and many of the pyrethroids; piperonyl butoxide (PBO) is the chief synergist for outdoor uses. The synergistic action is important because of the pyrethrins and pyrethroids mode of action (see **Section 3.1**). In short, natural pyrethrins quickly penetrate the neural system and induce temporary paralysis in target organisms, resulting in an effective "knockdown" action, but do not have high killing properties by themselves because they are quickly metabolized, being at best, moderately

persistent. To achieve lethality, the metabolic action is delayed (extended) by the co-application of a synergist that provides an alternative substrate for the mixed-function oxidase (MFO) enzyme system. Although, this toxicity enhancement applies most directly to the pyrethrins, it also applies to varying (and not yet well-defined) degrees to the synthetic pyrethroids (Wickham, 1998), which were developed in part to overcome the rapid breakdown.

Based on acute contact toxicity experiments for the house fly, Stewart (1998) demonstrated that the combined toxicity of pyrethrins and PBO displayed greater than additive effects (*i.e.,* true synergism) and that the toxicity enhancement (additive + synergistic effects) was variable and depended on the relative amounts of PBO and pyrethrins present in the mixture. So called "factors of synergism" which reflect synergistic effects beyond those predicted by additivity ranged from 1 to 6X, while factors for total toxicity enhancement (additivity + synergism) ranged from 1X to 18X, depending on the ratio of PBO to pyrethrins. Moreover, Stewart (1998) reported lower factors of synergism ($\leq$ 2X) for the more bioactive compound, bioresmethirin, compared to pyrethrins. Stewart hypothesized that the extent of synergism caused by the presence of PBO may be reduced for compounds that are more stable and "bioactive" compared to pyrethrins, which is considered less stable and subject to greater metabolic degradation *in vivo*.

PBO:Pyrethrins Synergism Studies

As a result of the need to better characterize the combined toxicity of PBO and pyrethroids, EPA requested data from the pyrethroid registrants on the combined toxicity of PBO and pyrethrins to the freshwater amphipod, *Hyalella azteca*, in addition to freshwater fish. The amphipod was selected due to its high sensitivity to pyrethroids while a freshwater fish species was selected to evaluate differences in toxicity enhancement between aquatic invertebrates and vertebrates. Results from the fish PBO/pyrethrins study were recently submitted and under review. Importantly, these studies were conducted at a range of PBO/pyrethrin concentrations within the same laboratory and using the same strain of organisms (MRID 49066504; Giddings *et al.*, 2016).

Results submitted for *H. azteca* indicate 96-h LC_{50} values of 0.76 µg a.i./L and 42 µg a.i./L, for pyrethrins and PBO, respectively. When exposed to various combinations of pyrethrins (~0.05 to 3 µg a.i./L) and PBO (~1 to 15 µg a.i./L), total toxicity enhancement (additive + synergistic effects) varied from 0.9X to 3.3X, with the higher toxicity enhancement factors occurring at higher concentrations of PBO relative to pyrethrins. The factors of synergism, however, were relatively constant across different PBO:pyrethrin ratios (0.9X for 2:1 and 3:1 PBO:pyrethrins ratios and 1.4X-1.7X for 7:1 to 52:1 PBO:pyrethrins ratios). These data suggest that the "true" synergism can be reasonably estimated for this species across PBO concentrations ranging from approximately 1-15 ppb and pyrethrins concentrations ranging from 0.05 to 3 ppb.

Application to Risk Assessment

In an attempt to estimate the toxicity enhancement to non-target aquatic invertebrates

resulting from combined exposure to PBO and pyrethroids, the aforementioned synergism results for *H. azteca* were considered in the context of two active ingredients: pyrethrins and deltamethrin. Pyrethrins was selected because the bulk of synergism data generated to date has focused on this active ingredient, and deltamethrin was selected because it is among the most toxic of the pyrethroids to *H. azteca*. Based on the PBO RED (USEPA 2005; D139408[3]), aquatic EECs range up to a maximum of 160 ppb. Since PBO is co-formulated or tank mixed with multiple pyrethroid active ingredients, it is reasonable to assume that PBO may co-occur at concentrations in the range of those tested with *H. azteca* (e.g., 1-15 ppb). As a screening analysis of the potential enhancement of toxicity due to the presence of PBO, the first step involved estimating the additive toxicity of PBO (assumed to be present at 15 ppb) and each of the two active ingredients (pyrethrins and deltamethrin) which are assumed to be present at their respective EECs[4].

(Eq. 1)

$$\frac{1}{Mixture\ LC_{50}} = \frac{P_{PYR}}{LC50_{PYR}} + \frac{P_{PBO}}{LC50_{PBO}}$$

where:

Mixture LC_{50} = LC_{50} of the combined mixture,
P_{PYR} = proportion of the mixture that is pyrethroid
P_{PBO} = proportion of the mixture that is PBO
$LC_{50\ PYR}$ = pyrethroid only LC_{50} and,
$LC_{50\ PBO}$ = PBO only LC_{50}.

To estimate the additivity-based LC_{50} of the pyrethroid component in the mixture, the LC_{50} for the mixture was multiplied by the proportion of mixture represented by the pyrethroid. Finally, this additivity-based LC_{50} was divided by a synergism factor of 1.7X based on data described previously and is then compared to the EEC to estimate the resulting RQ which considers both additive and synergistic effects. Results from this analysis are shown in **Table 142** (for pyrethrins) and **Table 143** (for deltamethrin) for the crop exposure scenarios associated with the maximum and minimum EEC.

[3] USEPA. 2005. (Piperonyl Butoxide: Environmental Risk Assessment, Revised September, 2005. D139408. Office of Pesticide Programs, Environmental Fate and Effects Division, Washington, DC

[4] Sun and Johnson, 1960. Analysis of joint action of insecticides against house flies. J. Econ. Entomol. 53:261-266.

Table 142. Estimation of acute risk to the freshwater amphipod (*Hyalella azteca*) resulting from combined exposure to pyrethrins and PBO

Use Scenario	Appl. Rate (# apps, interval) lb ai/A	Pyrethrins Only		Pyr + PBO (Additive)	Pyr + PBO (Additive + Synergistic)	
		Pore Water Acute EEC (ppb) [1]	Pore Water Acute RQ [1]	Expected Additive Pyr. LC_{50} (ppb) [2]	Pyr. LC_{50} (ppb) [3]	Acute RQ
NY grapes/ Blueberries (aerial)	0.050 (10 @ 3d)	0.563	**0.74**	0.513	0.30	**1.9**
FL citrus/ Citrus (airblast)	0.050 (10 @ 3d)	0.111	*0.15*	0.221	0.13	**0.9**

[1] From **Table 93** for freshwater benthic invertebrates (Acute RQ= acute EEC / Pyr. only LC_{50} of 76 ppb for *H. azteca*)

[2] Estimated using Equation 1 and assuming a mixture of the pyrethrins EEC + 15 ppb PBO (Pyr. LC_{50} =0.76 ppb and PBO LC_{50} = 42 ppb)

[3] Estimated by dividing the additivity-based LC_{50} by 1.7X (factor of synergism for PBO) determined for *H. azteca*

LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Table 143. Estimation of acute risk to the freshwater amphipod (*Hyalella azteca*) resulting from combined exposure to deltamethrin and PBO

Use Scenario	Appl. Rate (# apps, interval) lb ai/A	Deltamethrin Only		Delta. + PBO (Additive)	Delta. + PBO (Additive + Synergistic)	
		Pore Water Acute EEC (ppb) [1]	Pore Water Acute RQ [1]	Expected Additive Delta. LC_{50} (ppb) [2]	Delta. LC_{50} (ppb) [3]	Acute RQ
MS cotton/ Cotton (aerial)	0.030 (10 @ 5d)	0.007	**35**	0.00020	0.00012	**60**
ND wheat/ Sunflowers (aerial)	0.015 (3 @ 5d)	0.0003	**1.5**	0.00016	0.00010	**3.2**

[1] From **Table 92** for freshwater benthic invertebrates (Acute RQ = acute EEC / Delta. only LC_{50} of 0.0002 ppb for *H. azteca*)

[2] Estimated using Equation 1 and assuming a mixture of the Delta. EEC + 15 ppb PBO (Delta. LC_{50} =0.0002 ppb and PBO LC_{50} = 42 ppb)

[3] Estimated by dividing the additivity-based LC_{50} by 1.7X (factor of synergism for PBO) determined for *H. azteca*

LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For pyrethrins, the acute freshwater benthic invertebrate RQ is estimated to increase from **0.74 to 1.9** for the NY grapes/blueberry scenario and from **0.15 to 0.9** for the FL citrus scenario assuming the presence of 15 ppb PBO. The relative increase in acute RQ values is 2.5X and 6X for NY grapes/Blueberry and FL citrus scenarios, respectively. A smaller relative increase in the pyrethrins:PBO acute RQ is seen for the NY

grapes/Blueberry presumably because its EEC (0.563 ppb) is already approaching the acute LC_{50} of pyrethrins (0.76 ppb) which reduces the additive effect of PBO compared to the lower EEC for the FL citrus scenario. In other words, as the EEC for the pyrethroid component approaches (and exceeds) its LC_{50}, the additivity equation predicts lower additive effects of the other mixture component (PBO).

For deltamethrin, the acute freshwater benthic invertebrate RQ is estimated to increase from **35 to 60** for the MS cotton scenario and from **1.5 to 3.2** for the ND wheat/Sunflower scenario assuming the presence of 15 ppb PBO. This reflects a relative increase in the acute RQ values of 1.7 and 2.1X for the MS cotton and ND wheat/Sunflower scenarios, respectively. Again, since the deltamethrin EECs from these scenarios already exceed the acute LC_{50} of deltamethrin (0.0002 ppb), the predicted additive effect of PBO addition is minimal relative to the assumed synergistic effect (1.7X).

The previous analysis of the acute risk from combined pyrethroid/PBO exposure contains some limitations and uncertainties that should be understood. First, the co-occurrence of 15 ppb PBO and the pyrethroid EEC were *assumed to occur* rather than estimated via combined modeling of PBO and the pyrethroid. This assumption was made to provide an upper-bound estimate of the acute risk from the combined mixture of pyrethroid and PBO (*i.e.,* the highest possible RQ). A more precise estimate of the combined risk of PBO and pyrethroid would require each component to be modeled for 30 years and the relative amounts of each component estimated. However, since most of the acute RQ values for freshwater benthic invertebrates already exceed the acute risk LOC for individual pyrethroids, this refinement would not likely alter the overall acute risk conclusions relative to LOC exceedances. Another uncertainty is the extent of PBO synergism that would occur when the pyrethroid component of the mixture is already well above its acute LC_{50} value. It is questionable whether the 1.7X factor of synergism would still hold when the pyrethroid constituent is already present at concentrations many times its acute LC_{50} value (*e.g.,* acute RQ of 30 for deltamethrin). Furthermore, this analysis assumes that PBO and pyrethroids interact via additive toxicity, which typically assumes each component has a similar mode of action. At acutely lethal concentrations, PBO is expected to act via a different toxicity mechanism than pyrethroids. However, at sublethal concentrations, PBO is expected to reduce the metabolism of pyrethroids (*i.e.,* prolonging their internal concentrations) by reducing MFO activity. This interaction would appear to be more consistent with enhancing the activity of pyrethroids at their site(s) of toxic action in the organism rather than a completely separate mode of action. Therefore, this analysis is likely to be most applicable to situations when PBO is present substantially below its acute LC_{50}. Lastly, this analysis of synergism potential with PBO is limited to freshwater invertebrates (*H. azteca*) only. Although this is the taxonomic group considered most at risk from pyrethroid exposure, the applicability to other aquatic taxa (*e.g.,* fish) is not well understood, since data on fish PBO:pyrethroid synergism are currently under review by the Agency.

7.2.9. Uncertainties

Environmental Fate Database and Uncertainties

For the eight pyrethroids (plus pyrethrins), evaluated in this assessment, the environmental fate database was complete or nearly complete. For the environmental fate database and uncertainties for these chemicals, refer to **Section 7.2.8.1** of **Part II** of the PRA.

Exposure Issues

Meteorological data and scenario profiles, as well as best professional judgment, were used to establish an application date for modeling; however, the selected date may not represent the intended or actual application dates. The application date used for model runs can significantly alter the EECs; thus, EECs reported could over or under predict actual exposure. The applications used in this risk assessment were selected for the majority of the runs to be foliar. It is unclear how much each of the application dates differ from the typical timing of application, which is based on pest pressure.

According to the labels, all pyrethroids share a common mode of action, to which target pests can develop resistance if the chemicals are applied consecutively or repeatedly in the same field and/or in consecutive years with other chemicals belonging to the same group of insecticides. For that reason, it is recommended to avoid consecutive use of the pyrethroid insecticides and to base pyrethroid's use on a comprehensive Integrated Pest Management program. In this assessment, the minimum interval between applications, and the maximum application rate, were used for each crop use. It is uncertain whether this use pattern would be typical in the field. It appears unlikely that users will apply each chemical under these circumstances, and on a yearly basis for 30 consecutive years, as assumed in the modeling performed in this preliminary ecological risk assessment. The frequency at which actual uses approach this maximum use scenario may be dependent on pest resistance, timing of applications, cultural practices, and market forces.

Issues with unextracted radioactivity were identified in a number of the laboratory-based metabolism studies. Although these levels were not considered for all the pyrethroids, and to help clear this uncertainty, modeling of total toxic residues comprising parent plus unextracted radioactivity was performed for fenpropathrin.

In this assessment a large number of runs was performed to represent major uses of pyrethroids, and regions across the U.S. In order to accomplish this, the batch run function of the PWC was used. However, only the crop scenarios that yielded the highest EECs in high pyrethroids use areas were presented.

For the pyrethroids, the photolytic behavior depends on the specific chemical. For example, for cypermethrin, esfenvalerate and cyhalothrins, the half-lives range from 9-36 days, while for cyfluthrins, pyrethrins and fenpropathrin the aqueous photolysis half-lives are <1 day. For chemicals with short photolytic half-lives, the photolysis process is expected to occur only near the surface of the water body. Furthermore, it appears that only the portion of pyrethroid reaching surface waters via spray drift is subject to

photolysis. The reason is that these chemicals bind to sediments and the remaining portion reaching surface waters do so through runoff, but likely mostly through erosion. Eroded material does not appear to be subject to extensive aqueous photolysis in surface waters.

Use Information

For certain pyrethroids, such as permethrin, and for pyrethrins, EFED did not have Use Summary Tables (USTs) provided by the registrant(s). For permethrin, the latest LUIS report, issued by the Biological and Economic Analysis Division (BEAD) was used, plus the RED table. For the pyrethrins, the Table A from the RED, which summarizes all the uses of the chemical (agricultural and non-agricultural) was relied upon. Uncertainties may arise as a result of the use of these reports. The USTs are tables provided by the registrant that summarize the uses, maximum application rates, minimum interval between applications, and maximum number of applications that the registrant is willing to support. These tables were revised by BEAD prior to use by EFED.

Ecological Effects Database and Uncertainties

Although the aquatic toxicity dataset was fairly robust for this group of chemicals, some data gaps and uncertainties were present. For the ecological effects database and uncertainties for the pyrethroids and pyrethrins, refer to **Section 7.2.8.5** of **Part II** of the PRA.

Aquatic Modeling with the PWC

For the PWC aquatic modeling uncertainties, refer to **Section 7.2.8.6** of **Part II** of the PRA.

Aquatic Modeling with the PFAM

Based on the PFAM model White Paper, exposure of non-target aquatic organisms to pesticides applied to rice paddies may occur in the following sites (**Figure 6**):

1) The rice paddy;
2) Canals or waters adjacent to the rice paddy;
3) Waterbodies downstream from the canal.

Residues will occur in water whether the pesticide is applied to a dry or flooded field,

as after the field is flooded, residues may move from the soil into the water column.

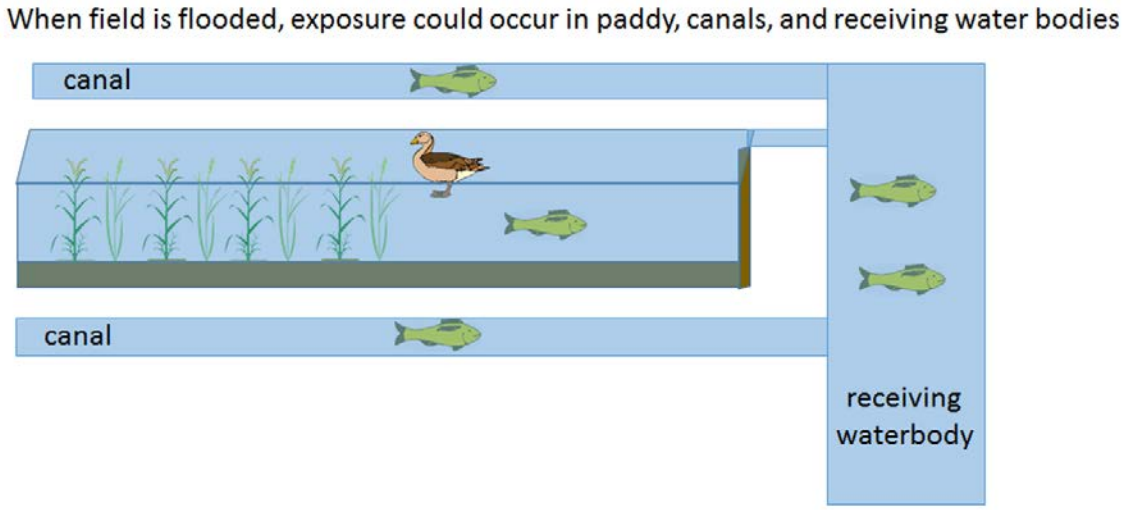


Figure 6. Areas where aquatic organisms may be exposed to pesticides applied in rice growing areas

Rice paddies and canals associated with rice paddies are promoted as an ecological resource and the water from rice paddies is an important source of water for nearby waters. In the Sacramento Valley, 57% percent of the managed wetlands and 40,000 acres of wetlands use tailwater from the Valley's rice fields (California Rice Commission, 2012). While fish are not as abundant as some of other taxa in the rice paddy, fish have been reported to occur in rice paddies and are abundant in canals and ditches next to rice paddies into which paddy water may be released (Eadie *et al.*, 2008; Pearlstine *et al.*, 2007). Therefore, the assumption that fish may occur in rice paddies is conservative. Fish serve as a surrogate for other aquatic vertebrates such as reptiles and amphibians, which are also documented to utilize rice fields. Crawfish are commonly cultivated in rice paddies in the southern United States (Eadie *et al.*, 2008) and aquatic invertebrates serve as an important food resource for other organisms that utilize rice paddies as a resource (Eadie *et al.*, 2008).

In assessing risk to aquatic animals (*i.e.*, fish, amphibians, invertebrates), exposure is evaluated in the rice paddy for organisms that may move onto the field by comparing toxicity endpoints to estimated exposure in the rice paddy. Exposure estimates are also characterized with concentrations in water that may be released after a specified holding period. These concentrations would represent exposures to organisms located in "receiving waters" (*i.e.*, those that are down stream of the rice paddy). The holding period is assumed to be one day if a holding period is not specified on the label. If a minimum water holding period is specified on the label, exposure is estimated in tailwater after that required minimum holding period. When water is held in the paddy, pesticide residues degrade according to pesticide-specific half-lives. In the ecological risk assessment for rice, a single paddy is simulated. Therefore, maximum application rates on the label are simulated.

As exposure is estimated in the rice paddy for ecological risk assessment, releases of

water after an application could reduce exposure in the paddy. It is uncertain to what extent residues in the water would be diluted after the water leaves the rice paddy as some canals that received water from the rice paddies may have little water in them or the water may be coming from releases from rice paddies upstream. It is expected that at least in some areas pesticide concentrations in canals and waters adjacent to the rice paddy are very similar to the pesticide concentrations in the rice paddy. Therefore, to follow the residues in the water and to provide a protective bound for risk to ecological organisms, water should be held on the rice paddy after the application and until harvest. Reports of humans using the canals right next to rice paddies for fishing are common and the canals are often promoted to be a resource for wildlife. It should also be noted that in some areas, water moves from one rice paddy to the next and there have been some cases where residues are applied in one paddy, the water is moved to another paddy, and more pesticide is applied resulting in residues in the water increasing as the water moves from rice paddy to rice paddy.

Uncertainties Regarding Dilution and Chemical Transformations in Estuaries

The uncertainties regarding dilution and chemical transformations in estuaries are described in **Section 7.2.8.7** of **Part II** of the PRA.

8. Conclusions

For the agricultural uses of pyrethroids, the risk hypothesis of this part of the PRA stated that (**Section 3.5.1**):

> *Pyrethroids and Pyrethrins, when used outdoors in agricultural environments in accordance with registered labels, will likely lead to off-site movement of the compound via agricultural runoff, spray drift, and eroded soil, leading to exposure of nontarget aquatic animals and plants. Based on information on the environmental fate, mode of action, direct toxicity and potential indirect effects, EFED assumes that registered uses of pyrethroids and pyrethrins have the potential to cause reduced survival, growth, and reproduction to non-target aquatic animals, but not to non-target aquatic plants.*

Based on first tier analysis, this assessment concludes that the agricultural use patterns of synthetic pyrethroids and pyrethrins result in multiple exceedances of acute and chronic LOCs for freshwater and estuarine/marine fish, and especially for freshwater and estuarine/marine invertebrates, resulting in a potential reduction in survival, growth and reproduction to non-target aquatic animals. In general, the RQs for aquatic plants were below the LOCs and are considered at less risk. Generally the freshwater aquatic invertebrate RQs were higher than the estuarine/marine invertebrates RQs (an example of an exception is cyfluthrin). For freshwater invertebrates in the water column, the acute/chronic maximum RQs were 74/115 for pyrethrins, 28/280 for bifenthrin, 1000/490 for deltamethrin, 160/30 for permethrin, 1060/1380 for esfenvalerate, 7090/>13400 for cypermethrin, 21/177 for cyfluthrin, 62500/1750 for *lambda*-cyhalothrin, and 1295/>251 for fenpropathrin. Organisms that depend on aquatic invertebrates for food may indirectly

be at risk as well. For the three chemicals with rice use, the RQs corresponding to that use was usually higher than for any of the other uses. For the pyrethrins, the LOC exceedances were generally fewer than for any of the other chemicals, perhaps with the exception of the rice use. As additional line of evidence, RQs were calculated based on the maximum monitored sediment concentrations, and they also exceeded the chronic LOCs, suggesting potential for effects.

As an additional line of evidence, a review of the OPP Incident Data System which now incorporates the Ecological Incident Information System (EIIS) database was conducted (**Attachment VI**). The IDS and EIIS databases contained 7 incidents for bifenthrin, 29 incidents for permethrin, 17 incidents for cypermethrin, 10 incidents for cyhalothrin (*lambda*- and *gamma*-), 11 incidents for esfenvalerate, 6 for cyfluthrin, 2 for deltamethrin, 2 for pyrethrins and only one for fenpropathrin (note that this is the total number of incidents, including those in agricultural and non-agricultural settings). The total for all pyrethroid actives searched was 84 aquatic incidents. Thirty-two of the reported incidents were determined to be from legally registered uses of the pesticides. The number of reports listed in the EIIS database is believed to be only a small fraction of the total incidents involving non-target organism mortality and damage caused by pesticides. These incidents appear to confirm the findings of the PRA.

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Appendix A. Risk Quotient Method

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of this integration is called the quotient method. Risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are used by OPP to analyze potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) acute risks - regulatory action may be warranted in addition to restricted use classification, (2) acute restricted use - the potential for acute risk is high, but may be mitigated through restricted use classification, (3) acute endangered species - endangered species may be adversely affected, and (4) chronic risk - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, or chronic risk from granular/bait formulations to birds or mammals.

The ecotoxicity test values (measurement endpoints) used in the acute and chronic risk quotients are derived from required studies. Examples of ecotoxicity values derived from short-term laboratory studies that assess acute effects are: (1) LC_{50} (fish and birds), (2) LD_{50} (birds and mammals), (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOAEL or LOAEC (birds, fish, and aquatic invertebrates) and (2) NOAEL or NOAEC (birds, fish and aquatic invertebrates). For birds, mammals, fish and aquatic invertebrates the NOAEL or NOAEC generally is used as the ecotoxicity test value in assessing chronic effects, although other values may be used when justified. Risk presumptions and the corresponding RQs and LOCs, are tabulated below.

Table A-1. Summary of the levels of concern used for the risk quotient method.

Risk Presumption	RQ	LOC
Birds and mammals		
Acute Risk	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.5
Acute Restricted Use	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50} (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.1
Chronic Risk	Diet or dose-based EEC/NOAEC	1
Aquatic Animals		
Acute Risk	EEC/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/NOAEC	1
Terrestrial and Semi-Aquatic Plants, and Aquatic Plants		
Acute Risk	EEC/EC_{25}	1
Acute Endangered Species	EEC/EC_{05} or NOAEC	1
Terrestrial Invertebrates		
Acute risk to bees	EEC/LD_{50}	0.4
Chronic risk to bees	EEC/NOAEC	1

Appendix B. Example Estimation of the Heat of Henry

Example estimation of Heat of Henry for *lambda*-cyhalothrin, using the HENRYWIN module of EPI Suite v.4.11

Heat of Henry = 6000 x 8.13 = 48780 J/mol

The following is the output file from HENRYWIN.

```
   Bond Est :  1.35E-005 atm-m3/mole  (1.37E+000 Pa-m3/mole)
       Group Est:  Incomplete

SMILES : FC(F)(F)C(CL)=CC1C(C)(C)C1C(=O)OC(C(#N))c2cc(Oc3ccccc3)ccc2
CHEM   : lambda-Cyhalothrin
MOL FOR: C23 H19 CL1 F3 N1 O3
MOL WT : 449.86
--------------------------- HENRYWIN v3.20 Results --------------------------

Experimental Database Structure Match:
  Name     :  CYHALOTHRIN
  CAS Num  :  068085-85-8
  Exp HLC  :  1.48E-06 atm-m3/mole  (0.15 Pa-m3/mole)
  Temper   :  20 deg C
  Exp Ref  :  VP/WSOL

Henry LC Temperature Variation:
  Source:  Estimated slope analogy
     HLC (atm-m3/mole) = exp(7.0432 - (6000/T)) {T in deg K}
  Temp (C)   atm-m3/mole    unitless     Pa-m3/mole
  --------   -----------    --------     ----------
      0       3.31E-007     1.48E-005     0.0335
      5       4.91E-007     2.15E-005     0.0497
     10       7.18E-007     3.09E-005     0.0728
     15       1.04E-006     4.39E-005     0.105
     20       1.48E-006     6.15E-005     0.15
     25       2.09E-006     8.53E-005     0.211
     30       2.91E-006     0.000117      0.295
     35       4.01E-006     0.000158      0.406
     40       5.47E-006     0.000213      0.554
     45       7.39E-006     0.000283      0.749
     50       9.89E-006     0.000373      1

----------+---------------------------------------------+---------+----------
   CLASS  |     BOND CONTRIBUTION DESCRIPTION           | COMMENT |  VALUE
----------+---------------------------------------------+---------+----------
 HYDROGEN |   9  Hydrogen to Carbon (aliphatic) Bonds   |         | -1.0771
 HYDROGEN |   1  Hydrogen to Carbon (olefinic) Bonds    |         | -0.1005
 HYDROGEN |   9  Hydrogen to Carbon (aromatic) Bonds    |         | -1.3886
 FRAGMENT |   5  C-C                                    |         |  0.5815
 FRAGMENT |   1  C-Car                                  |         |  0.1619
 FRAGMENT |   2  C-Cd                                   |         |  0.1269
 FRAGMENT |   1  C-CO                                   |         |  1.7057
 FRAGMENT |   1  C-O                                    |         |  1.0855
 FRAGMENT |   3  C-F                                    |         | -1.2553
 FRAGMENT |   1  C-CN                                   |         |  3.2624
```

```
 FRAGMENT |  12  Car-Car                                |         |  3.1657
 FRAGMENT |   1  Cd-CL                                  |         |  0.0426
 FRAGMENT |   1  CO-O                                   |         |  0.0714
 FRAGMENT |   2  Car-O                                  |         |  0.6945
 FRAGMENT |   1  Cd=Cd                                  |         |  0.0000
 FACTOR   |   1  -O-C-C#N   group                       |         | -3.8200
----------+---------------------------------------------+---------+----------
 RESULT   |    BOND ESTIMATION METHOD for LWAPC VALUE   |  TOTAL  |  3.257
----------+---------------------------------------------+---------+----------
HENRYs LAW CONSTANT at 25 deg C = 1.35E-005 atm-m3/mole
                                = 5.54E-004 unitless
                                = 1.37E+000 Pa-m3/mole

--------+---------------------------------------------+------------+--------
        |        GROUP CONTRIBUTION DESCRIPTION       |   COMMENT  |  VALUE
--------+---------------------------------------------+------------+--------
        |           1  CH (C)(C)(CO)                  |  ESTIMATE  |  0.13
        |           2  CH3 (X)                        |            | -1.24
        |           1  C (C)(C)(C)(C)                 |            |  0.71
        |           1  CdH (C)                        |            |  0.22
        |           9  Car-H (Car)(Car)               |            |  0.99
        |           1  Car (C)(Car)(Car)              |            |  0.70
        |           2  Car (Car)(Car)(O)              |            | -0.86
        |           1  CO (C)(O)                      |            |  4.09
        |           1  O (C)(CO)                      |            | -0.53
        |           1  O (Car)(Car)                   |  ESTIMATE  |  1.70
        |              MISSING Value for:  C (F)(F)(Cd)(F)
        |              MISSING Value for:  Cd (CL)(C)
        |              MISSING Value for:  CH (C)(C)(Cd)
        |              MISSING Value for:  CH (CN)(Car)(O)
--------+---------------------------------------------+------------+--------
 RESULT |  GROUP ESTIMATION METHOD for LOG GAMMA VALUE | INCOMPLETE |  5.91
--------+---------------------------------------------+------------+--------
```

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Preliminary Comparative Environmental Fate & Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins

Part IV. Assessing the Mosquito Adulticide Uses of Pyrethroids and Pyrethrins

Chemical Names	PC Code
Pyrethrins	069001
Permethrin	109701
Deltamethrin	097805

Date: September 30, 2016 **DP Barcode:** D433339

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Part IV. Assessing the Mosquito Adulticide Uses of Pyrethroids and Pyrethrins

1. Executive Summary

1.1. Purpose

The preliminary risk assessment (PRA) examines the potential ecological risks associated with labeled uses of a pesticide, based on the best available scientific and commercial information on the use, environmental fate and transport, and effects of the chemical on non-target organisms. The U.S. Environmental Protection Agency (U.S. EPA, USEPA, EPA, or the Agency) has developed a pyrethroid registration review risk assessment strategy that will assess the pyrethroids as a class with regard to ecological risks, rather than conducting assessments by individual chemical. The high toxicity of pyrethroids to aquatic animals and their potential chemical exposure in water are well established. As such, risks to aquatic animals are expected to be a dominant concern with currently registered uses of pyrethroids. Therefore, the assessment focuses on the risks to aquatic animals, although aquatic plants were included. The assessment also focuses on the pyrethroids for which the Pyrethroid Working Group (PWG), a consortium of registrants representing a number of pyrethroids, has conducted multiple studies and for which there is ample monitoring data. These include the synthetic pyrethroids bifenthrin, cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrin, and permethrin, with the addition of the pyrethrins. This document is **Part IV** of the comparative assessment and deals with assessing pyrethroid and pyrethrin wide area mosquito adulticide uses. Of the chemicals evaluated in this comparative PRA, only permethrin, deltamethrin, and the pyrethrins have this use pattern.[1]

1.2. Risk Conclusions

This comparative PRA examines the potential ecological risks associated with labeled uses of the insecticides deltamethrin, permethrin, and the pyrethrins, based on the best available scientific and commercial information on the use, environmental fate and transport, and ecological effects of these chemicals on non-target aquatic animals. This section of the PRA deals solely with the potential exposure from mosquito adulticide uses of the pyrethrins and pyrethroids, to freshwater and estuarine/marine bodies of water.

Environmental Fate and Transport

The pyrethrins and synthetic pyrethroids are highly hydrophobic compounds, showing relatively low to very low solubility in water (from 0.200 ppb for deltamethrin to 5.50 for

[1] Portions of this PRA are based on/ or are citations from Shamim, *et al.*, 2014.

permethrin, and 200-9000 ppb for pyrethrin 1 and pyrethrin 2, respectively). Their octanol/water partition coefficients (K_{OW}'s) for the pyrethroids are high (for solubility and K_{OW} values, see Laskowski, 2002). Based on these properties, there would be a potential to bioconcentrate in fish tissue. However, the fish bioconcentration factors (BCFs) for many of these compounds are lower than would be predicted based on K_{OW} alone, which would suggest they undergo metabolism in fish tissue and, with exceptions, relatively rapid depuration. The pyrethroids and pyrethrins have high organic carbon partition coefficients (K_{OC}s), suggesting a high tendency to sorb with organic carbon in soil, water and sediments and dissolved organic carbon, or particulate matter in the water environment. Pyrethroids are relatively persistent in the environment and slow to biodegrade and hydrolyze. The two pyrethroids involved in this assessment are generally more stable to sunlight than other synthetic pyrethroids, such as allethrin and resmethrin. They usually have other stable moieties attached to their backbone structure that cause them to persist longer. The major routes of dissipation of pyrethroids are generally metabolism in soil and water, and soil binding. Most pyrethroids are persistent to hydrolysis, aqueous and soil photolysis. Pyrethroids are usually more persistent in anaerobic than aerobic environments. It should be noted that *the pyrethrins are less persistent* in the environment than the eight synthetic pyrethroids involved in this PRA. For further discussion see **Section 5.2** (*Environmental Fate of Synthetic Pyrethroids and Pyrethrins*).

Mosquito adulticide applications are done by means of extremely small droplet sizes or Ultra-Low Volume (ULV) droplets, which are designed to kill mosquitoes in flight. These droplets remain in the air for longer periods of time than conventional droplets used in agricultural applications. For aerial adulticide applications, the modeling approach includes calculations using the AGricultural DISPpersal drift exposure model (AGDISP v.8.26). AGDISP provides a prediction of spray drift under circumstances where a mosquito adulticide is used. This computer program estimates the deposition of the pesticide to the treated area, which is the application efficiency (fraction of the material that deposits in the target area under the aircraft, which is expected to be lower than the default values for conventional agricultural applications). Further, by means of its toolbox "Deposition Assessment," the deposition to adjacent bodies of water (*i.e.* the standard pond) can be obtained (*i.e.*, the spray drift fraction). For ground applications, in the absence of a suitable model (since AGDISP has not been approved for ground applications), a review of literature information and other lines-of-evidence provided an upper bound deposition level.

EFED currently obtains estimated environmental exposure concentrations (EECs) for agricultural use patterns by modeling certain selected agricultural scenarios in the Pesticide in Water Calculator (PWC). For agricultural uses, exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models Pesticide Root Zone Model (PRZM) and Varying Volume Water Body Model (VVWM). A graphical user interface PWC v.1.52, developed by the EPA, was used to facilitate inputting chemical and use specific parameters into the appropriate input files and chemical files. The PWC estimates pesticide concentrations in water bodies that result from pesticide applications to land. EECs were determined using the standard pond scenario which describes a vulnerable surface water scenario for the VVWM component of the modeling exercise.

The USEPA considers the modeling approaches described above and resultant EECs as conservative ("high end") estimates of exposure that consider many factors that affect pesticide concentrations in aquatic systems (*e.g.*, application rates, timing, frequency, weather pattern, soil characteristics, chemical fate properties). However, as they are intended for use in national level assessment, they do not address all relevant factors which may be important in affecting pesticide concentrations on a site-specific basis. For further information about the models, refer to **Section 5.3**.

Ecological Effects

Synthetic pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} are <0.1 mg/L). Freshwater fish appear to be generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates appeared to be more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis (cyfluthrin is an example of an exception). On a chronic basis, there is no clear trend in the comparison of freshwater and estuarine/marine invertebrates. Aquatic invertebrates (freshwater and estuarine/marine) are usually orders of magnitude more sensitive to pyrethroids and pyrethrins than fish (freshwater and estuarine/marine). Benthic or sediment-dwelling invertebrates tend to be especially sensitive to pyrethrins and synthetic pyrethroids with freshwater species being generally more sensitive; however, bioavailability seems to vary widely with the type and amount of organic carbon present in natural sediments.

Risk Determinations

Risk determinations for the mosquito adulticide uses of pyrethroid and pyrethrins are summarized in **Table 1** to **Table 3**. In general, this assessment concludes that the use of pyrethrins, deltamethrin and permethrin, in accordance with registered labels, has the potential to result in exceedances of acute and/or chronic risk Levels of Concern (LOCs) for freshwater and estuarine/marine invertebrates, from the mosquito adulcide urban and agricultural uses of such chemicals. Additionally, it could result in a number of acute and/or chronic risk quotient LOC exceedances for freshwater and/or estuarine/marine fish for the chemicals analyzed. It was noted that the number of exceedances for the pyrethrins were fewer than for permethrin and deltamethrin, considering similar scenarios. For the pyrethrins and deltamethrin there were no non-listed species LOC exceedances for freshwater and estuarine/marine fish, with the exception of the applications of pyrethrins at the maximum rate and applications, stated in the label for difficult to control species (0.0025 lb a.i./A for wide area mosquito control; 0.008 lb a.i./A for difficult to control species).

For all these chemicals, the maximum application rate, number of applications and minimum interval between applications were modeled. For pyrethrins, the label does not

state a minimum interval, which could be 1 day; however, for multiple applications (*e.g.*, 25 applications), a 1-day interval was not considered appropriate, and 3 days were used. For permethrin and deltamethrin, 3 days is the minimum retreatment interval when the maximum rate is used.

The reader is directed to the risk characterization section for further details about risk estimation (*i.e.*, risk quotients) and risk description (**Sections 7.1** and **7.2**, respectively).

Table 1. Summary of Risk Determinations for Adulticide Uses of <u>Pyrethrins</u> for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA residential + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	*X*				*X*	**X**	*X*	**X**	*X*	**X**	*X*	
FL residential + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	*X*				*X*	**X**	*X*		*X*		*X*	
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	*X*		*X*	**X**	**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days					*X*		*X*		*X*			
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	*X*		*X*	**X**	**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days					*X*		*X*		*X*			
FL pepper Aerial, 0.008 lb a.i./A x 1 app	*X*				*X*				*X*			

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 2. Summary of Risk Determinations for Adulticide Uses of <u>Deltamethrin</u> for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA residential + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL residential + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	*X*				**X**	**X**	**X**	**X**	**X**		*X*	
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	*X*				**X**	**X**	**X**	**X**	**X**		*X*	
FL pepper Ground, 0.00134 lb a.i./A x 1 app	*X*				**X**	**X**	*X*	**X**	**X**			
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	*X*				**X**	**X**	**X**	**X**	**X**	**X**	*X*	**X**
FL residential + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	**X**		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1]A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

Table 3. Summary of Risk Determinations for Adulticide Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Scenarios	LOC Exceedances[1]											
	FW Fish		E/M Fish		FW Inverts		FW Benthic Inverts		E/M Inverts		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA residential + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	*X*	**X**	*X*	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL residential + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	*X*	**X**	*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
FL pepper Aerial, 0.007 lb a.i./A x 1 app	*X*		*X*		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] A light shaded and italics "*X*" means an exceedance of the acute listed species LOC (listed species LOC: acute = 0.05). A dark shaded and bolded "**X**" means an exceedance of the listed and non-listed species LOCs (non-listed species LOCs: acute = 0.5; chronic = 1.0).

1.3. Data Gaps and Uncertainties

For details about the uncertainties in this assessment, refer to **Section 7.2.5** in the Risk Description. In short, the uncertainties lie in the following major categories:

i. Uncertainties in the use information utilized in the assessment. In this assessment the *maximum number of applications* and the *minimum interval between applications*, according to the label were modeled for each use pattern and chemical. Additionally, a number of alternative scenarios were modelled, using higher interval between applications, or lower rates, plus single applications.
ii. Environmental fate database/data gaps and their uncertainties.
iii. Ecological effects data gaps and uncertainties.
iv. Uncertainties related to the Pesticide in Water Calculator model (PWC v.1.52) and other exposure assessment issues.
v. Uncertainties related to the drift modelling with AGricultural DISPersal model (AGDISP) and related exposure assessment issues.

vi. Uncertainties related to dilution and chemical transformations in estuarine/marine environments.

2. Introduction

This part of the PRA concentrates on the mosquito adulticide uses of pyrethroids. The combined adulticidal uses of pesticides can result in significant exposure to water bodies, especially through spray drift.

Mosquito control remains as an important issue in urban environments in the United States due to the need to limit mosquito-borne diseases, such as West Nile[2], Zika[3], dengue[4] and other viruses (affecting human health), or dog heartworm[5] (affecting pets). Wide area adult mosquito control is accomplished through a different pesticide method of application. In lieu of conventional ground or aerial applications using fine, medium or course droplets, according to American Society of Agricultural and Biological Engineers (ASABE) Standard S-572.1, mosquito adulticides are applied as ground or aerial mists, using extremely fine droplets, known as Ultra-Low Volume (ULV) droplets. Adulticide application rates are usually a very small fraction of the rate of coarser droplet applications used to control other insects in agriculture (*e.g.*, adulticides are applied in the ounces of product per acre range). Conventional pesticide applications are typically intended to hit the crop (*i.e.*, for foliar applications), while the ULV droplets are intended to remain airborne to hit adult mosquitoes in flight. A critical review of ULV technology, including efficacy, variables that affect space ULV applications, and some information on non-target impact, has been published (Bonds, 2012).

Examples of pesticides applied through ULV spray products are permethrin, prallethrin, *d*-phenothrin (commonly known as Sumithrin®), pyrethrins, etofenprox, malathion and naled. These chemicals are oftentimes co-formulated or co-applied with the synergist piperonyl butoxide (PBO) to enhance their activity. Given that many of these pesticides are considered very toxic to aquatic organisms, an approach to calculate aquatic estimated environmental exposure concentrations (EECs) is required. In this part of PRA, a description of how the USEPA assesses ecological exposure from adulticides is presented, using modeling and open literature data, for aerial and ground applications, respectively. The part will provide a synopsis of the use information and modeling, which includes discussions of aquatic and terrestrial exposure. For aerial applications, the AGricultural DISPpersal drift model (AGDISP v.8.26) is used for this purpose. For ground applications, a review of literature information and other lines-of-evidence provided an upper bound deposition level.

In **Part IV** of the OPP's comparative ecological risk assessment *"Preliminary*

[2] URL: http://www.cdc.gov/westnile/index.html (accessed July 13, 2016).
[3] URL: http://www.cdc.gov/zika/index.html (accessed July 13, 2016).
[4] URL: http://www.cdc.gov/dengue/ (accessed July 13, 2016).
[5] URL: http://www.mosquito.org/mosquito-borne-diseases (accessed July 13, 2016).

Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins", a summary of the currently available information regarding pyrethroid and pyrethrins pesticide releases due to adulticide applications in the U.S. and approaches considered for evaluating these exposure pathways is presented. Additionally, a summary of available monitoring data which have been generated specifically to characterize potential pyrethroid exposure due to adulticide uses in water/sediment is presented. Aquatic toxicological endpoints for the pyrethroids and pyrethrins assessed are provided and discussed (in first tier assessments, the most sensitive species is used). In the risk estimation section of the risk characterization, the risk quotient method is used to characterize the risk of pyrethroids reaching adjacent surface bodies of water. This is followed by the risk description, where data available about monitoring, and other lines-of-evidence are integrated with modeling results and resulting risk quotients are placed in proper context.

3. Problem Formulation

The Problem Formulation provides a strategic framework for the risk assessment. It sets the objectives for the risk assessment and provides a plan for analyzing the data and characterizing the risk (USEPA 1998). By identifying the important components of the risk assessment process, it focuses the assessment on the most relevant ecological receptors (species), chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA 2004).

3.1. Pesticide Class, Type and Mode of Action

Pyrethrins and synthetic pyrethroids are neurotoxic insecticides acting through direct contact and ingestion. The insecticidal effect of pyrethroids is characterized by a rapid "knock down," or paralysis, of insects. All pyrethroids act as axonic poisons, affecting both the peripheral and central nervous systems, and share similar modes of action. The primary biological effects of pyrethroids on insects and vertebrates reflect an inhibition of the correct firing of neurotransmitter delivery signals from one cell to another via nerve membrane inhibition of the voltage-gated Ca^{2+} (calcium ion) channels coupled with a stimulatory effect on the voltage-gated Na^{+} (sodium ion) channels. Type I pyrethroids do not have a cyano group substitution in the *alpha*-position of the alcohol moiety of the ester structure; in contrast, Type II pyrethroids have the *alpha*-cyano group. Permethrin is a Type I pyrethroid, while deltamethrin is a Type II pyrethroid. The pyrethrins are natural substances found in certain flowers. For additional discussion on pesticide class, type and mode of action, refer to **Section 3.1** of **Part I** of the PRA.

3.2. Conclusions from Previous Assessments

Ten of the pyrethrins, pyrethroids, and synergists were registered before November 1, 1984, and therefore were subject to reregistration. In 2008, EPA completed Reregistration Eligibility Decisions (REDs) for these 10 individual pesticides: among these substances, pyrethrins and permethrin were included. The remaining pyrethroids, registered later, were not subject to reregistration (*e.g.*, deltamethrin). Additionally, California Red Legged Frog (CRLF) and other threatened or endangered species in the San Francisco Bay (SFB) region endangered species assessments (ESAs), were issued for a number of pyrethroids, including permethrin and deltamethrin. More information about pyrethrins and individual pyrethroid assessments (including ESAs) can be found in the EPA Pesticide Chemical Search site (URL: https://iaspub.epa.gov/apex/pesticides/f?p=chemicalsearch:1).

Previous assessments for pyrethroids have generally concluded that they can be relatively persistent in the environment and slow to biodegrade and hydrolyze. The major routes of dissipation of pyrethroids are generally aerobic soil and aquatic metabolism, and soil binding, and for some of the pyrethroids, aqueous photolysis *in clear shallow* water. For pyrethroids, hydrolysis is pH dependent, and they are more prone to hydrolyze at higher pH values (*i.e.*, pH = 9). Pyrethroids generally are more persistent in anaerobic than aerobic environments. It should be noted that the pyrethrins are less persistent in most tested environments than the two synthetic pyrethroids involved in this Part IV of the PRA: permethrin and deltamethrin.

Pyrethroids are highly toxic to aquatic animals. Past assessments for permethrin and pyrethrins (during the RED process), were based on wind speeds of 10 mph, which tended to yield lower values of spray drift towards the standard pond. RQs approached or exceeded the levels of concern (LOCs) for aquatic animals, especially invertebrates. Current practice is to model the lowest wind speed consistent with the label and the model. Modelling lower wind speeds yield higher levels of spray drift and is, therefore, more conservative. Additionally, it is more realistic, since mosquito adulticide applications occur more often at dawn or dusk, when wind speeds are lower.

The application for a new product containing deltamethrin for use as a mosquito adulticide via ground methods is more recent (2014). In the assessment, in the aquatic environment, risks were not indicated for aquatic plants. However, marginal acute risks were indicated for freshwater and estuarine/marine fish in one of the eight application scenarios assessed, based on an acute risk quotient (RQ) of 0.06, which just exceeds the listed species LOC of 0.05. For aquatic invertebrates (benthic and pelagic), the potential for both acute and chronic risks was indicated for the majority of application scenarios modeled. Furthermore, the precise magnitude of chronic risks could not be quantified with precision because toxicity data reflect "non-definitive" values (*i.e.*, adverse effects were observed at all concentrations tested in both the freshwater and estuarine/marine studies and RQs were expressed as a greater than (>) value).

Because the pyrethroids can accumulate in sediments, risk to sediment-dwelling organisms is an area of particular concern. Previous risk assessments have been largely unable to adequately estimate risk to this group of organisms due to data gaps. Additionally, bioavailability has been difficult to ascertain due to strong influences from varied types and amounts of organic carbon in natural sediments.

Additionally, water quality, and sediment monitoring efforts in California and other states have identified pyrethroids in sediments of water bodies adjacent to agricultural and residential/urban areas. These monitoring data, coupled with additional pyrethroid-specific data submitted to EPA, highlight existing concerns regarding agricultural and residential uses of pyrethroid pesticide products and movement into non-target areas through runoff or spray drift that may occur during applications. However, monitoring of specifically adulticide applications is scarce.

To reduce exposure to water bodies from adulticide uses of pyrethroids, EPA deployed a number of labeling initiatives, as shown briefly in the next **Section 3.3**, and in **Section 5.1.1**.

3.3. Overview of Pesticide Uses

Adulticide spray methods use ultra-low volume (ULV) nozzles which suspend the product in the air for a longer duration, in order to intercept flying insects. In 2005, a Pesticide Registration (PR) Notice, titled "Labeling Statements on Products Used for Adult Mosquito Control", was issued (PR Notice 2005-1[6]). The PR Notice 2005-1 provided recommendations for label language for pesticides products for wide area ground or aerial adult mosquito control products, applied only through ULV spray or fog. The PR Notice 2005-1 included seven major recommendations. One of its main recommendations was related to the droplet size spectrum. Two droplet dimensions should be specified in the mosquito adulticide ULV labels: one is the $D_{v0.5}$ (the volume median diameter: half of the volume of spray contains droplets which are smaller than the stated value), and the other is the $D_{v0.9}$ (90% of the spray is contained in droplets smaller than this value), both expressed in microns. For additional information and details about use and usage of pyrethroids, refer to **Section 5.1.1**.

3.4. Conceptual Model

For a pesticide to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a pesticide moves in the environment from a source to an ecological receptor. For an ecological pathway to be complete, it must have a source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a plausible route of exposure. The conceptual model is intended to provide a written description and visual representation of predicted relationships between pyrethroids or pyrethrins, potential routes of exposure, and the effects related to the Agency assessment endpoints. The conceptual model consists of two major components: the risk hypotheses and a conceptual diagram (USEPA 1998).

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[6] URL: https://www.epa.gov/pesticide-registration/prn-2005-1-labeling-statements-products-used-adult-mosquito-control (accessed July 12, 2016).

3.4.1. Risk Hypothesis

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA 1998). For this assessment, the risk is stressor-initiated, where the stressor is the release of pyrethrins and pyrethroids into the environment. The following risk hypothesis is presumed for this assessment:

Pyrethroids and Pyrethrins, when used outdoors in agricultural and non-agricultural environments in accordance with registered labels, and applied via ULV sprays, will likely lead to off-site movement of the compound via spray drift, runoff and eroded soil, leading to exposure of nontarget aquatic animals and plants. Based on information on the environmental fate, mode of action, direct toxicity and potential indirect effects, EFED assumes that registered uses of pyrethroids and pyrethrins as adulticides have the potential to cause reduced survival, growth, and reproduction to non-target aquatic animals, but not to non-target aquatic plants.

This risk assessment will evaluate the aforementioned risk hypothesis and determine if it is supported by the risk conclusions.

3.4.2. Conceptual Diagram

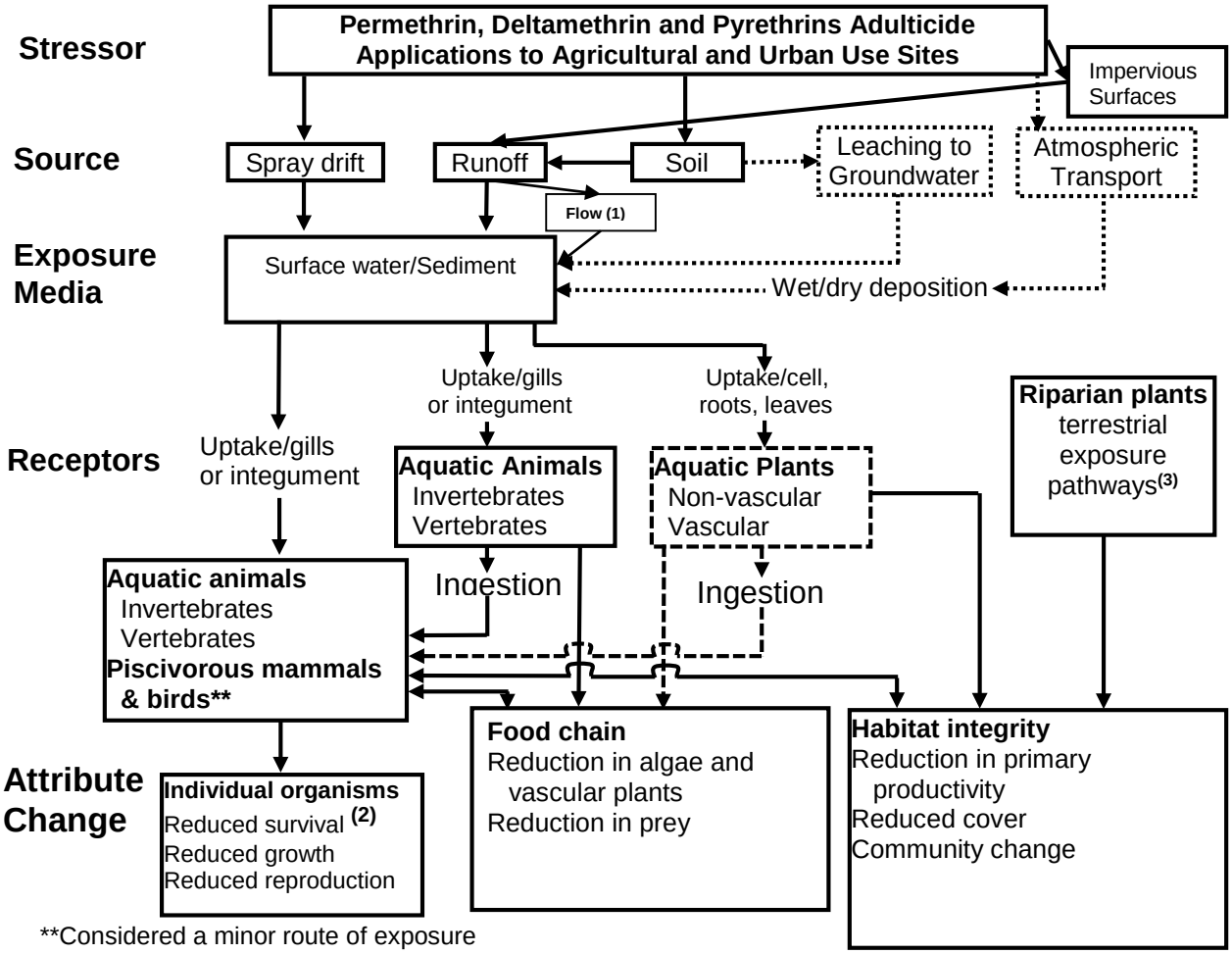
The conceptual model for potential risks of adulticide uses of pyrethroids and pyrethrins to aquatic organisms for various outdoor urban uses of the chemical that could potentially end up in adjacent bodies of water is depicted in **Figure 1**.

Under the possible adulticide uses of pyrethroids and pyrethrins, the sources and mechanisms of release of the compounds are from ground and aerial applications. Note that this conceptual model considers only certain non-agricultural and agricultural adulticidal applications. Spray drift results in contaminated adjacent areas, including bodies of water. Surface runoff from the areas of application is assumed to depend on factors such as topography, irrigation, and rainfall events. Leaching to groundwater is not considered an important source because the pyrethroids and pyrethrins show low mobility in a variety of soils due to high binding (sorption). Generally, these chemicals appear to have a low potential for volatilization, with a low vapor pressure and Henry's Law Constants. Further, the hydroxyl radical reaction half-life is relatively short for most chemicals, as estimated by quantitative structure-activity relationship (QSAR) methods (*i.e.*, EPI Suite). The short (atmospheric) half-life, the low vapor pressure and relatively low Henry's Law Constants, and their binding capacity, suggest that the potential for atmospheric transport for pyrethroids and pyrethrins is low and that this source of the chemical is of low importance, compared to spray drift and/or runoff after application.

For aquatic receptors, the major point of exposure is through direct contact with the water column, sediment, and pore water (gill/integument) contaminated with spray drift (from spray application) and/or runoff from treated areas. Indirect effects to aquatic organisms (both fish and aquatic invertebrates) can also occur through impact to various

food chains for some of the chemicals. The representative aquatic receptors are certain freshwater and estuarine/marine fish, invertebrates, and aquatic plants. It should be noted, that these species do not cover all the possible species in the animal and plant kingdoms; certain taxa are considered as surrogates for other taxa. For example, freshwater fish are considered surrogates for aquatic phase amphibians.

Pyrethroids and pyrethrins show low solubilities, high K_{OW}'s and high sorption coefficients. These properties suggest that the chemicals partition with the sediments and particulate suspended in bodies of water. Pyrethroids and pyrethrins are likely to concentrate in the sediments, especially after repeated exposures (applications), where they could persist. Such sediments could serve as repositories of the chemical for extended periods of time and could potentially be toxic to sediment dwelling organisms, affecting the food chain. Also, they could serve as sources of pyrethroids in the water column due to desorption. Aquatic plants show much lower sensitivity to pyrethroids and pyrethrins than aquatic animals; it appears that the pyrethroids and pyrethrins risk to non-target plants is low.



Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

[1] Includes flow across vegetation and vegetated drainage systems (*e.g.*, swales) and flow across impervious surfaces and through impervious (piped) storm drains.

[2] Immobilization is considered equivalent to mortality in toxicity tests for aquatic invertebrates.
[3] Riparian plants are not dealt with in this part of the PRA.

Figure 1. Conceptual diagram for potential risks of pyrethroids and pyrethrins to aquatic organisms for various outdoor uses of the chemicals that could potentially end up in surface water or sediment due to ULV sprays

4. Analysis Plan

The primary method used to assess risk in this assessment is the risk quotient (RQ) and follows closely methods outlined in the EPA Overview Document (USEPA, 2004). The RQ is the risk value for the assessment and is the result of comparing measures of exposure to measures of effect. Risk presumptions, along with the corresponding RQs, equations, and LOCs are summarized in **Section 7** and **Appendix A** of this assessment.

4.1. Measures of Exposure

In order to estimate risks of pyrethrins and pyrethroids exposures in aquatic environments, all exposure modeling and resulting risk conclusions are made based on maximum application rates for the current use patterns, maximum number of applications, and minimum retreatment interval. Available monitoring data are also considered when describing potential environmental exposure to non-target organisms. Measures of exposure are based on aquatic models, such as the Pesticides in Water Calculator (PWC), that predicts estimated environmental exposure concentrations of pyrethrins and pyrethroids using maximum labeled application rates and methods, as well as any mitigation measures specifically indicated on the label.

The modeling approach for the aerial adulticide use includes calculations of spray drift using the exposure model AGDISP. This software estimates the deposition of the pesticide to the treated area, which is the application efficiency and the value of spray drift.

More information on pesticide exposure models can be found at http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment (accessed June 29, 2016), and in **Section 5.3**.

4.2. Measures of Effects

Measures of ecological effects are obtained from a suite of registrant-submitted guideline studies conducted with a limited number of surrogate species. The test species are not intended to be representative of the most sensitive species but rather were selected based on their ability to thrive under laboratory conditions. Measures of effect are based on deleterious changes in an organism as a result of chemical exposure. Functionally, measures of effect typically used in risk assessments include changes in survival,

reproduction, or growth as determined from standard laboratory toxicity tests. The focus on these effects for quantitative risk assessment is due to their clear relationship to higher-order ecological systems such as populations, communities, and ecosystems, and especially their ability to be readily reduced to population sustainability. The measures of effect for the adulticide uses of pyrethroids and pyrethrins are similar to the ones for the non-agricultural uses and they are described in **Section 4.2** of **Part II** of the PRA.

5. Exposure Assessment

5.1. Use and Usage Information

Adulticide Uses and Considerations

Of the eight pyrethroids and pyrethrins involved in this comparative PRA, only permethrin, deltamethrin and the pyrethrins have mosquito adulticide uses. All three chemicals can be used in urban and agricultural environments via ULV for vector control.

In 2005 the Agency determined that the existing spray drift language for pyrethroid adulticide (vector control) products needed to be updated and issued PR Notice 2005-1. It included seven major recommendations. Among the recommendations, adult mosquito control applications should be limited to trained personnel and users should consult their State and Tribal agency to determine if permits or regulatory requirements exist. Additionally, adulticide applications should be clearly distinguished from conventional applications of insecticides in the label directions. The "Environmental Hazards" section of the labels should be clear and direct applications over bodies of water should be allowed only under certain circumstances. Also, bee precautionary language should allow adulticide applications in order to respond to threats to public health that might be identified. As of October 15, 2005, registrants were expected to submit label amendments reflecting recommended label language; however, it appears that some labels have been brought into compliance after this date. This language also provided more consistent instructions across different products relative to the quality of spray droplet, application rate, seasonal or annual rate, *etc*. Adulticide application parameters are also highly dependent on actual weather conditions, such as wind speed and direction. PR Notice 2005-1 addresses such issues as well. The labels for mosquito adulticides now include restrictions surrounding the size of the droplets from the applications. According to the recommendation, two droplet dimensions should be specified: one is the $D_{v0.5}$ (the volume median diameter or VMD: half of the volume of spray contains droplets which are smaller than the stated value), and the other is the $D_{v0.9}$ (90% of the spray is contained in droplets smaller than this value), both expressed in microns (µ or µm; *e.g.*, for permethrin, $D_{v0.5}$ <60 µm and $D_{v0.9}$ <100 µm, for aerial applications with a boom height of 75-200 ft). Furthermore, labels now indicate the frequency and timing of applications, and the maximum annual application rate. This information is useful and allows the assessor to determine which conditions should be assessed for risk of aquatic (and terrestrial) exposure. Moreover, the altitude of aerial applications is oftentimes also specified (*e.g.*, ≥75 ft for rotary aircraft and ≥100 ft for fixed wing aircraft).

Permethrin

The sample label selected for modeling permethrin was BIOMIST® 4+4 ULV (EPA Reg. No. 8329-35). It contains 4.00% permethrin and 4.00% piperonyl butoxide (PBO, a synergist for pyrethroids, see more on PBO in the risk characterization section of this part of the PRA). Only aerial applications were modeled because it appears that they bring more exposure. The maximum application rate is 0.007 lb a.i./A/application and 0.18 lb a.i./A/year (equivalent to 26 applications per year at the maximum rate). The range of aerial application rates is 0.0035 to 0.007 lb a.i./A/application. BIOMIST® 4+4 ULV is a ready to use adulticide; the flow rate for an application rate of 0.007 lb a.i./A is 3.1 fl oz product/acre. According to the label, for the aerial applications at a boom height of ≤200 ft, the spray equipment must be adjusted so that the $D_{v0.5}$ < 60 µm and $D_{v0.9}$ < 100 µm. If the boom height is > 200 ft, then the $D_{v0.5}$ < 70 µm and $D_{v0.9}$ < 145 µm. For modeling, a boom height of 100 ft was selected, which is the lowest value allowed, for fixed wing aerial applications. The wind speed is specified at greater than 1 mph. A temperature inversion and a light breeze are preferred. Furthermore, air temperatures should be greater than 50°F when conducting all types of applications. The temperature and relative humidity were selected to simulate those conditions where mosquitoes are more likely to grow (85°F and 90% relative humidity). The lowest wind speed possible in the model was selected. The spray material was "oil" and its relative density is 7.28 lb/gal (equivalent to a specific gravity is 0.872 g/cm^3; information that was obtained from the safety data sheet [SDS] for the product, which in turn was obtained from the registrant's website[7]). The spray volume was 0.0242 gal/A (obtained from the label (equivalent to 3.1 oz/A). This product may be applied "in residential and recreational areas and other areas these insects occur, such as but not limited to parks, campsites, woodlands, athletic fields, golf courses, residential areas and municipalities, gardens, playgrounds, and overgrown waste areas." Additionally, it can be applied on a number of crops listed in the label.

Pyrethrins

The sample pyrethrins label used in this assessment is the one for Pyrenone® 25-5 M.A.G.C. (EPA Reg. No. 432-1050). This product contains 5.0% pyrethrins and 25.0% piperonyl butoxide (PBO), and 70.0% other ingredients. The single maximum application rate is 0.008 lb a.i./A (for difficult to control species, such as *Aedes taeirorhynchus*); however, for wide area mosquito control, the recommended application rate is 0.0025 lb a.i./A (both rates were included in this assessment). The maximum yearly application rate (for the active ingredient pyrethrins, and excluding PBO), is 0.2 lb a.i./A/year, which means a maximum of 25 applications at 0.008 lb a.i/A/application, or 80 applications at 0.0025 lb a.i./A/application, are allowed. According to the Material Safety Data Sheet (MSDS), Pyrenone® 25-5 M.A.G.C.'s specific gravity is equivalent to 0.881 g/cm^3 (or 7.36 lb/gal). At the maximum application rate of 0.008 lb a.i./A, the spray volume can be calculated from the label. The product contains 0.367 lb pyrethrins/gal; therefore, the spray volume

[7] URL: https://www.clarke.com/biomist (the SDS is dated June 1, 2015 and the URL was accessed July 15, 2016).

is equal to:

(0.008 lb pyrethrins/A) / (0.367 lb pyrethrins/gal) = 0.0218 gal product/A

According to the label, the product can be applied undiluted or diluted with oil. The minimum boom height is 75 ft for rotary aircraft and 100 ft for fixed wing aircraft, like for permethrin. An inversion of air temperature and a light breeze are also preferred. The ground wind speed should be ≥1 mph and the temperature >50°F. The specified droplet sizes are as follows: for ground applications, the $D_{v0.5}$ < 30 µm and $D_{v0.9}$ < 50 µm; for aerial applications, the $D_{v0.5}$ < 60 µm and $D_{v0.9}$ < 80 µm. Per the label, typical use sites for this product include, "industrial areas, urban areas, parks, campsites, woodlands, athletic fields, golf courses, playgrounds, recreational and overgrown waste areas, roadsides, and other public areas where adult mosquitoes and flies occur." The pyrethrins can also be applied over all crops for mosquito control.

Deltamethrin

Deltamethrin is used for mosquito control in the product BES0668 Insecticide (EPA Reg. No. 432-1534, alternate name DeltaGard Insecticide). As opposed to the products containing permethrin and pyrethrins, the formulation is a *water-based* liquid, containing 2.0% deltamethrin and 98.0% other ingredients, or 0.17 lb a.i./gallon. It contains *no piperonyl butoxide* (PBO). The product may be applied either diluted (in water) or undiluted. The maximum application rate is 0.00134 lb a.i./A during any 3-day period and a maximum of 25 applications are allowed per year in non-crop sites and 10 applications per year on crops. The maximum annual rates are 0.036 lb a.i./A/year and 0.0134 lb a.i./A per year, for non-crop and crop use sites, respectively. *Only ground applications are currently allowed in the label.* Note that more than 25 applications *may be* made "to prevent or control a threat to public and/or animal health determined by a state, tribal or local health or vector control agency on the basis of documented evidence of disease causing agents in vector mosquitoes or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort." The density of the product is 1.02 g/cm^3 (8.50 lb/gal) (MRID 49114108).

BES0668 Insecticide (or DeltaGard Insecticide) is used to control flying or resting adult mosquitoes in residential, industrial, urban, recreational, and municipal areas. According to the label, the product is used for control of mosquitoes in areas such as residential areas, industrial areas, urban areas (such as utility tunnels, sewers, storm drains and catch basins, pipe chases, basements, underground passages, parking decks, crawl spaces, or uninhabited buildings), parks, campsites, woodlands, athletic fields, golf courses, playgrounds, recreational and overgrown waste areas, roadsides, swamps. marshes, tidal areas, corrals, feed lots, swine lots, poultry ranges, zoos, animal quarters, barns, orchards, dumps, junkyards, tire dumps, and other areas where adult mosquitoes may be found. Furthermore, the product may be applied over any and all crops or agricultural areas, including pastures for the control of adult mosquitoes within or adjacent to the treatment areas. DeltaGard can be applied over any and all crops, but the maximum number of applications at the

maximum rate is smaller than for the urban use applications.

For *ground* ULV applications, the label specifies droplet sizes as follows: 8 µm ≤ $D_{v0.5}$ ≤ 30 µm), and $D_{v0.9}$ < 50 µm. The product has a proprietary FFAST™ formulation (*i.e.*, Film Forming Aqueous Spray Technology). According to the label, it "greatly reduces the evaporation rate of water from the sprayed droplets and allows the water-based spray cloud to behave as that produced by a typical oil-based formulation. This enables the spray droplets to maintain optimum size and stability while drifting through the target area."

5.2. Environmental Fate of Synthetic Pyrethroids and Pyrethrins

A brief discussion about some environmental fate properties of the pyrethroids was provided in the **Section 1.2** (of the *Risk Conclusions*). A comprehensive review about the physicochemical and environmental fate properties of several pyrethroids was published in 2002 (Laskowski, 2002). Since then, during the Registration Review process, new environmental fate studies were requested and submitted to the Agency. See the **Attachment I** for the nomenclature (*e.g.*, common names, chemical names), CAS numbers, as well as structures of the pyrethroids and pyrethrins; refer to the **Attachment III** for detailed environmental fate assessments for individual synthetic pyrethroids and pyrethrins. **Section 5.2** of **Part II** of the "*Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins*" contain a summary of environmental fate properties for these compounds. Refer to those sections for additional detals. For specific environmental fate properties and values of each of the pyrethroids and pyrethrins used to calculate EECs in this part of the PRA, refer to the tables in the **Section 5.3.1** (*Description of Model Inputs*).

5.3. Modeling Approach

As indicated earlier, the modeling approach for the aerial adulticide use includes calculations of spray drift using the exposure model AGDISP. This computer program estimates the deposition of the pesticide to the treated area, which is the application efficiency. Further, by means of its toolbox "Deposition Assessment," the deposition to adjacent bodies of water (*i.e.* the standard pond) can be obtained (*i.e.*, spray drift fraction). AGDISP provides a prediction of spray drift under circumstances where a mosquito adulticide is used. Besides the $D_{v0.5}$, $D_{v0.9}$, and boom height, other parameters of importance in modeling in AGDISP include the spray volume (expressed in gallons per acre), wind speed range (miles per hour), wind direction, spray material (*e.g.*, oil or water based), and specific gravity. The spray volume, material, and specific gravity, are specified or can be estimated from the label or the safety data sheet (SDS) for the product, or from product chemistry submissions. To model aerial applications, the lowest boom height allowed in the label is selected, which is expected to result in the highest deposition and drift. The model output of AGDISP includes the spray drift fraction (obtained from the "Deposition Assessment" tool of the model's Toolbox tab), and application efficiency (fraction of the material that deposits in the target area under the aircraft, which is expected

to be much lower than the default values for typical agricultural applications). In order to obtain aquatic EECs, these values are utilized as input parameters in the aquatic model PWC (see next paragraph).

EFED currently obtains estimated exposure concentrations (EECs) for uses on agricultural and non-agricultural areas by modeling PRZM scenarios in the Pesticide in Water Calculator (PWC v.1.52). For agricultural uses, exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models Pesticide Root Zone Model (PRZM v.5.02, February 23, 2016) and Varying Volume Water Body Model (VVWM v.1.02, February 23, 2016). A graphical user interface PWC v.1.52 (February 23, 2016), developed by the EPA, was used to facilitate inputting chemical and use specific parameters into the appropriate input files and chemical files.

Additional information about EFED's models is provided in the Agency's website at http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment (accessed June 27, 2016).

5.3.1. Description of Model Inputs

Model input parameters for the synthetic pyrethroids lie in two categories: use information parameters, and environmental fate input parameters. The use information includes among others the application rate, number of applications, interval between applications, method of application and associated value of spray drift fraction and application efficiency, *etc.* In order to determine the spray drift fraction, and application efficiency, the model AGDISP was used. Additionally, the specific modeling scenario for each of the modeled uses are presented. The maximum use scenario was modeled (*e.g.*, for a crop that is applied through ground or aerial methods, aerial applications were modeled).

Additionally, the fate input parameters include for example, the pH 7 hydrolysis, aqueous photolysis, aerobic soil metabolism, aerobic aquatic metabolism, and anaerobic aquatic metabolism representative half-lives, vapor pressure, and solubility.

For all three chemicals when modeling in AGDISP, no canopy was assumed, which is more suitable to estimate the deposition. Generally, the remaining input parameters in AGDISP were kept at their default value (unless otherwise specified in the tables below). In order to obtain the level of drift, the toolbox "Deposition Assessment" was utilized. The dimensions of the standard pond are entered in the toolbox, and the return is the fraction of the applied deposited on the standard pond. This is the input value utilized in the PWC for spray drift fraction.

The tables below provide model input parameters used in this assessment, the sources (when applicable), and justification for the selected values.

Estimating the Application Efficiency and Drift for the Aerial Applications for Permethrin and Pyrethrins

For permethrin and the pyrethrins, both ground and aerial applications are allowed. Since the aerial spray applications appear to have a greater potential to drift, they were selected for modeling in AGDISP. **Table 5** shows the major input parameters in the AGDISP model for permethrin and pyrethrins. A swath width and three flight lines were selected in lieu of the default values in AGDISP. The resulting values of spray drift and application efficiency are presented in **Table 6**.

Table 5. AGDISP input parameters for the ULV aerial applications of Permethrin and Pyrethrins

Parameter	Permethrin	Pyrethrins
Aircraft type	Air tractor AT-401, fixed wing	Air tractor AT-401, fixed wing
Swath width	*500 ft*	*500 ft*
Wing semispan	24.5 ft	24.5 ft
Swath displacement	0 ft	0 ft
Propeller rpm	2000, propeller rad. 4.5 ft	2000, propeller rad. 4.5 ft
Fixed wing	1 engine	1 engine
Flight lines	*3*	*3*
Flight speed	120 mph	120 mph
Boom height	100 ft	100 ft
Number of nozzles	1	1
Vortex decay rate	1.25 mph	1.25 mph
Aircraft drag coefficient	0.1	0.1
Propeller efficiency	0.8	0.8
Ambient pressure	29.91 in Hg	29.91 in Hg
Planform area	294 ft^2	294 ft^2
Nozzle spacing	N/A	N/A
Wind speed	*3 mph*	*3 mph*
Wind direction	90°, perpendicular to flight path	90°, perpendicular to flight path
Canopy	*None*	*None*
Surface roughness	*0.0246 ft*	*0.0246 ft*
Stability	Overcast	Overcast
Relative humidity	*90%*	*90%*
Temperature	*85°F*	*85°F*
Droplet type	*User defined*	*User defined*
$D_{v0.1}$	*28.94 µm*	*28.67 µm*
$D_{v0.5}$	*59.08 µm*	*59.15 µm*
$D_{v0.9}$	*99.82 µm*	*81.02 µm*
Relative span	*1.2*	*0.885*
<141 µm	*99%*	*99.76%*
Spray material	*Oil*	*Oil*
Specific gravity	*7.28 lb/gal = 0.872 g/cm^3*	*7.36 lb/gal = 0.882 g/cm^3*
Non-volatile active	*0.04*	*0.05*
Nonvolatile additive	*0.959*	*0.949*
Other non-volatile	*0.001*	*0.001*
Application Rate	*0.007 lb a.i./A/3 day period*	*0.008 lb a.i./A*[1]
Spray volume	*3.1 oz./A = 0.0242 gal/A*	*0.0218 gal/A*[1]
Evaporation rate	84.76 µm^2/°C/sec	84.76 µm^2/°C/sec
Buffer zone	0 ft	0 ft

Parameter	Permethrin	Pyrethrins
Downwind water body width in "Deposition Assessment" tool	208.7 ft	208.7 ft

Values in *italics* are different than the default values in AGDISP.
[1] An application rate of 0.008 lb a.i./A is for difficult to control species.

Table 6. AGDISP results for Permethrin and the Pyrethrins

Parameter	Permethrin	Pyrethrins
Application efficiency	0.6528 (65.3%)	0.605 (60.5%)
Spray drift to standard pond or initial average deposition in the Deposition Assessment tool	0.6787 (67.9%)	0.7255 (72.6%)

Estimating the Application Efficiency and Drift for the Ground Applications of Deltamethrin

Currently EFED does not have a validated model to estimate the level of deposition on the field and on the adjacent standard pond, from *ground* applications of an adulticide via ULV. The drift model AGDISP is currently accepted in the Division only for *aerial* ULV applications.

The Division previously performed an analysis of eight open literature studies that provided levels of deposition for four chemicals: permethrin, malathion, naled, and fenthion. According to the analysis, the levels of deposition were variable and it appeared that they are strongly dependent on the weather condition (*i.e.*, wind speed), application conditions and other factors. The peak deposition levels ranged from 2 to 33% of the applied (**Table 7**). Based upon these data, EFED recommended at the time to use a deposition (*i.e.*, application efficiency) of 33% for ground based wide area mosquito control ULV sprays. The value of 33% corresponded to an application of naled and it was measured 50 meters (164 ft) from the application site. The wind speed was 1.5 mph. This analysis was vetted by the Environmental Fate and Transport Technology Team (FTT[8]). The following table provides EFED's previous compilation (MRID 48922201). For further details, refer to the Data Evaluation Record (DER) (associated with DP Barcode D407817).

Table 7. Summary of peak deposition rates reported in literature studies

Reference / Number	Material	Peak deposition (ng/cm^2)	Peak deposition (% applied)[1]	Distance from application source to peak deposition (m)	Wind speed (mph)
Tucker *et al.* 1987	Fenthion	2.92	2	8	Not reported
	Malathion	85.8	15	8	Not reported
	Naled	57.3	20	8	Not reported
Moore *et al.* 1993	Malathion	84.1	14	30.4	0.9 – 3.4

[8] The Fate and Transport Technology and Water Quality Technology Teams have since merged in the Water Transport and Fate Team.

Reference / Number	Material	Peak deposition (ng/cm^2)	Peak deposition (% applied)[1]	Distance from application source to peak deposition (m)	Wind speed (mph)
Tietze *et al.* 1994	Malathion	50	9	5	2.1 – 4.0
Knepper *et al.* 1996	Malathion	9,222	NA	7.6	1
	Permethrin	14,389	NA	7.6	1
Tietze *et al.* 1996	Malathion	473	NA	Unknown	0 – 2.5
Schleier and Peterson 2010	Naled	74	**33**	50	1.5
	Permethrin	4.6	5.9	25	4.3
Pierce *et al.* 2005	Permethrin	5.1	10	Unknown	6 - 12
Preftakes *et al.* 2011	Permethrin	8	10	25-50 m	4.8

Value in **bold** an underlined font was the highest peak deposition, expressed as a percent of the applied.

Additionally, EFED evaluated four deposition studies submitted by the registrant (MRIDs 49114102 to 49114105). Deltamethrin was applied to fields in Florida, Texas, California and North Carolina, using ground ULV spray. Three applications at ~0.0005, 0.0010 and 0.0015 lb a.i./A were made. Test plots had three rows at 100, 200 and 300 ft downwind from the sprayer with stations set up with the following: two fine mesh containers with adult mosquitoes, a vertical frame to hold screen mesh (412.9 cm^2 area) 5-ft above ground, a board on the ground holding 6-inch diameter filter paper (182.4 cm^2 area), and aerosol droplet sampler (5-ft above ground). **Table 8** presents the ranges of percent of the applied deposited on filter paper for the different application rates range.

Table 8. Summary of maximum deposition in four field studies for Deltamethrin

Study ID	Location	Range of maximum depositions (%)	Range of wind speed (mph)
49114102	Manatee County, FL	14.0-17.9	4-7
49114103	Chambers County, TX	2.40-11.1	4-7
49114104	Merced County, CA	8.79-20.8	7-10
49114105	Caswell County, NC	3.87-**25.1**	1-4

Value in **bold** and underlined font was the highest maximum deposition, expressed as a percent of the applied.

The maximum of ~25% was observed at 100 ft from treatment, at the highest application rate (~0.0015 lb a.i./A) in the North Carolina site. The droplets, in all the above studies, measured at each sampling station (100-300-ft distance) was smaller than the label specified.

Additionally, to support the modeling of aquatic exposure, EFED conducted modeling of ground ULV using AGDISP. A run was conducted assuming a $D_{v0.5}$ of 30 µm, and a $D_{v0.9}$ of 50 µm. In the run, the wind speed was 5 mph (at wind speeds below this value, an "out of range" error was obtained in the AGDISP "Deposition Assessment" tool). A nozzle pressure of 50 psi was assumed. A second run was conducted with a lower $D_{v0.5}$ (25 µm) with a larger relative span, a lower wind speed (4 mph), and lower nozzle pressure (40 psi). In both cases, the spray drift value is ~33%, with an application efficiency of ~18 to 19%. A summary of the input values, as well as results are provided in **Tables 9 & 10**.

Table 9. AGDISP input parameters for Deltamethrin

Parameter	Value for Run #1	Value for Run #2
Method	Ground	Ground
Nozzle type	Flat fan	Flat fan
Boom pressure	*60 psi*	*40 psi*
Boom height	*5 ft*	*5 ft*
Spray lines	*1 rep*	*1 rep*
Number of nozzles	*1*	*1*
Vehicle	Ground sprayer	Ground sprayer
½ Swath width	*150 ft (swath width = 300 ft)*	*150 ft (swath width = 300 ft)*
Droplet type	*User defined (ground ULV)*	*User defined (ground ULV)*
$D_{v0.1}$	*14.72 µm*	*9.94 µm*
$D_{v0.5}$	*30.04 µm*	*25.17 µm*
$D_{v0.9}$	*50.76 µm*	*47.76 µm*
Relative span	*1.2*	*1.5*
<141 µm	*99.89%*	*99.73%*
Spray material	*Water*	*Water*
Specific gravity	*1.02 (carrier, active and additive)*[1]	*1.02 (carrier, active and additive)*[1]
Non-volatile active	*0.02*	*0.02*
Nonvolatile additive	*0.97*	*0.97*
Other non-volatile	*0.01*	*0.01*
Spray volume	*0.008 gal/A (based on application rate)*	*0.008 gal/A (based on application rate)*
Evaporation rate	84.76 μm^2/°C/sec	84.76 μm^2/°C/sec
Wind speed	5 mph	4 mph
Wind direction	90°, perpendicular to flight path	90°, perpendicular to flight path
Stability	Overcast	Overcast
Relative humidity	90%	90%
Temperature	85°F	85°F
Surface roughness	0.0246 ft	0.0246 ft
Buffer zone	0 ft	0 ft
Downwind water body width in "Deposition Assessment" tool	207.8 ft (standard pond)	207.8 ft (standard pond)

Values in *italics* are different than the default values in AGDISP.
[1] Based on MRID 49114108 (8.50 lb/gal).

Table 10. AGDISP results for Deltamethrin

Parameter	Values	
Application efficiency	18.06%	19.19%
Spray drift to standard pond or initial average deposition in the Deposition Assessment tool	0.3276 fraction of the applied (~33%)	0.3328 fraction of the applied (~33%)

The 18-19% values obtained for application efficiency compares to values previously obtained in the field for deltamethrin as shown in **Table 8**, and are somewhat lower than the 33% obtained for naled in the field (**Table 7**). Note that the 33% drift is the same magnitude than the 33% maximum deposition obtained from field studies; however, these values refer to different things (*i.e.*, drift and application efficiency). It appears that there are multiple lines-of-evidence for using this value for both application efficiency and drift. In this assessment, a conservative level of application efficiency of 33% was assumed as a

first tier value, based on empirical data and comparing it to modeling in AGDISP. Further, the same value (33%) was used in estimating the value of drift towards the standard pond, based on modeling in AGDISP.

Estimating the Application Efficiency and Drift for the Aerial Applications of Deltamethrin

EFED received and processed recently an experimental use permit for the aerial use of deltamethrin. Based on the proposed label, the Division also calculated the spray drift for the aerial applications and conducted a few additional runs for the chemical using such ULV applications. Per the EUP label, "DeltaGard Insecticide is approved for application as an Ultra-Low Volume (ULV) aerosol to control flying or resting adult mosquitoes in residential, industrial, urban, recreational, and municipal areas where adult mosquitoes are found." Note that the aerial applications on *agricultural areas are excluded* from the above list for this EUP. For aerial ULV applications, the label specifies droplet sizes as follows: volume median diameter (VMD or $D_{v0.5}$, which means that 50% of the spray volume is contained in droplets smaller than this value) should be less than 60 microns ($D_{v0.5}$ < 60 µm), and 90% of the spray should be contained in droplets smaller than 115 microns ($D_{v0.9}$ < 115 µm). Note that these droplets are larger than specified above for the aerial applications of permethrin and pyrethrins.

To support the modeling of aquatic exposure, EFED conducted modeling of aerial ULV using AGDISP. Runs were conducted assuming a $D_{v0.5}$ of ~60 µm, and a $D_{v0.9}$ of ~115 µm. In the runs, wind speeds of 3 mph were utilized. At lower wind speeds, an "out of range" error was obtained in the AGDISP "Deposition Assessment" tool. A summary of the input values is provided in **Table 11**. **Table 12** provides a summary of the results obtained from the model.

Table 11. Input Parameters for AGDISP for Deltamethrin Aerial Applications

Parameter	Value
Aircraft type	Air tractor AT-401, fixed wing
Swath width	*500 ft*
Wing semispan	24.5 ft
Swath displacement	0 ft
Propeller rpm	2000, propeller rad. 4.5 ft
Fixed wing	1 engine
Flight lines	*3*
Flight speed	120 mph
Boom height	100 ft (minimum allowed for fixed wing applicators)
Number of nozzles	*1*
Vortex decay rate IGE	1.25 mph
Aircraft drag coefficient	0.1
Propeller efficiency	0.8
Ambient pressure	29.91 in Hg
Planform area	294 ft^2
Nozzle spacing (even)	*N/A, only one nozzle*
Wind speed	*3 mph*
Wind direction	90°, perpendicular to flight path

Parameter	Value
Canopy	*None*
Surface roughness	*0.0246 ft*
Stability	Overcast
Relative humidity	*90%*
Temperature	*85°F*
Droplet type	*User defined*
$D_{v0.1}$	*23.65*
$D_{v0.5}$	*60.23*
$D_{v0.9}$	*114.3*
Relative span	*1.5*
<141 µm	*96.17%*
Spray material	Water
Specific gravity	*1.02 (carrier, active and additive)*[1]
Non-volatile active	*2%*
Nonvolatile additive	*96%*
Other non-volatile	*2%*
Spray volume	*0.008 gal/A (based on application rate)*
Evaporation rate	84.76 μm^2/°C/sec
Buffer zone	0 ft
Downwind water body width in "Deposition Assessment" tool	207.8 ft (standard pond)

Values in *italics* are different than the default values in AGDISP.
[1] Based on MRID 49114108.

Table 12. Results Obtained from AGDISP for the Aerial Applications for Deltamethrin

Application efficiency	0.715 (71.5%)
Spray drift to standard pond or initial average deposition in the Deposition Assessment tool	0.544 (54.4%)

Input Parameters in the PWC

EFED has typically modelled 25 or 26 applications, which is the previous maximum number of applications that the old model PE5 allowed. For pyrethrins, technically the number of applications at 0.0025 lb a.i./A could be greater than 25, based on the stated annual rate; however, it appears highly unlikely that over 25 applications would be performed in any given year or for 30 consecutive years. Mosquitoes could develop resistance to the chemical if it is applied for 80 applications/year for 30 years, which is the actual maximum number of applications allowed at the typical rate.

Although the pyrethrins label does not say the minimum interval between applications (presumably it could be one day), it is also highly unlikely that 25 *daily* applications would be used for 30 consecutive years for the same chemical.

Table 13. Pyrethrins Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	No. of Apps.	Min. Interval Between Apps. (days)	Day of First App.	Incorp. depth (cm)	PHI (days)
CA residential + impervious	Aerial ULV	0.726	0.605	0.00280 (0.0025)[1]	25	3[3]	01-06	0	N/A
CA residential + impervious, FL met file W12839.dvf	Aerial ULV	0.726	0.605	0.00280 (0.0025)	25	3	01-06	0	N/A
CA turf[4]	Aerial ULV	0.726	0.605	0.00280 (0.0025)	25	3	01-06	0	N/A
FL turf[4]	Aerial ULV	0.726	0.605	0.00897 (0.008)[2]	25	1	01-06	0	N/A
FL turf[4]	Aerial ULV	0.726	0.605	0.00280 (0.0025)	10	7	01-06	0	N/A
ID potato[5]	Aerial ULV	0.726	0.605	0.00280 (0.0025)	25	3	01-06	0	N/A
MS soybean[5]	Aerial ULV	0.726	0.605	0.00280 (0.0025)	25	3	01-06	0	N/A
FL cabbage[5]	Aerial ULV	0.726	0.605	0.00280 (0.0025)	25	3	01-06	0	N/A
FL pepper[5]	Aerial ULV	0.726	0.605	0.00897 (0.008)[2]	25	1	01-06	0	N/A
FL pepper[6]	Aerial ULV	0.726	0.605	0.00280 (0.0025)	10	7	01-06	0	N/A
FL pepper[6]	Aerial ULV	0.726	0.605	0.00897 (0.008)[2]	1	N/A	01-06	0	N/A

1 According to the label, an application rate of 0.0025 lb a.i./A is considered the maximum for wide area mosquito control.
2 An application rate of 0.008 lb a.i./A is to be used only on difficult to control species.
3 Although the minimum retreatment interval is not stated (presumably 1 day), it is highly unlikely that 25 applications at this rate be done at 1 day intervals consecutively for 30 years, since insects develop pyrethroids and pyrethrins resistance.
4 The CA and FL turf scenarios represent uses such as parks, campsites, athletic fields and golf courses.
5 The ID potato, MS soybean, FL cabbage and FL pepper scenarios represent agricultural uses in diverse areas of the US.
6 Additional runs were performed assuming an interval between application of 7 days and 10 applications, and a single application for the FL turf and the FL pepper scenarios.

Table 14. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Pyrethrin 1[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	328.4 g/mole	USEPA 2006[2]
Vapor Pressure	2 x 10^{-5} torr	USEPA 2006[2]
Solubility in Water	0.2 mg/L	USEPA 2006[2]
Photolysis in Water (34°N)	0.49 days	MRID 43096601, 43567501, 43567601 11.8 days for the combination of pyrethrin and the (E)-Isomer of pyrethrin 1; irradiated with sunlight in Irvine, California (33º41' N, 117º15' W)
Aerobic Soil Metabolism Half-lives (25°C)	7.26 days	MRID 43499803, 49687101 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 9.5 days at 25ºC, and 5.53, 3.51, 0.742 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 9.5, 3.91, 2.48, 0.525 days; average 4.1038 days; standard deviation 3.8558 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Hydrolysis Half-life at pH 7	0	MRID 43188201, 43567502 Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 10.25 days	MRID 43499802; 49123501 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 10.5 days at 25ºC, and 6.44, 5.37 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 10.5, 3.85, 3.80 days; average 6.050 days; standard deviation 3.8539 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	258 days	MRID 43499801 Single available value multiplied by 3 (86 days x 3).
Soil Water Partition Coefficient (K_F)	301.5 mL/g	MRID 43096603 Average of the following four values: 198, 268, 430, 310 mL/g. The K_F model represents the mobility better than the K_{FOC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_F dataset is less than for the K_{FOC} dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1" dated October 22, 2009.
2 USEPA 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

Table 15. Deltamethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	No. of Apps.	Min. Interval Between Apps. (days)	Day of First App.[4]	Incorp. depth (cm)	PHI (days)
CA residential + impervious	Ground ULV	0.33	0.33	0.00150 (0.00134)	25	3	01-06	0	N/A
CA residential + impervious, FL met file W12839.dvf	Ground ULV	0.33	0.33	0.00150 (0.00134)	25	3	01-06	0	N/A
CA turf[1]	Ground ULV	0.33	0.33	0.00150 (0.00134)	25	3	01-06	0	N/A
FL turf[1]	Ground ULV	0.33	0.33	0.00150 (0.00134)	25	3	01-06	0	N/A

Table 15. Deltamethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	No. of Apps.	Min. Interval Between Apps. (days)	Day of First App.[4]	Incorp. depth (cm)	PHI (days)
FL turf[1]	Ground ULV	0.33	0.33	0.00100 (0.00089)[4]	10	7	01-06	0	N/A
ID potato[2]	Ground ULV	0.33	0.33	0.00150 (0.00134)	10	3	01-06	0	N/A
MS soybean[2]	Ground ULV	0.33	0.33	0.00150 (0.00134)	10	3	01-06	0	N/A
FL cabbage[2]	Ground ULV	0.33	0.33	0.00150 (0.00134)	10	3	01-06	0	N/A
FL pepper[2]	Ground ULV	0.33	0.33	0.00150 (0.00134)	10	3	01-06	0	N/A
FL pepper[3]	Ground ULV	0.33	0.33	0.00100 (0.00089)[4]	10	7	01-06	0	N/A
FL pepper[3]	Ground ULV	0.33	0.33	0.00150 (0.00134)	1	N/A	01-06	0	N/A
FL turf[1]	Aerial ULV	0.544	0.715	0.00150 (0.00134)	25	3	01-06	0	N/A
CA residential + impervious, FL met file W12839.dvf	Aerial ULV	0.544	0.715	0.00150 (0.00134)	25	3	01-06	0	N/A

1 The CA and FL turf scenarios represent uses such as parks, campsites, athletic fields and golf courses.
2 The ID potato, MS soybean, FL cabbage and FL pepper scenarios represent agricultural uses in diverse areas of the US.
3 Additional runs were performed assuming an interval between application of 7 days and 10 applications, and a single application for the FL turf and the FL pepper scenarios.
4 According to the label, three example application rates are presented. The middle-one is 0.00089 lb a.i./A, which was used in modeling typical scenarios.

Table 16. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Deltamethrin[1]

Fate Property	Value (unit)	Source/Comment[1]
Molecular Weight	505.2 g/mole	Laskowski 2002[2]
Vapor Pressure (25ºC)	9.32×10^{-11} torr	Laskowski 2002
Solubility in Water (20ºC)	0.000200 mg/L	Laskowski 2002
Photolysis in Water (40°N)	86 days	MRID 42114818 Highest available value. Artificial light was compared to natural sunlight, but the latitude was not stated in the DER. Assumed to be 40°N.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 50.5 days	MRID 41677404, 41677405, 42114820 Represents the 90th percentile of the upper confidence bound on the mean for the following six values: 52.5, 54.6, 46.2, 50.2, 22, 26 days at 25°C; average 41.917 days; standard deviation 14.212 days; n = 6; one sided student's t value $t_{90,n-1}$ = 1.476.
Hydrolysis Half-life at pH 7	0	MRID 41651038; Stable
Aerobic Aquatic Metabolism Half-life (water column) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 86.1 days	MRID 44977005, 48988201 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 25.9, 120.3, 21.2, 9.29 days at 20°C; average 44.1725 days; standard deviation 51.2309 days; one sided student's t value $t_{90,n-1}$ = 1.638. Half-lives based on the sum of deltamethrin plus the *alpha*-R-isomer.

Table 16. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Deltamethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Anaerobic Aquatic Metabolism Half-life (benthic) (20°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 138.6 days	MRID 49114109 Represents the 90th percentile of the upper confidence bound on the mean for the following two values: 98.9, 60.7 days at 20°C; average 79.8 days; standard deviation 27.011 days; one sided student's t value $t_{90,n-1}$ = 3.078.
Organic Carbon Normalized Soil Water Partition Coefficient (K_{OC})	449,000 mL/g_{OC}	MRID 41651039, 42976501 Average of the following four values: 317000, 255000, 516000, 708000 mL/g. The K_{OC} model represents the mobility better than the K_d model (binding is correlated with organic carbon, the coefficient of variation for the K_{OC} dataset is less than for the K_d dataset).
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

[1] Inputs determined in accordance with EFED *"Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
[2] Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Table 17. Permethrin Ecological Exposure Assessment Uses, Scenarios, and Application Information Used for Aquatic Exposure in the PWC

Run Number: PWC Scenario/ Uses Represented	Method of App.	Spray Drift	App. Efficiency	Max. App. Rate kg a.i./ha (lb a.i./A)	No. of Apps.	Min. Interval Between Apps. (days)	Day of First App.[5]	Incorp. depth (cm)	PHI (days)
CA residential + impervious	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
CA residential + impervious, FL met file W12839.dvf	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
CA turf[1]	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
FL turf[1]	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
FL turf[1]	Aerial ULV	0.679	0.653	0.00392 (0.0035)	10	7	01-06	0	N/A
ID potato[2]	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
MS soybean[2]	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
FL cabbage[2]	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
FL pepper[2]	Aerial ULV	0.679	0.653	0.00785 (0.007)	25	3	01-06	0	N/A
FL pepper[3]	Aerial ULV	0.679	0.653	0.00392 (0.0035)[4]	10	7	01-06	0	N/A
FL pepper[3]	Aerial ULV	0.679	0.653	0.00785 (0.007)	1	N/A	01-06	0	N/A

1 The CA and FL turf scenarios represent uses such as parks, campsites, athletic fields and golf courses.
2 The ID potato, MS soybean, FL cabbage and FL pepper scenarios represent agricultural uses in diverse areas of the US.
3 Additional runs were performed assuming an interval between application of 7 days and 10 applications, and a single application for the FL turf and the FL pepper scenarios.
4 According to the label, three example application rates are presented. The mid-value is 0.0035 lb a.i./A, which was used in modeling typical scenarios.

Table 18. Summary of PWC Environmental Fate Data Used for Aquatic Exposure Inputs for Permethrin[1]		
Fate Property	**Value (unit)**	**Source/Comment[1]**
Molecular Weight	391.3 g/mole	Laskowski 2002[2]
Vapor Pressure	1.48 x 10^{-8} torr	Laskowski 2002[2]; MRID 42109801
Solubility in Water	0.0055 mg/L	Laskowski 2002[2]
Photolysis in Water (40°N)	94 days	MRID 40242801, 49542801 Highest available value.
Aerobic Soil Metabolism Half-lives (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 211 days	MRID 42410002, 49622001 Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 37 days at 25ºC, and 12.3, 50.4, 431 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 37, 8.70, 35.6, 305 days; average 96.575 days; standard deviation 139.559 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Hydrolysis Half-life (at pH 6)	0	MRID 00102043; Stable
Aerobic Aquatic Metabolism Half-life (water column) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 56.7 days	MRID 43938201, Represents the 90th percentile of the upper confidence bound on the mean for the following four values: 38.18, 42.88 days at 25ºC, and 89.1, 9.77 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 38.18, 42.88, 63.0, 6.91 days; average 37.743 days; standard deviation 23.203 days; one sided student's t value $t_{90,n-1}$ = 1.638.
Anaerobic Aquatic Metabolism Half-life (benthic) (25°C)	$t_{input} = \overline{t_{1/2}} + \frac{t_{90,n-1}s}{\sqrt{n}}$ = 193 days	MRID 43982001 Represents the 90th percentile of the upper confidence bound on the mean for the following three values: 144 days at 25ºC, and 262, 116 days at 20ºC; the corrected half-lives at 25ºC[3] are as follows: 144, 185, 82.0 days; average 137.00 days; standard deviation 51.856 days; one sided student's t value $t_{90,n-1}$ = 1.886.
Soil Water Partition Coefficient (K_d)	3186.8 mL/g	MRID 45170102, 49624901 Average of the following nine values: 1450, 1970, 2710, 2530, 5877, 2991, 3373, 411, 7369 mL/g. The K_d model represents the mobility better than the K_{OC} model (binding does not correlate with organic carbon, the coefficient of variation for the K_d dataset is less than for the K_{OC} dataset). Study 41868001 was not found to be appropriate for use in risk assessment.
Foliar Half-life	35	Default value.
Post-harvest Foliar Pesticide Disposition (IPSCND)	Surface applied	Default value.

1 Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1"* dated October 22, 2009.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
3 USEPA 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5; and WQTT Advisory Note Number 9 (September 21, 2010). OPP/Environmental Fate and Effects Division. Memorandum from D. Brady, dated October 18, 2010.

5.3.2. Model Results

The modeling results are presented in **Tables 19 to 21**. All these scenarios were run in batch mode in the PWC. The water column and pore water EECs are the freely dissolved pyrethroid or pyrethrins concentrations. This is the fraction of the chemical that is bioavailable. For some of the chemicals, the calculated EEC was above the limit of solubility. In such instances, the value was set to the solubility limit.

The EECs presented in the **Tables 19 to 21** include a moderately large number of turf and agricultural scenario results. It was noted that the EECs for all the agricultural scenarios were similar for a given chemical. In addition, the EECs for the CA and FL turf

scenarios were also usually similar for a given chemical. One possible reason for this behavior is the high level of spray drift towards the standard pond, and as a consequence, the EECs may have tended to be similar for a given group. In the risk quotient tables, the CA turf, ID potato, MS soybean and FL cabbage EECs are, therefore, not presented, nor RQs calculated. The remaining EECs were used as surrogates for all the agricultural and urban uses for RQ calculations.

Table 19. Water Column, Pore Water, and Sediment EECs for Pyrethrins[1]

Scenario / Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application day-month	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg-dw)	21-day average EEC (µg/kg-dw)
CA residen + imperv	Aerial ULV	0.00280 (0.0025)	01-06	25	3	0.337	0.273	0.248	0.185	0.182	55.8	54.9
CA residen + imperv, FL met file W12839.dvf	Aerial ULV	0.00280 (0.0025)	01-06	25	3	0.251	0.188	0.173	0.117	0.113	35.3	34.1
CA turf	Aerial ULV	0.00280 (0.0025)	01-06	25	3	0.342	0.278	0.253	0.189	0.186	57.0	56.1
FL turf	Aerial ULV	0.00897 (0.008)	01-06	25	1	1.69	1.36	0.770	0.501	0.485	151	146
FL turf	Aerial ULV	0.00280 (0.0025)	01-06	10	7	0.150	0.0853	0.0790	0.0528	0.0513	15.9	15.5
ID potato	Aerial ULV	0.00280 (0.0025)	01-06	25	3	0.333	0.274	0.259	0.196	0.192	59.1	57.9
MS soybean	Aerial ULV	0.00280 (0.0025)	01-06	25	3	0.270	0.207	0.189	0.134	0.130	40.4	39.2
FL cabbage	Aerial ULV	0.00280 (0.0025)	01-06	25	3	0.259	0.195	0.178	0.123	0.119	37.1	35.9
FL pepper	Aerial ULV	0.00897 (0.008)	01-06	25	1	1.63	1.29	0.714	0.467	0.450	141	136
FL pepper	Aerial ULV	0.00280 (0.0025)	01-06	10	7	0.144	0.0789	0.0730	0.0482	0.0466	14.5	14.0
FL pepper	Aerial ULV	0.00897 (0.008)	01-06	1	N/A	0.321	0.0678	0.0309	0.0199	0.0192	6.00	5.79

[1] EECs were rounded to three significant figures.

Table 20. Water Column, Pore Water, and Sediment EECs for Deltamethrin[1]

Scenario / Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application day-month	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day average EEC (µg/kg$_{oc}$)
CA residen + imperv	Ground ULV	0.00150 (0.00134)	01-06	25	3	0.125	0.00310	0.00248	0.00183	0.00176	822	790
CA residen + imperv, FL met file W12839.dvf	Ground ULV	0.00150 (0.00134)	01-06	25	3	0.183	0.00515	0.00414	0.00245	0.00232	1100	1042
CA turf	Ground ULV	0.00150 (0.00134)	01-06	25	3	0.0132	0.00202	0.00183	0.00132	0.00128	593	575
FL turf	Ground ULV	0.00150 (0.00134)	01-06	25	3	0.0128	0.00163	0.00146	0.000912	0.000872	410	392
FL turf	Ground ULV	0.00100 (0.00089)	01-06	10	7	0.00818	0.000455	0.000411	0.000252	0.000238	113	107
ID potato	Ground ULV	0.00150 (0.00134)	01-06	10	3	0.0126	0.00132	0.000929	0.000639	0.000616	287	277
MS soybean	Ground ULV	0.00150 (0.00134)	01-06	10	3	0.0134	0.00118	0.000784	0.000476	0.000453	214	203
FL cabbage	Ground ULV	0.00150 (0.00134)	01-06	10	3	0.0128	0.00111	0.000717	0.000425	0.000399	191	179
FL pepper	Ground ULV	0.00150 (0.00134)	01-06	10	3	0.0128	0.00111	0.000717	0.000424	0.000399	190	179
FL pepper	Ground ULV	0.00100 (0.00089)	01-06	10	7	0.00832	0.000446	0.000404	0.000241	0.000227	108	102
FL pepper	Ground ULV	0.00150 (0.00134)	01-06	1	N/A	0.0120	0.000158	7.89×10^{-5}	4.51×10^{-5}	4.33×10^{-5}	20.3	19.4
FL turf	Aerial ULV	0.00150 (0.00134)	01-06	25	3	0.0211	0.00269	0.00242	0.00151	0.00144	678	647
CA residen + imperv, FL met file W12839.dvf	Aerial ULV	0.00150 (0.00134)	01-06	10	3	0.200 (0.390)	0.0104	0.00824	0.00488	0.00462	2191	2075

*EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling (solubility from Laskowski 2002). The value in (parenthesis) was the modeled EEC, which is provided for reference only.

[1]EECs were rounded to three significant figures.

Table 21. Water Column, Pore Water, and Sediment EECs for Permethrin[1]

Scenario / Uses Represented	App Method	App Rate kg a.i./ha (lb a.i./A)	Date of First Application day-month	Number of Apps	App Interval (days)	Water Column			Pore Water		Sediment	
						Peak EEC (µg/L)	21-day average EEC (µg/L)	60-day average EEC (µg/L)	Peak EEC (µg/L)	21-day average EEC (µg/L)	Peak EEC (µg/kg-dw)	21-day average EEC (µg/kg-dw)
CA residen + imperv	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.349	0.167	0.155	0.125	0.124	398	395
CA residen + imperv, FL met file W12839.dvf	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.307	0.116	0.105	0.0736	0.0716	235	228
CA turf[1]	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.350	0.168	0.156	0.127	0.125	405	398
FL turf[1]	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.308	0.124	0.113	0.0823	0.0804	262	256
FL turf[1]	Aerial ULV	0.00392 (0.0035)	01-06	10	7	0.0127	0.0257	0.0235	0.0167	0.0162	53.2	51.6
ID potato[2]	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.370	0.189	0.179	0.146	0.144	465	459
MS soybean[2]	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.454	0.146	0.135	0.102	0.0995	325	317
FL cabbage[2]	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.324	0.124	0.114	0.0823	0.0803	262	256
FL pepper[2]	Aerial ULV	0.00785 (0.007)	01-06	25	3	0.313	0.122	0.112	0.0801	0.0782	255	249
FL pepper[3]	Aerial ULV	0.00392 (0.0035)	01-06	10	7	0.129	0.0253	0.0233	0.0163	0.0158	51.9	50.3
FL pepper[3]	Aerial ULV	0.00785 (0.007)	01-06	1	N/A	0.225	0.0104	0.00584	0.00368	0.00361	11.7	11.5

[1]EECs were rounded to three significant figures.

5.4. Adulticide Insecticides Monitoring Data

Monitoring data for adulticides is scarce. Given that they are applied at extremely low rates, and some of these pesticides have other uses, monitoring results can be confounded with other uses. For example, permethrin can be used as an adulticide; however, it can be used on agricultural crops (conventional applications), residential settings, and industrial sites, and it has indoor urban uses that may lead to residues in wastewater discharges, and consequently in treatment plant effluents.

Milam *et al.* (2000) published a report of monitoring for toxicity of ground and aerial permethrin adulticidal applications (product Biomist®) in Arkansas. Toxicity was performed *in situ* in 10 replicate test chambers plus controls. Test organisms included *Daphnia pulex*, *Ceriodaphnia dubia*, and *Pimephales promelas*. Five test organisms were placed in each chamber. Once permethrin was allowed to settle, the chambers were transferred to the laboratory for the remainder of the exposure period (24 or 48 hours). *P. promelas* did not appear to be susceptible to aerial or ground ULV permethrin applications, showing 100% survival in all instances. Both *D. pulex* and *C. dubia* appeared to be more susceptible to aerial than to ground applications and showed variable survival rates from ground applications of permethrin.

Weston *et al.* (2006) reported their results from monitoring of aerial applications of pyrethrins and PBO in August 2005, using the product Evergreen Crop Protection EC 60-6 (containing 6% pyrethrins and 60% PBO), on ~50,000 hectares over the densely populated area of Sacramento, CA. (across the American River). Treated areas were primarily commercial and residential. Water and sediments from six creeks draining the treatment area were sampled and tested for toxicity (water *C. dubia* test (~6-8-day tests); sediment *Hyalella azteca* (10-day test) and chemistry (pyrethrins, chlorpyrifos, diazinon and PBO in water; pyrethroids, pyrethrins, PBO and chlorpyrifos in sediment). Additionally, two separate experiments were performed to determine the effect of PBO on sediment sorbed pyrethroids: one was conducted with a sediment that showed near total lethality to *H. azteca*, and another with a sediment spiked with bifenthrin. The sediment's LC_{50}s were determined, with PBO present in the overlaying water at 0, 4, and 25 µg/L. Water analysis indicated that the sum of pyrethrins I and II, were not detected above the reporting limit of 0.01 µg/L, which was attributed to degradation via photolysis and adsorption by bed sediments; however, PBO was undetected prior to application and reached a maximum level of 3.92 µg/L after application. Sediment sample analyses revealed that pyrethrins I were present at a concentration of up to 403 µg/kg dry weight after application and PBO concentrations were up to 61.4 µg/kg dry weight. There was no evidence of aquatic toxicity due to the application of pyrethrins and PBO alone. The additional testing indicated that PBO concentrations of 2-4 µg/L in the overlaying water were sufficient to enhance previously present sediment pyrethroid toxicity to *H. azteca* by a factor of up to two. Even though there is uncertainty about the PBO actual exposure duration in the environment, at the treatment site PBO was applied on three consecutive nights. This could cause prolonged PBO concentrations in the environment. Water

sampling occurred at 10 and 34 hours after application and the difference in PBO concentration between samplings was not appreciable. This article was the first to show that the synergist PBO could pose additional risk to aquatic animals, compared to risk posed by individual insecticide active ingredients, at an environmentally realistic PBO concentration.

The Sacramento-Yolo Mosquito and Vector Control District provided a water quality monitoring effort for the same applications by Weston *et al.* (2006) (Ziegler, 2006). No sediment samples were taken for analysis. Water samples were analyzed for pyrethrins and PBO, with respective reporting limits of 0.2 and 1.0 µg/L. Since applications were made in the evening (usually after 8:00 pm), for each application event water samples were taken three times, which represented before application (baseline), in the morning on the day after application (representing immediate post-application), and in the afternoon on the day after application (next day post-application, taken approximately 15 hours after the immediate post-application samples). For the first application event, immediate post-application samples were not taken. Results indicated that the pre-application (baseline) samples were non-detects at the reporting limit for both pyrethrins and PBO. For the immediate post-application samples, 35% and 56% of the water samples were reported as detects for pyrethrins and PBO, respectively. For the next day post-application samples, pyrethrins were not detected in any samples and PBO was detected in 35% of the samples. The maximum pyrethrins concentration reported was 3.77 µg/L and PBO was at a maximum concentration of 20 µg/L.

Schleier and Peterson (2010) derived LC_{50}s for permethrin, permethrin synergized with PBO, permethrin in the product Permanone®, Permanone® plus PBO, technical naled, and naled in the product Trumpet®, towards the representative medium-to-large ground-dwelling non-target insect, the house cricket (*Acheta domesticus* (L.)). Using ground ULV applications, there were no significant differences in mortalities of caged house crickets exposed to Permanone® or naled, compared to controls. The authors calculated EECs using the Industrial Source Complex Short-Term (ISCST3) dispersion model, which resulted in exceedance of the levels of concern (LOCs) for the house cricket in all cases, except for technical grade permethrin. However, using actual environmental concentrations, only the risk quotient (RQ) for technical grade naled exceeded the LOC. RQs were 10- to 100-fold lower using the measured environmental concentrations than using modeling.

In another monitoring effort, Kuivila *et al.* (2012) reported sampling for several synthetic pyrethroids in 7 metropolitan areas across the U.S., which excluded California. Among the pyrethroids analyzed, resmethrin was included, which has been used primarily for mosquito abatement. The study reported a frequency of detection of resmethrin in sediment samples of 4% and a highest concentration of 38.3 µg/kg dry weight, a median 5.3 µg/kg, with a method detection limit of 0.5 µg/kg dry weight. According to the article, given that resmethrin is used primarily as an adulticide, the source of the chemical for the site that showed the maximum resmethrin concentration at a site within Estes Park, Colorado (an undeveloped watershed), is aerial applications of resmethrin for mosquito control. According to this article, a previous study had reported a maximum resmethrin concentration in suspended sediment of a San Joaquin Valley, California watershed of 19

µg/kg (Hladik & Kuivila, 2009).

Phillips *et al.* (2014) incorporated toxicity testing to monitoring relative to mosquito adulticide applications. As a requirement of a National Pollutant Discharge Elimination System (NPDES) General Permit to comprise discharges to waters from mosquito control applications in California in 2011, the California State Water Resources Control Board and the Mosquito Vector Control Association of California conducted chemical and toxicity analyses in the water column and sediment pre- and post-applications of malathion, naled (and its degradate dichlorvos), permethrin, *d*-phenothrin, pyrethrins, etofenprox, and PBO (plus a suite of other pyrethroids), during 15 mosquito adulticide applications in 2011 and 2012. Settings included and were labeled as urban, agricultural and wetland environments. Pre-application water and sediment samples were collected in the evening of each application day. Post-application water samples were collected in the early morning hours (12-hr post-application) and evenings of the day after each application (24-hr post-application). The post-application sediment samples were taken 4-7 days post-applications, to allow time for partitioning with the sediments. The toxicity of malathion and naled was assessed using *Ceriodaphnia dubia*, while the toxicity of pyrethroids and pyrethrins was assessed using *Hyalella azteca*.

Only four post-application sediment samples were more toxic than their corresponding pre-application samples; however, the toxicity could not be attributed to the spray events and there was a limited number of chemicals tested (**Table 22**).

Toxicity of nine out of 16 toxic water samples was related to applications of naled and attributed to it's degradate dichlorvos. Given the limited number of adulticide chemicals available in the market, and that naled is only one of two organophosphate pesticides used for this purpose, the authors recommended best management practices to prevent toxicity due to naled applications. They indicated that some practices were already being implemented (**Table 22**).

Table 22. Summary of Sampling Results from Monitoring Mosquitocide Applications (Source: Phillips *et al.*, 2014)

Chemical	Toxicity	Concentrations and Other Notes
Sediment		
Pre-App Samples	Out of 17 samples, only one exhibited significant toxicity (*Hyalella azteca*), taken before a *d*-phenothrin application.	The corresponding post-application sample exhibited the same mean survival (74%), and it was not found to be significant.
Permethrin	Only one urban site was sampled for permethrin, which exhibited significant toxicity pre-application (*H. azteca*). See above.	The permethrin concentration was below the toxicity threshold.
Pyrethrins	Two of the urban sites exhibited toxicity post-application (*H. azteca*).	There were no detections of pyrethrins and no sample exceeded the PBO toxicity threshold.
d-phenothrin	Five wetland and five agricultural sites were sampled for *d*-phenothrin, all of which did not exhibit significant toxicity pre- and post-application (*H. azteca*).	No sample had concentrations of *d*-phenothrin or PBO exceeding their toxicity thresholds.
Water Column		

Chemical	Toxicity	Concentrations and Other Notes
Pre-App Samples	Out of 53 samples, only one exhibited significant toxicity (*H. azteca*), taken before a *d*-phenothrin application.	The corresponding post-application sample was not significantly toxic at the same site.
Malathion	Two sites were tested, which did not exhibit significant toxicity (*C. dubia*).	The concentrations of malathion were below the organism threshold.
Naled	Six urban, two wetland and one agricultural sites were tested. Significant toxicity was observed in both wetland and all six urban sites (*C. dubia*).	Naled was not detected in any of the sites but its degradate, dichlorvos, was observed at concentrations exceeding the organism threshold in both wetland and four of the urban sites. Trichlorfon, another precursor of dichlorvos, was noted at levels exceeding thresholds in one of the wetland sites.
Etofenprox	The 24-hr post-application sample exhibited significant toxicity (*H. azteca*).	The chemical's concentration was below the reporting limit.
Permethrin	Six agricultural, one wetland and five urban sites were sampled. Three permethrin post-application sites exhibited significant toxicity (one agricultural and two urban) (*H. azteca*).	Permethrin, bifenthrin and PBO concentrations were all below toxicity thresholds in these samples (*H. azteca*) with the exception of one bifenthrin concentration exceeding the threshold in one of the urban sites that exhibited toxicity (12- and 24-hours post-application).
Pyrethrins	Six urban and six wetland sites were monitored, of which only one urban site exhibited toxicity (*H. azteca*).	Even though the concentration of pyrethrins and PBO were below their toxicity thresholds, it turned out that the concentrations of PBO were the highest reported for the samples that exhibited toxicity. The authors speculated that the PBO may have synergized the toxicity of other pyrethroids present in the samples.
d-phenothrin	None of the six agricultural, six wetland and six urban sites monitored exhibited significant toxicity post-application (*H. azteca*).	The concentrations of *d*-phenothrin and PBO were below their toxicity thresholds.

6. Aquatic Receptors and Ecological Effects Characterization

In ecological risk assessments, effects characterization describes the types of effects a pesticide can produce in an aquatic (or terrestrial) organism. This characterization is based chiefly on registrant-submitted studies that describe acute and chronic effects toxicity information for various aquatic and terrestrial animals and plants. Data from the open literature are also considered; in this case, when updated ECOTOX queries were available, papers were screened to see if data from any of those studies contained apical toxicity endpoints (*e.g.*, survival, growth, reproduction, development) that were more sensitive than available data from submitted studies and, if so, reviewed according to approved procedures (USEPA, 2011). Acute and chronic laboratory studies with pyrethroids and pyrethrins with aquatic organisms provide information regarding survival, growth, and reproduction. Data on the technical grade active ingredient (TGAI) and the effects on freshwater and estuarine/marine fish and invertebrates, aquatic vascular and nonvascular plants (algae), and freshwater and estuarine/marine sediment dwelling organisms are used to evaluate the potential risk from aquatic exposure resulting from runoff or spray drift from the assessed uses. Refer to **Section 6** of **Part II** of the PRA for a summary of the endpoints selected for use in this assessment. Further information about the endpoints listed in **Section 6** of **Part II** of the PRA (which are the most sensitive ones across species tested), including species, study identification, and effects observed, is presented in the **Attachment II**. For a comprehensive list of toxicity data for each chemical, see the **Attachment IV**. The endpoints selected for RQ calculations are presented in the footnotes to each of the RQ tables in **Section 7.1** (*Risk Estimation*).

7. Risk Characterization

Risk characterization provides the final step in the risk assessment process. In this step, exposure and effects characterization are integrated to provide an estimate of risk relative to established levels of concern (LOCs; **Section 7.1**). The results are then interpreted for the risk manager through a risk description and synthesized into an overall conclusion (**Section 7.2**). In addition, the risk description also contains a discussion of relevant sources of uncertainty in the risk assessment and sensitivity of the risk assessment findings to important methodological assumptions.

7.1. Risk Estimation

Results of the exposure modeling and toxicity effects data are used to evaluate the likelihood of adverse ecological effects on non-target species. For the assessment of pyrethroids and pyrethrins, the risk quotient (RQ) method is used to compare exposure and measured toxicity values (refer to **Appendix A**). Estimated environmental concentrations (EECs) are divided by the most sensitive acute and chronic toxicity values. The RQs are then compared to the Agency's levels of concern (LOCs). These LOCs, summarized in **Appendix A**, are the Agency's interpretive policy and are used to analyse potential risk to non-target organisms and the need to consider regulatory action. These criteria are used to

indicate when a pesticide's use as directed on the label has the potential to cause adverse effects on non-target organisms. LOCs currently address the following risk presumption categories:

Aquatic Animals:

- **Acute risk** – potential for acute risk to non-target organisms which may warrant regulatory action in addition to restricted use classification,
- **Acute risk, listed species** – listed species may be potentially affected by use,
- **Chronic risk** – potential for chronic risk may warrant regulatory action, listed species may potentially be affected through chronic exposure.

The reader is reminded that in **Section 5.3.2** it was said that… "The EECs presented in the **Tables 19 to 21** include a moderately large number of turf and agricultural scenario results. It was noted that the EECs for all the agricultural scenarios were similar for a given chemical. In addition, the EECs for the CA and FL turf scenarios were also usually similar for a given chemical. One possible reason for this behavior is the high level of spray drift towards the standard pond, and as a consequence, the EECs may have tended to be similar for a given group. *In the risk quotient tables, the CA turf, ID potato, MS soybean and FL cabbage EECs are, therefore, not presented, nor RQs calculated. The remaining EECs were used as surrogates for all the agricultural and urban uses for RQ calculations.*" [Emphasis added.]

7.1.1. Freshwater and Estuarine/Marine Fish Risk Quotients

For freshwater fish exposed to deltamethrin, on an acute basis, only the CA and FL residential scenarios (ground or aerial), exceeded the listed and non-listed species LOCs (0.05 and 0.5, respectively), with RQs of 0.83-1.3. The RQs for the remaining scenarios exceeded only the listed species LOC with RQs in the range of 0.05 to 0.14. Further, none of the chronic RQs exceeded the LOC (1.0). The highest chronic RQ was only 0.48, for the FL residential scenario, when applied aerially.

For estuarine/marine fish exposed to deltamethrin, on an acute basis, only the CA and FL residential scenarios (ground or aerial), exceeded the listed species LOC (0.05), with RQs of 0.22-0.34 (the RQs were the same, since the endpoint for estuarine/marine fish is the same than for freshwater fish; different species were tested, but the endpoint turned out to be the same). None of the chronic RQs exceeded the LOC of 1.0. The chronic RQs were <0.01 for a single application to 0.34 for the maximum number of aerial applications.

Table 28. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.125	0.00248	**0.83**	0.15	*0.22*	0.10
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.183	0.00414	**1.2**	0.24	*0.32*	0.17
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.0128	0.00146	*0.09*	0.09	0.02	0.06
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.00818	0.000411	*0.05*	0.02	0.01	0.02
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	0.0128	0.000717	*0.09*	0.04	0.02	0.03
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.00832	0.000404	*0.06*	0.02	0.01	0.02
FL pepper Ground, 0.00134 lb a.i./A x 1 app	0.0120	7.89×10^{-5}	*0.08*	<0.01	0.02	<0.01
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.0211	0.00242	*0.14*	0.14	0.04	0.10
FL residen + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.200 (0.390)*	0.00824	**1.3**	0.48	*0.34*	0.34

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.15 ppb [for Rainbow trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 0.017 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 0.58 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.024 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

For the pyrethrins and freshwater fish, five out of seven of the scenario RQs exceeded the listed species acute LOC (0.05), while none of the scenarios exceeded the chronic LOC. The highest acute RQ was 0.33, for the FL turf scenario, representing the maximum number of applications at the maximum rate and 3-day interval. The highest chronic RQ was only 0.41 for the same scenario.

For estuarine/marine fish exposed to pyrethrins there were two RQs exceeding the acute listed species LOC (0.05), but not the non-listed species LOC (0.5). The highest acute RQ was 0.11. For the same scenarios, the chronic RQs approached or marginally exceeded the LOC. Both scenarios represented the maximum application rate and number of applications and a 3-day interval. On an acute basis, the RQs ranged from 0.01 to 0.11. The chronic RQs ranged from 0.04 to 1.1 for all the scenarios.

Table 29. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.337	0.248	*0.07*	0.13	0.02	0.35
FL residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.251	0.173	*0.05*	0.09	0.02	0.25
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	1.69	0.770	*0.33*	0.41	*0.11*	**1.1**
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.150	0.0790	0.03	0.04	0.01	0.11
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	1.63	0.714	*0.32*	0.38	*0.10*	**1.0**
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.144	0.0730	0.03	0.04	0.01	0.10
FL pepper Aerial, 0.008 lb a.i./A x 1 app	0.321	0.0309	*0.06*	0.02	0.02	0.04

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 5.1 ppb [for Rainbow Trout, *Oncorhynchus mykiss*]. Chronic RQ = use-specific 60-day EEC / 1.9 ppb [for Fathead Minnow, *Pimephales promelas*].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 16 ppb [for Sheepshead minnow, *Cyprinodon variegatus*]. Chronic RQ = use-specific 60-day EEC / 0.7 ppb [for Sheepshead minnow, *Cyprinodon variegatus*].

For freshwater fish exposed to permethrin, all the scenario RQs exceeded the acute listed LOCs (0.05), but not the non-listed species LOC (0.5). The acute RQs ranged from 0.16 to 0.44. On a chronic basis, four out of seven of the scenario RQs exceeded the non-listed LOC (1.0). The chronic RQs ranged from 0.11 to 3.0. The scenarios representing 25 applications at the maximum rate were the ones that exceeded the chronic LOC. The

scenarios representing 1 and 10 applications did not exceed the LOC.

For estuarine/marine fish exposed to permethrin on an acute basis all the RQs exceeded the listed species LOC (0.05) and none of the scenarios exceeded the non-listed species LOC (0.5). The range in acute RQs was 0.10 to 0.16. Only the CA residential scenario marginally exceeded the chronic LOC (RQs of 1.08; LOC = 1.0).

Table 30. Acute and Chronic RQs for Freshwater and Estuarine/Marine Fish Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	60-day EEC (µg/L)	FW Fish		E/M Fish	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.349	0.155	*0.44*	**3.0**	*0.16*	**1.08**
FL residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.307	0.105	*0.39*	**2.0**	*0.14*	0.73
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.308	0.113	*0.39*	**2.2**	*0.14*	0.79
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.127	0.0235	*0.16*	0.45	*0.06*	0.16
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.313	0.112	*0.40*	**2.2**	*0.14*	0.78
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.129	0.0233	*0.16*	0.44	*0.06*	0.16
FL pepper Aerial, 0.007 lb a.i./A x 1 app	0.225	0.00584	*0.28*	0.11	*0.10*	0.04

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater fish, Acute RQ = use-specific peak EEC / 0.79 ppb [for Bluegill sunfish, *Lepomis macrochirus*]. Chronic RQ = use-specific 60-day EEC / 0.052 ppb [for Bluegill sunfish, *Lepomis macrochirus*, based on an ACR].

For estuarine/marine fish, Acute RQ = use-specific peak EEC / 2.2 ppb [for Atlantic Silverside, *Menidia menidia*]. Chronic RQ = use-specific 60-day EEC / 0.143 ppb [for Atlantic Silverside, *Menidia menidia*].

7.1.2. Freshwater and Estuarine/Marine Invertebrates Risk Quotients

For freshwater invertebrates exposed to deltamethrin, all the acute RQs exceeded the listed and non-listed LOCs (acute LOCs of 0.05 and 0.5, respectively). The acute RQs ranged from 41 for the FL turf ground applications at 7-day intervals to 1000 for the FL residential scenario, when applied aerially. On a chronic basis, all of the RQs exceeded the LOC (chronic LOC = 1.0). The chronic RQs ranged from 6.1 to 400. The lowest chronic RQ was for the single application on the FL pepper scenario.

For estuarine/marine invertebrates exposed to deltamethrin, all the scenario's acute RQs exceeded the listed and non-listed species LOC (LOCs are 0.05 and 0.5, respectively). The highest acute RQ was 54 for the FL residential scenario, when applied aerially (at the limit of solubility). On a chronic basis, six out of nine of the RQs exceeded the chronic LOC (1.0). Chronic RQs ranged from 0.34 to 22. The scenarios that did not exceed the RQ were those using a 7-day interval and the single application.

Table 31. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.125	0.00310	**625**	**119**	**34**	**6.6**
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.183	0.00515	**915**	**198**	**49**	**11**
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.0128	0.00163	**64**	**63**	**3.5**	**3.5**
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.00818	0.000455	**41**	**17**	**2.2**	0.97
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	0.0128	0.00111	**64**	**43**	**3.5**	**2.4**
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.00832	0.000446	**42**	**17**	**2.6**	0.95
FL pepper Ground, 0.00134 lb a.i./A x 1 app	0.0120	0.000158	**60**	**6.1**	**3.2**	0.34
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.0211	0.00269	**106**	**103**	**5.7**	**5.7**
FL residen + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.200 (0.390)*	0.0104	**1000**	**400**	**54**	**22**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0002 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0037 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00047 ppb [for Mysid shrimp,

Americamysis bahia].

For freshwater invertebrates exposed to the pyrethrins, two out of the seven of the scenario acute RQs exceeded the listed and non-listed species LOCs (acute LOC = 0.05 for listed species and 0.5 for non-listed species). The remaining scenario exceeded the only the listed species LOC. The scenarios that exceeded both LOCs were those representing the maximum application rate and number of applications (FL turf and FL pepper). The acute RQs ranged from 0.19 to 2.2. Furthermore, all the chronic RQs exceeded the LOC (chronic LOC = 1.0). The chronic RQs ranged from 1.7 to 34.

For estuarine/marine invertebrates exposed to the pyrethrins, there were two exceedances of the acute non-listed species LOC, for the maximum application rates and number of applications (FL turf and FL pepper). For the remaining scenarios, only the acute listed species LOC was exceeded (acute listed species LOC = 0.05, and non-listed LOC = 0.5). The acute RQs ranged from 0.10 to 1.2. Additionally, three out of the seven chronic RQs exceeded the LOC (LOC = 1.0). The chronic RQs ranged from 0.27 to 5.4. Besides the two scenarios representing the maximum rate and number of applications (FL turf and FL pepper), the CA residential scenario exceeded the chronic LOC.

Table 32. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.337	0.273	*0.44*	**6.8**	*0.24*	**1.1**
FL residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.251	0.188	*0.33*	**4.7**	*0.18*	0.75
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	1.69	1.36	**2.2**	**34**	**1.2**	**5.4**
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.150	0.0853	*0.19*	**2.1**	*0.11*	0.34
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	1.63	1.29	**2.1**	**32**	**1.2**	**5.2**
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.144	0.0789	*0.19*	**2.0**	*0.10*	0.32
FL pepper Aerial, 0.008 lb a.i./A x 1 app	0.321	0.0678	*0.42*	**1.7**	*0.23*	0.27

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.76 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.04 ppb [for midge, *Chironomus dilutus*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 1.4 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.25 ppb [for Mysid shrimp, *Americamysis bahia*].

For freshwater invertebrates exposed to permethrin the acute RQs exceeded the listed and non-listed species LOCs (acute LOCs = 0.05 and 0.5, respectively) for all the scenarios tested. The range of acute RQs was 19 to 53. On a chronic basis, all the scenario RQs also exceeded the LOC (chronic LOC = 1.0). The highest chronic RQ was 40 for the CA residential scenario.

For estuarine/marine invertebrates exposed to permethrin, all the RQs exceeded the acute and chronic listed and non-listed species LOCs (all acute RQs > 0.5; all chronic RQs > 1.0). The highest acute and chronic RQs were 19 and 70, respectively, for the CA residential scenario.

Table 33. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Invertebrates		E/M Invertebrates	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.349	0.167	**53**	**40**	**19**	**70**
FL residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.307	0.116	**47**	**28**	**17**	**48**
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.308	0.124	**47**	**30**	**17**	**52**
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.127	0.0257	**19**	**6.1**	**7.1**	**11**
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.313	0.122	**47**	**29**	**17**	**51**
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.129	0.0253	**20**	**6.0**	**7.2**	**11**
FL pepper Aerial, 0.007 lb a.i./A x 1 app	0.225	0.0104	**34**	**2.5**	**13**	**4.3**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0066 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific 21-day EEC / 0.0042 ppb [for the amphipod, *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.018 ppb [for Stone crab, *Menippe mercenaria*]. Chronic RQ = use-specific 21-day EEC / 0.0024 ppb [for Mysid shrimp, *Americamysis bahia*].

7.1.3. Freshwater Benthic Invertebrates Risk Quotients

For freshwater benthic organisms exposed to deltamethrin, there were multiple exceedances of LOCs (acute listed and non-listed, and chronic). On an acute basis, all scenario RQs exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), with the exception of the FL pepper single application (exceeded only the listed species LOC). Acute RQs ranged from 0.23 to 24. On a chronic basis (pore water and sediment-based), all scenario RQs exceeded the chronic LOC (1.0). The lowest RQs were for the FL pepper single application scenario. The highest acute and chronic RQs were for the FL residential scenario representing aerial applications (RQs of 24 and 178, respectively).

Table 34. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Deltamethrin

Uses	Pore Water		Sediment		Pore Water		Sediment	
	Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residential + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.00183	0.00176	822	790	**9.2**	**68**		**66**
FL residential + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.00245	0.00232	1100	1042	**12**	**89**		**87**
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.000912	0.000872	410	392	**4.6**	**34**		**33**
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.000252	0.000238	113	107	**1.3**	**9.2**		**8.9**
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	0.000424	0.000399	190	179	**2.1**	**15**		**15**
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.000241	0.000227	108	102	**1.2**	**8.7**		**8.5**
FL pepper Ground, 0.00134 lb a.i./A x 1 app	4.51×10^{-5}	4.33×10^{-5}	20.3	19.4	*0.23*	**1.7**		**1.6**
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.00151	0.00144	678	647	**7.6**	**55**		**54**
FL residential + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.00488	0.00462	2191	2075	**24**	**178**		**173**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0002 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 12 µg/kg$_{OC}$ [for *Hyalella azteca*].

For freshwater benthic organisms exposed to the pyrethrins, there were two scenarios that exceeded the acute listed and non-listed LOCs (0.05 and 0.5, respectively). These scenarios were the FL turf and FL pepper, at the maximum application rate and number of applications (RQs of 0.66 to 0.61, respectively). Of the four remaining scenarios, they

exceeded the listed species LOC except for the FL pepper single application, with an RQ of only 0.03. The pore water-based and sediment-based RQs were different in magnitude. On a chronic basis, based on pore water EECs and its associated endpoint, all but one of the seven scenarios exceeded the chronic LOC (1.0). The only scenario that did not exceed the LOC is the single application (RQ = 0.48). The RQs ranged from 0.48 to 12.

Table 35. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Pyrethrins

Uses	Pore Water		Sediment		Pore Water		Sediment	
	Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.185	0.182	55.8	54.9	*0.24*	**4.6**		**1.3**
FL residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.117	0.113	35.3	34.1	*0.15*	**2.8**		0.83
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	0.501	0.485	151	146	**0.66**	**12**		**3.6**
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.0528	0.0513	15.9	15.5	*0.07*	**1.3**		0.38
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	0.467	0.450	141	136	**0.61**	**11**		**3.3**
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.0482	0.0466	14.5	14.0	*0.06*	**1.2**		0.34
FL pepper Aerial, 0.008 lb a.i./A x 1 app	0.0199	0.0192	6.00	5.79	0.03	0.48		0.14

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.76 ppb [water column test for the Amphipod, *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.04 ppb [for Midge, *Chironomus dilutus*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 41 µg/kg$_{-dw}$ [for Midge, *Chironomus dilutus*].

For freshwater benthic organisms exposed to permethrin, all the scenarios exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), and the chronic LOC (1.0). The acute RQs ranged from 0.56 to 19. The range in chronic RQs was 1.6 for the single application (FL peppers) to 53 (for the CA residential scenario). The pore water based RQs were slightly lower than the sediment-based RQs.

Table 36. Summary of Acute and Chronic RQs for Aquatic Freshwater Benthic Invertebrates Exposed to Permethrin

Uses	Pore Water		Sediment		Pore Water		Sediment	
	Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.125	0.124	398	395	**19**	**30**		**53**
FL residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.0736	0.0716	235	228	**11**	**17**		**31**

Uses	Pore Water		Sediment		Pore Water		Sediment	
	Peak EEC (µg/L)	**21-day EEC (µg/L)**	**Peak EEC (µg/kg$_{dw}$)**	**21-day EEC (µg/kg$_{dw}$)**	**Acute RQ#**	**Chronic RQ#**	**Acute RQ#**	**Chronic RQ#**
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.0823	0.0804	262	256	**12**	**19**		**35**
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.0167	0.0162	53.2	51.6	**2.5**	**3.9**		**7.0**
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.0801	0.0782	255	249	**12**	**19**		**34**
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.0163	0.0158	51.9	50.3	**2.5**	**3.8**		**6.8**
FL pepper Aerial, 0.007 lb a.i./A x 1 app	0.00368	0.00361	11.7	11.5	**0.56**	0.86		**1.6**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0066 ppb [water column test for the amphipod *Hyalella azteca*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0042 ppb [for the amphipod, *Hyalella azteca*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 7.4 µg/kg$_{-dw}$ [for the amphipod, *Hyalella azteca*].

7.1.4. Estuarine/Marine Benthic Invertebrates Risk Quotients

For estuarine/marine benthic invertebrates exposed to deltamethrin, two out of nine of scenarios exceeded only the acute listed and non-listed species LOC (listed LOC = 0.05, non-listed LOC = 0.5). Of the remaining seven scenarios, one did not exceed the acute listed species LOC (single application, FL pepper, ground application). The highest acute RQ was 1.3 for the FL residential scenario (aerial application). The range in acute RQs was 0.01 to 1.3. Five out of the nine scenarios exceeded the chronic LOC (1.0). The range in chronic RQs was 0.09 to 9.8.

Table 37. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Deltamethrin

Uses	Pore Water		Sediment		Pore Water	
	Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{oc}$)	21-day EEC (µg/kg$_{oc}$)	Acute RQ#	Chronic RQ#
CA residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.00183	0.00176	822	790	*0.49*	**3.7**
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.00245	0.00232	1100	1042	**0.66**	**4.9**
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.000912	0.000872	410	392	*0.24*	**1.9**
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.000252	0.000238	113	107	*0.07*	0.51
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	0.000424	0.000399	190	179	*0.11*	0.85
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.000241	0.000227	108	102	*0.06*	0.48
FL pepper Ground, 0.00134 lb a.i./A x 1 app	4.51×10^{-5}	4.33×10^{-5}	20.3	19.4	0.01	0.09
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.00151	0.00144	678	647	*0.41*	**3.1**
FL residen + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.00488	0.00462	2191	2075	**1.3**	**9.8**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.0037 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.00047 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = N/A [no sediment study was submitted].

For estuarine/marine benthic invertebrates exposed to pyrethrins, four out of seven of the acute RQs exceeded the listed species LOC (0.05), but not the non-listed species LOC (0.5). The range in acute RQs was 0.01 to 0.36. The highest acute RQ of 0.36 was for the FL turf scenario at the maximum application rate. Of the chronic RQs, two marginally exceeded the LOC (1.0) as follows: FL turf and FL peppers at the maximum application rate and number of applications. For these two scenarios, the range of chronic RQs was 1.8 to 1.9. For the remaining scenarios, the chronic RQs were 0.08 to 0.73.

Table 38. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Pyrethrins

Uses	Pore Water		Sediment		Pore Water	
	Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.185	0.182	55.8	54.9	*0.13*	0.73
FL residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.117	0.113	35.3	34.1	*0.08*	0.45
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	0.501	0.485	151	146	*0.36*	**1.9**
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.0528	0.0513	15.9	15.5	0.04	0.20
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	0.467	0.450	141	136	*0.33*	**1.8**
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.0482	0.0466	14.5	14.0	0.03	0.19
FL pepper Aerial, 0.008 lb a.i./A x 1 app	0.0199	0.0192	6.00	5.79	0.01	0.08

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 1.4 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.25 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. No sediment toxicity study was submitted.

For estuarine/marine benthic invertebrates exposed to permethrin all the scenarios exceeded the acute listed and non-listed species LOCs (0.05 and 0.5, respectively), with the exception of a single application (FL peppers). The range in acute RQs was 0.20 to 6.9. Furthermore, for all the scenarios tested, the pore-water based RQs exceeded the chronic LOC (1.0). The pore water-based chronic RQs were higher than the sediment-based RQs. The reason is that the water column test with mysid shrimp, *Americamysis bahia*, used in pore water, yielded more sensitive endpoints than the sediment study, conducted with the amphipod, *Leptocheirus plumulosus*. The range in chronic RQs was 1.5 to 52 (pore water based), and 0.30 to 10 (sediment based).

Table 39. Summary of Acute and Chronic RQs for Aquatic Estuarine/Marine Benthic Invertebrates Exposed to Permethrin

Uses	Pore Water		Sediment		Pore Water		Sediment	
	Peak EEC (µg/L)	21-day EEC (µg/L)	Peak EEC (µg/kg$_{dw}$)	21-day EEC (µg/kg$_{dw}$)	Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
CA residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.125	0.124	398	395	**6.9**	**52**		**10**
FL residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.0736	0.0716	235	228	**4.1**	**30**		**6.0**
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.0823	0.0804	262	256	**4.6**	**34**		**6.7**

Uses	Pore Water		Sediment		Pore Water		Sediment	
	Peak EEC (µg/L)	**21-day EEC (µg/L)**	**Peak EEC (µg/kg$_{dw}$)**	**21-day EEC (µg/kg$_{dw}$)**	**Acute RQ#**	**Chronic RQ#**	**Acute RQ#**	**Chronic RQ#**
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.0167	0.0162	53.2	51.6	**0.93**	**6.8**		**1.4**
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.0801	0.0782	255	249	**4.5**	**33**		**6.6**
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.0163	0.0158	51.9	50.3	**0.91**	**6.6**		**1.3**
FL pepper Aerial, 0.007 lb a.i./A x 1 app	0.00368	0.00361	11.7	11.5	0.20	**1.5**		0.30

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used. +G=ground; GR=granular.

= LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

Acute pore water RQ = use-specific pore water peak EEC / 0.018 ppb [water column test for the Stone crab, *Menippe mercenaria*]. Chronic pore water RQ = use-specific pore water 21-day EEC / 0.0024 ppb [water column test for Mysid shrimp, *Americamysis bahia*]. Chronic sediment RQ = use-specific sediment 21-day EEC normalized for organic carbon content / 38 µg/kg$_{-dw}$ [for the amphipod, *Leptocheirus plumulosus*].

7.1.5. Vascular and Non-Vascular Aquatic Plants Risk Quotients

For vascular plants exposed to pyrethrins there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). For vascular plants, all the RQs were <0.01, for listed and non-listed plants. For non-vascular plants exposed to pyrethrins, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to 0.06.

Table 40. Acute RQs for Vascular and Non-vascular Plants Exposed to Pyrethrins

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
CA residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.337	<0.01	<0.01	0.01	<0.01
FL residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	0.251	<0.01	<0.01	0.01	<0.01
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	1.69	<0.01	<0.01	0.06	0.02
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.150	<0.01	<0.01	0.01	<0.01
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	1.63	<0.01	<0.01	0.06	0.02
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.144	<0.01	<0.01	<0.01	<0.01
FL pepper Aerial, 0.008 lb a.i./A x 1 app	0.321	<0.01	<0.01	0.01	<0.01

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 480 ppb [NOAEC = 480 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 1230 ppb [EC_{50} of 1230 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 29 ppb [NOAEC = 29 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC/ 105 ppb [EC_{50} = 105 ppb for green algae, *Pseudo-kirchneriella subcapitata*].

For vascular plants exposed to deltamethrin there were no exceedances of the acute listed and non-listed species LOC (LOC = 1.0). For vascular plants, all the RQs were <0.01, for listed and non-listed plants. For non-vascular plants exposed to deltamethrin, all the listed and non-listed RQs were below the LOC (1.0). The RQ values were very low in all instances, ranging from <0.01 to 0.06.

Table 41. Acute RQs for Vascular and Non-vascular Plants Exposed to Deltamethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
CA residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.125	<0.01	<0.01	0.04	<0.04
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.183	<0.01	<0.01	0.06	<0.06
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	0.0128	<0.01	<0.01	<0.01	<0.01
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.00818	<0.01	<0.01	<0.01	<0.01
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	0.0128	<0.01	<0.01	<0.01	<0.01
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	0.00832	<0.01	<0.01	<0.01	<0.01
FL pepper Ground, 0.00134 lb a.i./A x 1 app	0.0120	<0.01	<0.01	<0.01	<0.01
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.0211	<0.01	<0.01	0.01	<0.01
FL residen + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	0.200 (0.390)*	<0.01	<0.01	0.06	<0.06

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 779 ppb [NOAEC = 779 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 779 ppb [EC_{50} of >779 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 3.1 ppb [NOAEC = 3.1 ppb for freshwater diatom, *Navicula pelliculosa*]; the non-listed species acute RQ = use-specific peak EEC / 3.1 ppb [EC_{50} >3.1 ppb for freshwater diatom, *Navicula pelliculosa*].

For vascular plants exposed to permethrin, all the RQs were below the LOCs in all cases (LOC for listed and non-listed aquatic plants = 1.0). The range of RQs was <0.04 to 0.11, for listed and non-listed species. For non-vascular plants, all the RQs were also below the LOC in all cases. For non-listed and listed non-vascular plants exposed to permethrin, the RQs ranged from <0.03 to 0.54 in all instances.

Table 42. Acute RQs for Vascular and Non-vascular Plants Exposed to Permethrin

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
CA residential + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.349	0.11	<0.11	0.54	<0.08
FL residential + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.307	0.10	<0.10	0.47	<0.07

Scenario/Uses	Peak EEC (µg/L)	Vascular Plants		Non-vascular Plants	
		Listed Acute RQ#	Non-Listed Acute RQ#	Listed Acute RQ#	Non-Listed Acute RQ#
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.308	0.10	<0.10	0.47	<0.07
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.127	0.04	<0.04	0.20	<0.03
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	0.313	0.10	<0.10	0.48	<0.07
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	0.129	0.04	<0.04	0.20	<0.03
FL pepper Aerial, 0.007 lb a.i./A x 1 app	0.225	0.07	<0.07	0.34	<0.05

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

= LOC for acute risk 1, and acute listed species 1.

For vascular plants, the listed species acute RQ = use-specific peak EEC / 3.2 ppb [NOAEC = 3.2 for duckweed, *Lemna gibba*]; the non-listed species acute RQ = use-specific peak EEC / 3.2 ppb [IC_{50} of >3.2 for duckweed, *Lemna gibba*].

For non-vascular plants, the listed species acute RQ = use-specific peak EEC / 0.65 ppb [NOAEC = 0.65 ppb for green algae, *Pseudo-kirchneriella subcapitata*]; the non-listed species acute RQ = use-specific peak EEC / 4.4 ppb [IC_{50} > 4.4 ppb, for green algae, *Pseudo-kirchneriella subcapitata*].

7.2. Risk Description

7.2.1. Main Factors Affecting the Risk Quotients

One of the major factors that affect the risk quotients for the synthetic pyrethroids and pyrethrins is their toxicity to aquatic animals. As indicated earlier, previous assessments had shown the potential for hazard of these chemicals to aquatic animals, and for risk concerns in agricultural settings.

Pyrethroids and pyrethrins can be characterized as very highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute basis (*i.e.*, LC_{50} or EC_{50} <0.1 mg/L). Freshwater fish are generally more sensitive to pyrethroids and pyrethrins than estuarine/marine fish on an acute and chronic basis. In general, freshwater invertebrates are more sensitive to pyrethroids than estuarine/marine invertebrates on an acute basis. On a chronic basis, a trend is not clear for freshwater invertebrates, when compared to estuarine/marine invertebrates. Freshwater and estuarine/marine invertebrates are orders of magnitude more sensitive to pyrethroids and pyrethrins than freshwater and estuarine/marine fish. Vascular and non-vascular plants endpoints for the pyrethroids for which data are available indicate that these organisms are much less sensitive than aquatic animals.

The use information utilized in the risk assessment is another factor that could affect the risk quotients. For adulticides, the label information is very important in determining the potential spray drift towards the standard pond, which was found to be much higher than for standard or typical agricultural applications. For this reason, example representative labels were described in this part of the PRA. The spray drift value assumed a wind speed of 3 mph; however, since adulticide uses are designed to remain in the air, it is possible that the values of spray drift and application efficiencies are overestimations. These values drift and efficiency were determined, based on conservative input values in AGDISP.

7.2.2. Summary of Risk Quotients

Tables 28 to **42** (above), provided detailed RQ tables including EECs and endpoints used for each pyrethroid and for the pyrethrins (see also the footnotes in those tables). **Tables 43** to **45** provide overall summaries of all the risk quotients for freshwater and estuarine/marine animals for pyrethroids and pyrethrins, for the uses assessed. The summary tables below are presented to show trends for each chemical and across chemicals.

Acute and chronic risks quotients (RQs) for freshwater and estuarine/marine fish were generally orders of magnitude lower than for freshwater and estuarine/marine invertebrates. For freshwater fish, there were a fewer exceedances of the acute and chronic LOCs, compared to invertebrates, and further, for estuarine/marine fish there were even

fewer exceedances of acute and chronic LOCs. For deltamethrin, some of the peak EECs were limited by the solubility of the compound. Refer to the EEC or RQ tables for the particular runs for which this occurred. Deltamethrin is the chemical that shows the highest freshwater invertebrates risk quotients. In these tables, when the EEC exceeded the limit of solubility, the EEC from the run was added in a (parenthesis) for informative purposes. The pyrethroids are highly hydrophobic, and should not be bioavailable above the limit of solubility.

No RQ *summary tables* were presented for vascular and non-vascular plants, since for these species there were no exceedances of the listed and/or non-listed species LOC (LOC = 1.0) for any of the pyrethroids for which aquatic plant data were available (aquatic plant toxicity data were available for 8 out of 9 chemicals, or 3 out of 3 chemicals involved in this part of the PRA). Based on the above information, and in the absence of further data, it is presumed that no risks of concern are present for the remaining chemical for aquatic plants.

Table 43. Summary of Risk Quotients for Certain Non-agricultural and Urban Adulticidal Uses of Pyrethrins for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	*0.07*	0.13	0.02	0.35	*0.44*	**6.8**	*0.24*	**4.6**	*0.24*	**1.1**	*0.13*	0.73
FL residen + impervious Aerial, 0.0025 lb a.i./A x 25 @ 3 days	*0.05*	0.09	0.02	0.25	*0.33*	**4.7**	*0.15*	**2.8**	*0.18*	0.75	*0.08*	0.45
FL turf Aerial, 0.008 lb a.i./A x 25 @ 3 days	*0.33*	0.41	*0.11*	**1.1**	**2.2**	**34**	**0.66**	**12**	**1.2**	**5.4**	*0.36*	**1.9**
FL turf Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.03	0.04	0.01	0.11	*0.19*	**2.1**	*0.07*	**1.3**	*0.11*	0.34	0.04	0.20
FL pepper Aerial, 0.008 lb a.i./A x 25 @ 3 days	*0.32*	0.38	*0.10*	**1.0**	**2.1**	**32**	**0.61**	**11**	**1.2**	**5.2**	*0.33*	**1.8**
FL pepper Aerial, 0.0025 lb a.i./A x 10 @ 7 days	0.03	0.04	0.01	0.10	*0.19*	**2.0**	*0.06*	**1.2**	*0.10*	0.32	0.03	0.19
FL pepper Aerial, 0.008 lb a.i./A x 1 app	*0.06*	0.02	0.02	0.04	*0.42*	**1.7**	0.03	0.48	*0.23*	0.27	0.01	0.08

RQs with *italics* font and shaded light grey exceed only the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 44. Summary of Risk Quotients for Certain Non-agricultural and Urban Adulticidal Uses of Deltamethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	**0.83**	0.15	*0.22*	0.10	**625**	**119**	**9.2**	**68**	**34**	**6.6**	*0.49*	**3.7**
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days	**1.2**	0.24	*0.32*	0.17	**915**	**198**	**12**	**89**	**49**	**11**	**0.66**	**4.9**
FL turf Ground, 0.00134 lb a.i./A x 25 @ 3 days	*0.09*	0.09	0.02	0.06	**64**	**63**	**4.6**	**34**	**3.5**	**3.5**	*0.24*	**1.9**
FL turf Ground, 0.00089 lb a.i./A x 10 @ 7 days	*0.05*	0.02	0.01	0.02	**41**	**17**	**1.3**	**9.2**	**2.2**	0.97	*0.07*	0.51
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days	*0.09*	0.04	0.02	0.03	**64**	**43**	**2.1**	**15**	**3.5**	**2.4**	*0.11*	0.85
FL pepper Ground, 0.00089 lb a.i./A x 10 @ 7 days	*0.06*	0.02	0.01	0.02	**42**	**17**	**1.2**	**8.7**	**2.6**	0.95	*0.06*	0.48
FL pepper Ground, 0.00134 lb a.i./A x 1 app	*0.08*	<0.01	0.02	<0.01	**60**	**6.1**	*0.23*	**1.7**	**3.2**	0.34	0.01	0.09
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days	*0.14*	0.14	0.04	0.10	**106**	**103**	**7.6**	**55**	**5.7**	**5.7**	*0.41*	**3.1**
FL residen + impervious Aerial, 0.00134 lb a.i./A x 25 @ 3 days	**1.3**	0.48	*0.34*	0.34	**1000**	**400**	**24**	**178**	**54**	**22**	**1.3**	**9.8**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

Table 45. Summary of Risk Quotients for Certain Non-agricultural and Urban Adulticidal Uses of Permethrin for Freshwater and Estuarine/Marine Fish and Invertebrates

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
CA residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	*0.44*	**3.0**	*0.16*	**1.08**	**53**	**40**	**19**	**53**	**19**	**70**	**6.9**	**52**

Description	Risk Quotients											
	FW Fish		E/M Fish		FW Inverts WC		FW Benthic Inverts		E/M Inverts WC		E/M Benthic Inverts	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
FL residen + impervious Aerial, 0.007 lb a.i./A x 25 @ 3 days	*0.39*	**2.0**	*0.14*	0.73	**47**	**28**	**11**	**31**	**17**	**48**	**4.1**	**30**
FL turf Aerial, 0.007 lb a.i./A x 25 @ 3 days	*0.39*	**2.2**	*0.14*	0.79	**47**	**30**	**12**	**35**	**17**	**52**	**4.6**	**34**
FL turf Aerial, 0.0035 lb a.i./A x 10 @ 7 days	*0.16*	0.45	*0.06*	0.16	**19**	**6.1**	**2.5**	**7.0**	**7.1**	**11**	**0.93**	**6.8**
FL pepper Aerial, 0.007 lb a.i./A x 25 @ 3 days	*0.40*	**2.2**	*0.14*	0.78	**47**	**29**	**12**	**34**	**17**	**51**	**4.5**	**33**
FL pepper Aerial, 0.0035 lb a.i./A x 10 @ 7 days	*0.16*	0.44	*0.06*	0.16	**20**	**6.0**	**2.5**	**6.8**	**7.2**	**11**	**0.91**	**6.6**
FL pepper Aerial, 0.007 lb a.i./A x 1 app	*0.28*	0.11	*0.10*	0.04	**34**	**2.5**	**0.56**	**1.6**	**13**	**4.3**	0.20	**1.5**

RQs with *italics* font and shaded light grey exceed the acute listed species LOC (acute listed species LOC = 0.05); RQs with a **bold** font and shaded dark grey exceed the listed and non-listed species LOCs (acute non-listed species LOC = 0.5; chronic non-listed species LOC = 1.0). WC = Water Column.

7.2.3. EPA's Experimental PWC v.1.53, Calculated PRBEN

PWG has provided comments on the PRBEN function of the PWC, which represents the initial distribution of eroded phase pesticide between the sediment (benthic zone) and the water column. The PWG had argued that setting a value of 0.5 for all chemicals was not appropriate, especially for the pyrethroids, which have high K_{OC} values and are transported preferentially by soil erosion rather than by runoff. In such cases, the PWG reasoned that the pyrethroids would be quickly transported to the benthic zone in proportions greater than suggested by the default PRBEN value of 0.5 and acute water column concentrations should be lower. Following up on these PWG concerns, EFED issued an experimental version of the PWC (v. 1.53, dated 03/17/2016). This version of the model incorporates an alternative to the fixed PRBEN function. For this new version, during a runoff-erosion event, incoming pesticide (whether entering by runoff, erosion, or drift) equilibrates instantaneously with the water column which includes any eroded solids that may have entered during the event. After equilibrations calculations are performed, any pesticide that remains sorbed to the suspended solids is distributed to the benthic zone instantaneously and does not contribute to peak water column concentrations. Any pesticide that remains in the aqueous phase remains in the water column and does contribute to peak concentrations. This conceptualization is more in line with the

equilibrium concept upon which the PWC components are built, is not overly mechanistic nor overly parameterized like sedimentation models, and was endorsed by the SAP in 2008.

EFED selected a number of scenarios for one chemicals (deltamethrin). The three representative scenarios were run at the maximum rate and number of applications. They were run both ways (constant PRBEN = 0.5 and calculated PRBEN). Comparing the water column, pore water and sediment EECs, they were nearly the same for the default PRBEN *vs.* the alternative calculation of PRBEN for deltamethrin.

Table 46. Water Column, Pore Water, and Sediment EECs for Deltamethrin, for Standard Runs & Runs Using the PWC v.1.53[1]												
Scenario (bold font)/ Crops/Uses Represented	**App Method**	**App Rate (lb a.i./A)**	**Date of First Application (dd-mm)**	**Number of Apps**	**App Interval (days)**	**Water Column**			**Pore Water**		**Sediment**	
						Peak EEC (µg/L)	**21-day average EEC (µg/L)**	**60-day average EEC (µg/L)**	**Peak EEC (µg/L)**	**21-day average EEC (µg/L)**	**Peak EEC (µg/kg$_{oc}$)**	**21-day average EEC (µg/kg$_{oc}$)**
FL residential + impervious *Constant PRBEN = 0.5*	Ground ULV	0.00150 (0.00134)	01-06	25	3	0.183	0.00515	0.00414	0.00245	0.00232	1100	1042
FL pepper *Constant PRBEN = 0.5*	Ground ULV	0.00150 (0.00134)	01-06	10	3	0.0128	0.00111	0.000717	0.000424	0.000399	190	179
FL turf *Constant PRBEN = 0.5*	Aerial ULV	0.00150 (0.00134)	01-06	25	3	0.0211	0.00269	0.00242	0.00151	0.00144	678	647
FL residential + impervious *Variable PRBEN*	Ground ULV	0.00150 (0.00134)	01-06	25	3	0.183	0.00516	0.00414	0.00245	0.00232	1100	1042
FL pepper *Variable PRBEN*	Ground ULV	0.00150 (0.00134)	01-06	10	3	0.0127	0.00111	0.000714	0.000424	0.000399	190	179
FL turf *Variable PRBEN*	Aerial ULV	0.00150 (0.00134)	01-06	25	3	0.0211	0.00269	0.00242	0.00151	0.00144	678	647

[1] EECs were rounded to three significant figures.

For these adulticide scenarios, the actual eroded materials (*i.e.*, soil) appear to be low so that it does not affect the suspended solids concentration. The reason is that the values of spray drift for the adulticide applications is very high and therefore, the spray drift constitutes a very large component of the EECs. In these instances, the actual effective (calculated) PRBEN may actually be similar to the standard default value of 0.5. Hence the concentrations are the same for those scenarios with comparatively low amounts of eroded material. Additionally, spray drift is a contributor to the EEC values and inputs from spray drift occur independently of erosion events and thus will tend to temper differences in the results of the two PRBEN methods.

Table 47 summarizes the freshwater invertebrates RQs, which are among the most sensitive species to the pyrethroids. The acute and chronic RQs are the same using the variable PRBEN; the risk picture is the same.

Table 47. Acute and Chronic RQs for Freshwater and Estuarine/Marine Invertebrates Exposed to Deltamethrin, Using Constant PRBEN = 0.5 and Calculated PRBEN

Scenario/Uses	Peak EEC (µg/L)	21-day EEC (µg/L)	FW Inverts		E/M Inverts	
			Acute RQ#	Chronic RQ#	Acute RQ#	Chronic RQ#
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days *Constant PRBEN = 0.5*	0.183	0.00515	**915**	**198**	**49**	**7.1**
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days *Constant PRBEN = 0.5*	0.0128	0.00111	**64**	**43**	**3.5**	**1.5**
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days *Constant PRBEN = 0.5*	0.0211	0.00269	**106**	**103**	**5.7**	**3.7**
FL residen + impervious Ground, 0.00134 lb a.i./A x 25 @ 3 days *Variable PRBEN*	0.183	0.00516	**915**	**198**	**49**	**7.1**
FL pepper Ground, 0.00134 lb a.i./A x 10 @ 3 days *Variable PRBEN*	0.0127	0.00111	**64**	**43**	**3.4**	**1.5**
FL turf Aerial, 0.00134 lb a.i./A x 25 @ 3 days *Variable PRBEN*	0.0211	0.00269	**106**	**103**	**5.7**	**3.7**

Generally, numbers were rounded to three significant figures, except for the RQs, for which no more than two decimal places were used.

* EECs marked with an asterisk were set to 0.200 ppb because they exceeded the limit of solubility of deltamethrin in the aquatic modeling.

= LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0, for listed species) are shaded. A light shaded and italics "*RQ*" means it exceeds the listed species LOC. A dark shaded and bolded "**RQ**" represents LOC exceedances of the listed species and non-listed species LOCs.

For freshwater invertebrates, Acute RQ = use-specific peak EEC / 0.0002 ppb [for Amphipod, *Hyalella azteca*]. Chronic RQ = use-specific pore water 21-day EEC / 0.000026 ppb [for *Hyalella azteca*].

For estuarine/marine invertebrates, Acute RQ = use-specific peak EEC / 0.0037 ppb [for Mysid shrimp, *Americamysis bahia*]. Chronic RQ = use-specific 21-day EEC / 0.00073 ppb [for Mysid shrimp, *Americamysis bahia*].

7.2.4. Co-Applied and Co-Formulated Synergists

Synergists are often co-applied or co-formulated with pyrethrins and many of the pyrethroids. Piperonyl butoxide (PBO) is the chief synergist for outdoor uses. The synergistic action is important because of the pyrethrins and pyrethroids mode of action (see **Section 3.1**). In short, natural pyrethrins quickly penetrate the neural system and induce temporary paralysis in target organisms, resulting in an effective "knockdown" action, but do not have high killing properties by themselves because they are quickly metabolized, being at best, moderately persistent. To achieve lethality, the metabolic action is delayed (extended) by the co-application of a synergist that provides an alternative substrate for the mixed-function oxidase (MFO) enzyme system. Although, this synergistic toxicity enhancement applies most directly to the pyrethrins, it also applies to varying (and not yet well-defined) degrees to the synthetic pyrethroids (Wickham, 1998), which were developed in part to overcome the rapid breakdown. Refer to **Section 7.2.8** of Part III of the PRA for additional characterization of PBO synergism to pyrethroids and pyrethrins. It should be emphasized that of the three chemicals assessed in this part of the PRA: pyrethrins, permethrin and deltamethrin, two of them are formulated with PBO in the example products assessed (pyrethrins and permethrin).

7.2.5. Uncertainties

Environmental Fate Database and Uncertainties

For the eight pyrethroids plus pyrethrins, evaluated in this overall PRA, the environmental fate database was complete or nearly complete. For the environmental fate database and uncertainties for these chemicals, refer to **Section 7.2.8.1** of **Part II** of the PRA.

Exposure Issues

Meteorological data and scenario profiles, as well as best professional judgment, were used to establish an application date for modeling; however, the selected date may not represent the intended or actual application dates. For the adulticide applications, a date for the first application was selected as June 1, since they are more likely to occur towards the summer months. The application date used for model runs can significantly alter the EECs; thus, EECs reported could over or under predict actual exposure. It is unclear how much each of the application dates differ from the typical timing of application, which is based on pest pressure.

According to the labels, all pyrethroids share a common mode of action, to which target pests can develop resistance if the chemicals are applied consecutively or repeatedly in the same field and/or in consecutive years with other chemicals belonging to the same group of insecticides. For that reason, it is recommended to avoid consecutive use of the pyrethroid insecticides and to base pyrethroid's use on a comprehensive Integrated Pest Management program. In this assessment, the minimum interval between applications,

and the maximum application rate, were used for each crop use. It is uncertain whether this use pattern would be typical in the field. It appears unlikely that users will apply each chemical under these circumstances, and on a yearly basis for 30 consecutive years, as assumed in the modeling performed in this preliminary ecological risk assessment. The frequency at which actual uses approach this maximum use scenario may be dependent on pest resistance, timing of applications, cultural practices, and market forces.

For the pyrethroids, the photolytic behavior depends on the specific chemical. For example, for cypermethrin, esfenvalerate and cyhalothrins, the half-lives range from 9-36 days, while for cyfluthrins, pyrethrins and fenpropathrin the aqueous photolysis half-lives are <1 day. For chemicals with short photolytic half-lives, the photolysis process is expected to occur only near the surface of the water body. Furthermore, it appears that only the portion of pyrethroid reaching surface waters via spray drift is subject to photolysis.

Use Information

In the PRA, for certain pyrethroids, such as permethrin and for pyrethrins, EFED did not have Use Summary Tables (USTs) provided by the registrant. For permethrin, the latest LUIS report, issued by the Biological and Economic Analysis Division (BEAD) was used, plus the RED table. For the pyrethrins, the Table A from the RED, which summarizes all the uses of the chemical (agricultural and non-agricultural) was relied upon. Uncertainties may arise as a result of the use of these reports. The USTs are tables provided by the registrant that summarize the uses, application rates, and intervals, which the registrant is willing to support. However, since this part of the PRA deals with the mosquito adulticide applications, via ULV, the use information was derived from example labels for permethrin and pyrethrins, and corroborated with other labels for the same chemicals. For deltamethrin, there is only one product containing the active ingredient that is applied via ULV against mosquitoes, which was used to derive the exposure estimates. Additionally, spray drift factors and droplet size spectra were derived from the labels, and compared against PR Notice 2005-1 requirements.

Ecological Effects Database and Uncertainties

Although the aquatic toxicity dataset was fairly robust for this group of chemicals, some data gaps and uncertainties were present. For the ecological effects database and uncertainties for the pyrethroids and pyrethrins, refer to **Section 7.2.8.5** of **Part II** of the PRA.

Spray Drift Modeling with AGDISP

Many of the inputs in AGDISP were kept at their default values, while others were modified to fit the specified label recommendations. The droplets were user defined in all instances. The relative humidity was set to 90% and the temperature to 85°F, which are conditions conducive to mosquito growth.

For AGDISP, a wind speed of 3 mph was assumed, this was the lowest wind speed that could be modeled, since at 2 mph, the model yielded an out of range result for all three chemicals. Further, for the aerial applications, three flight lines were assumed in a 500 ft swath width, in contrast to the traditional 20 flight lines and 60 ft swath width used in conventional agricultural aerial modelling. Given that mosquito control applications occur most often early in the morning or late in the afternoon, a low wind speed is expected to occur in the field. The wind speed has been found to be among the most important factors in estimating spray drift and application efficiency for aerial ULV applications.

For the aerial applications, values of spray drift and application efficiency were derived by modelling with AGDISP. It was observed that the percent drift towards the standard pond were very high, if compared against the conventional agricultural modelling. The modelling was done simulating conditions at dawn or dusk, when wind speeds decrease, and with high temperatures and relative humidities, most likely encountered when mosquitoes grow.

For deltamethrin, for which labeled applications allow only ground methods, the spray drift and application efficiency were derived partially from modelling, and from results of field studies. The values of spray drift for the ground applications were nearly one half the ones than for the aerial applications. As a result, the EECs obtained for the ground applications were approximately half as high as for the aerial applications. Since drift appears to be the highest component of the EECs, this is not surprising. For the aerial applications, the estimate of drift was 54.4%, compared to 33% used in the ground applications. The value of 54.4% was based on AGDISP modelling alone, while for the ground applications 33% was based on modelling and monitoring results.

For the deltamethrin product and draft label, the droplets for the aerial applications are relatively large, especially the $D_{v0.9}$ (for the aerial applications, $D_{v0.5} \leq 60$ µm, and $D_{v0.9} \leq 115$ µm). Based on these specifications, the value of spray drift was found to be 54.4%. Deltamethrin, as opposed to any other pyrethroid adulticide in the market, is a Type II pyrethroid, and it is water-based.

Aquatic Modeling with the PWC

For the PWC aquatic modeling uncertainties, refer to **Section 7.2.8.6** of **Part II** of the PRA.

Uncertainties Regarding Dilution and Chemical Transformations in Estuaries

The uncertainties regarding dilution and chemical transformations in estuaries are described in **Section 7.2.8.7** of **Part II** of the PRA.

8. Conclusions

For the adulticidal applications of pyrethroids and pyrethrins, the risk hypothesis stated the following (**Section 3.4.1**):

Pyrethroids and Pyrethrins, when used outdoors in agricultural and non-agricultural environments in accordance with registered labels, and applied via ULV sprays, will likely lead to off-site movement of the compound via spray drift, runoff and eroded soil, leading to exposure of nontarget aquatic animals and plants. Based on information on the environmental fate, mode of action, direct toxicity and potential indirect effects, EFED assumes that registered uses of pyrethroids and pyrethrins as adulticides have the potential to cause reduced survival, growth, and reproduction to non-target aquatic animals, but not to non-target aquatic plants.

Based on this analysis, the greatest potential for risks occurs for aquatic invertebrates which inhaabit both pelagic and benthic habitats, resulting in a potential reduction in survival, growth and reproduction to non-target aquatic animals. This occurs despite the very low application rates for pyrethrins, permethrin and deltamethrin adulticide uses (up to 0.008 lb a.i./A/application for pyrethrins, 0.007 lb a.i./A/application for permethrin and 0.0134 lb a.i./A/application for deltamethrin). Further, this is an indication of the exceptionally high sensitivity of aquatic invertebrates to these chemicals with acute toxicity values approaching 1 ng a.i./L and chronic toxicity values below 1 ng a.i./L in some cases. Both acute and chronic RQ values exceeded their respective LOCs for many or a majority of application scenarios evaluated, particularly for permethrin and deltamethrin (**Tables 43 to 45**). Generally the freshwater aquatic invertebrate RQs were higher than the estuarine/marine invertebrates RQs. For *freshwater invertebrates* in the water column, the acute/chronic maximum RQs were 2.2/34 for pyrethrins, 1000/400 for deltamethrin, and 47/30 for permethrin. Organisms that depend on aquatic invertebrates for food may be indirectly at risk as well.

Unlike aquatic invertebrates, acute risks to fish (freshwater and estuarine/marine) were lower and mainly indicated for deltamethrin and permethrin. For pyrethrins, exceedances occurred when the maximum application rate and number of applications were used. No risks are indicated for aquatic plants from these pyrethroid uses, based on the available data. In general, the RQs for aquatic plants were below the LOCs and are considered at less risk. The pyrethrins show the lowest persistence values of all three chemicals. This is plainly illustrated in the aqueous photolysis study, which shows a half-life of 0.49 days for pyrethrins, and 86-94 days for permethrin and deltamethrin. However, in surface waters, the aqueous photodegradation process takes place mainly in the upper surficial layer of clear water. In lower layers, the light does not penetrate as strongly in order to break down a susceptible compound.

As an additional line of evidence, a review of the OPP Incident Data System which now incorporates the Ecological Incident Information System (EIIS) database was conducted (**Attachment VI**). The IDS and EIIS databases contained 7 incidents for bifenthrin, 29 incidents for permethrin, 17 incidents for cypermethrin, 10 incidents for cyhalothrin (*lambda*- and *gamma*-), 11 incidents for esfenvalerate, 6 for cyfluthrin, 2 for

deltamethrin, 2 for pyrethrins and only one for fenpropathrin (note that this is the total number of incidents, including those in agricultural and non-agricultural settings). The total for all pyrethroid actives searched was 84 aquatic incidents. Thirty-two of the reported incidents were determined to be from legally registered uses of the pesticides. The number of reports listed in the EIIS database is believed to be only a small fraction of the total incidents involving non-target organism mortality and damage caused by pesticides. These incidents appear to confirm the findings of the PRA.

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Appendix A. Risk Quotient Method

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of this integration is called the quotient method. Risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are used by OPP to analyze potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) acute risks - regulatory action may be warranted in addition to restricted use classification, (2) acute restricted use - the potential for acute risk is high, but may be mitigated through restricted use classification, (3) acute endangered species - endangered species may be adversely affected, and (4) chronic risk - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, or chronic risk from granular/bait formulations to birds or mammals.

The ecotoxicity test values (measurement endpoints) used in the acute and chronic risk quotients are derived from required studies. Examples of ecotoxicity values derived from short-term laboratory studies that assess acute effects are: (1) LC_{50} (fish and birds), (2) LD_{50} (birds and mammals), (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOAEL or LOAEC (birds, fish, and aquatic invertebrates) and (2) NOAEL or NOAEC (birds, fish and aquatic invertebrates). For birds, mammals, fish and aquatic invertebrates the NOAEL or NOAEC generally is used as the ecotoxicity test value in assessing chronic effects, although other values may be used when justified. Risk presumptions and the corresponding RQs and LOCs, are tabulated below.

Table A-1. Summary of the levels of concern used for the risk quotient method.

Risk Presumption	RQ	LOC
Birds and mammals		
Acute Risk	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.5
Acute Restricted Use	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50} (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	Diet-based EEC/LC_{50} or dose-based EEC/LD_{50}	0.1
Chronic Risk	Diet or dose-based EEC/NOAEC	1
Aquatic Animals		
Acute Risk	EEC/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/NOAEC	1
Terrestrial and Semi-Aquatic Plants, and Aquatic Plants		
Acute Risk	EEC/EC_{25}	1
Acute Endangered Species	EEC/EC_{05} or NOAEC	1
Terrestrial Invertebrates		
Acute risk to bees	EEC/LD_{50}	0.4
Chronic risk to bees	EEC/NOAEC	1

Appendix B. Example AGDISP Input/Output Files

Example chemical is Permethrin

Input Summary

```
AGDISP Input Data Summary

Title: Permethrin
Notes:

Calculations Done: Yes
Run ID: AGDISP Permethrin1.ag 8.26 07-14-2016 11:27:47

--APPLICATION METHOD--                          ----------------------------
Method                                                             Aerial
--Aircraft--                                    ----------------------------
Name                                                   Air Tractor AT-401
Type                                                              Library
Wing Type                                                     Fixed-Wing
Semispan (ft)                                                       24.5
Weight (lbs)                                                        6000
Typical Speed (mph)                                               119.99
Propeller RPM                                                       2000
Propeller Radius (ft)                                                4.5
Biplane Separation (ft)                                                0
Planform Area (ft²)                                                  294
Engines                                                                1
Engine Vert Distance (ft)                                           -1.2
Engine Fwd Distance (ft)                                            11.9
Engine Horiz Distance 1 (ft)                                           0
Engine Horiz Distance 2 (ft)                                           0
Wing Vertical Distance (ft)                                         1.51
Boom Vertical Distance (ft)                                        -1.15
Boom Forward Distance (ft)                                       -0.8333
--Spray Lines--                                 ----------------------------
Release Height (ft)                                                  100
Spray Lines                                                            3
Optimize Spray Reps                                                   No
Spray Line Reps                                 #                   Reps
                                                1                      1
                                                2                      1
                                                3                      1

--APPLICATION TECHNIQUE--                       ----------------------------
Application Technique                                              Liquid
--Nozzles--                                     ----------------------------
Boom Length (%)                                                        0
Nozzle Locations                                #    Hor(ft)  Ver(ft)  Fwd(ft)
                                                1          0        0        0

--Drop Size Distribution--                      ----------------------------
Name                                                   ASAE Fine to Medium
Type                                                         User-defined
Drop Categories                                 #       Diam (um)         Frac
                                                1            4.00       0.0010
                                                2            8.10       0.0028
                                                3           12.29       0.0063
                                                4           16.58       0.0120
                                                5           20.96       0.0198
                                                6           25.45       0.0293
```

7	30.04	0.0395
8	34.74	0.0496
9	39.55	0.0590
10	44.46	0.0670
11	49.50	0.0732
12	54.64	0.0768
13	59.91	0.0766
14	65.30	0.0749
15	70.81	0.0708
16	76.45	0.0643
17	82.22	0.0568
18	88.13	0.0488
19	94.17	0.0410
20	100.35	0.0335
21	106.67	0.0266
22	113.14	0.0205
23	119.76	0.0153
24	126.53	0.0111
25	133.46	0.0079
26	140.55	0.0054
27	147.80	0.0036
28	155.22	0.0024
29	162.81	0.0015
30	170.58	0.0010
31	178.53	0.0006
32	186.66	0.0010

--SWATH--	
Swath Width	500 ft
Swath Displacement	0 ft
--METEOROLOGY--	
Wind Speed (mph)	3
Wind Direction (deg)	-90
Temperature (deg F)	85
Relative Humidity (%)	90
--SPRAY MATERIAL--	
Name	Oil
Spray Material Evaporates	No
Spray Volume Rate (gal/ac)	0.0242
Active Fraction	0.04
Nonvolatile Fraction	0.999
Active Fraction of Tank Mix	0.04
Fraction of Active Solution that is Nonvolatile	1
Additive Fraction of Tank Mix	0.959
Fraction of Additive Solution that is Nonvolatile	1
--ATMOSPHERIC STABILITY--	
Atmospheric Stability	Overcast
--SURFACE--	
Upslope Angle (deg)	0
Sideslope Angle (deg)	0
--Canopy--	
Type	None
Surface Roughness (ft)	0.0246
--TRANSPORT--	
Flux Plane Distance (ft)	0
--ADVANCED SETTINGS--	
Wind Speed Height (ft)	6.56

Max Compute Time (sec)	600
Max Downwind Dist (ft)	2608.24
Vortex Decay Rate (OGE) (mph)	0.3355
Vortex Decay Rate (IGE) (mph)	1.25
Aircraft Drag Coeff	0.1
Propeller Efficiency	0.8
Ambient Pressure (in hg)	29.91
Ground Reference (ft)	0
Save Trajectory Files	No
Half Boom	No
Default Swath Offset	1/2 Swath
Specific Gravity (Carrier)	0.872
Specific Gravity (Active/Additive)	0.872
Evaporation Rate (μm^2/deg C/sec)	84.76

Numerical Values

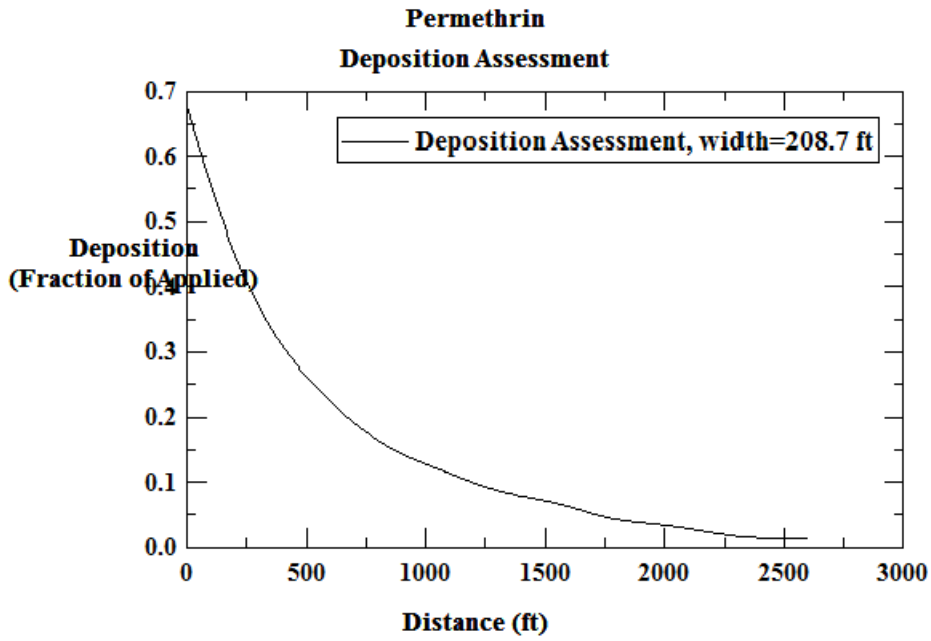
AGDISP Numerical Values

Drop Size Distribution:
Initial DSD
Dv0.1 28.94 µm
Dv0.5 59.08 µm
Dv0.9 99.82 µm
Relative Span: 1.2
< 141 µm: 99 %

Accountancy of Active:
Application Efficiency: 65.28 %
Downwind Deposition: 31.03 %
Airborne Drift: 3.69 %
Carrier Evaporated: 0 %

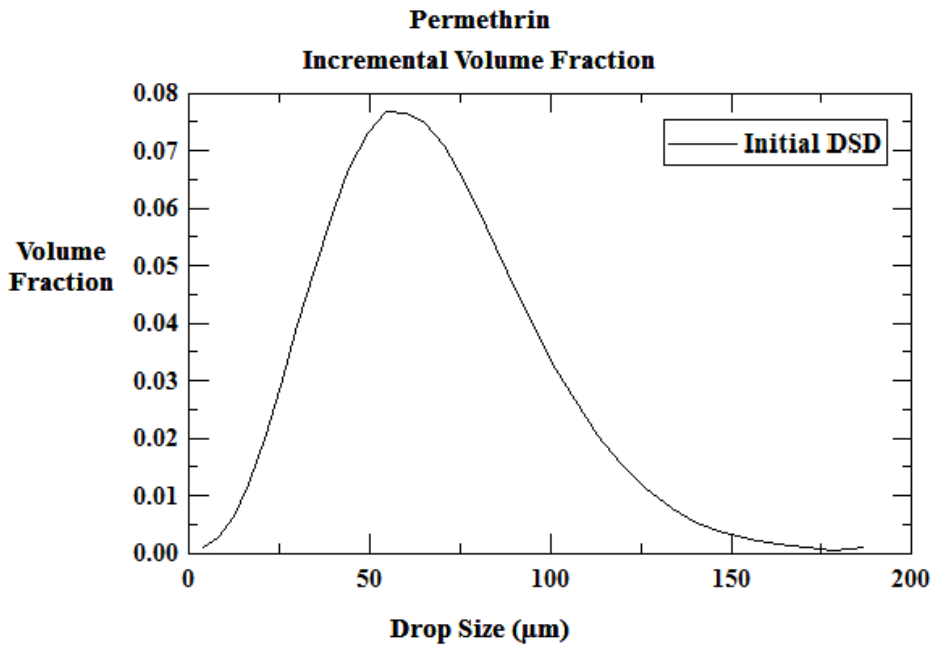
RunID:
  AGDISP Permethrin1.ag 8.26 07-14-2016 11:27:47

Deposition Assessment Curve



AGDISP Permethrin1.ag 8.26 07-14-2016 11:27:47

Drop Size Distribution



AGDISP Permethrin1.ag 8.26 07-15-2016 08:47:06

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins

Part V. Tier 1 Risk Assessment of Agricultural Uses of Pyrethroids and Pyrethrins for Bees

Chemical Names	PC Codes
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

Date: September 30, 2016 **DP Barcode:** D435888

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Part V. Tier 1 Risk Assessment of Agricultural Uses of Pyrethroids and Pyrethrins for Bees

1 INTRODUCTION

Estimating risks to bees associated with the current uses of pyrethroids follows the harmonized published guidance entitled: *"Guidance for Assessing Pesticide Risks to Bees"* (USEPA *et al.*, 2014). This guidance presents an iterative, tiered process for assessing risks to bees which considers multiple lines of evidence related to exposure and effects. This process involves:

1. Estimating the potential for exposure of bees to the pesticide for each of the proposed uses;
2. Conducting a Tier 1 risk assessment based on default (high-end) exposure estimates for those uses where a reasonable potential for exposure exists compared to toxicity estimates on individual adult and larval bees;
3. Conducting a refined Tier 1 risk assessment based on measured residues in pollen and nectar; and,
4. Evaluating risks based on higher-tier (Tier 2 or Tier 3) colony level-effects data (as necessary) in the context of risk estimates for individual bees.

Historically, only the acute contact and foliar residue toxicity studies with adult bees were required for pyrethroids. Since issuance of harmonized risk assessment guidance for bees in 2014, additional toxicity and exposure data are currently being required for conventional pesticides for which exposure to bees is considered likely. Such data include Tier 1 acute and chronic toxicity studies for individual adult and larval bees. Pending results of these studies and the Tier 1 risk assessment, additional higher-tier effects and exposure data are often required (*e.g.*, residue studies quantifying pesticide concentrations in pollen and nectar, semi-field and full-field colony-level toxicity studies). However, since EPA's Registration Review of pyrethroids began prior to the 2014 bee risk assessment guidance, these additional Tier 1 and higher-tier data are mostly lacking for pyrethroids.

According to OPP's recently published document: *Process for Requiring Exposure and Effects Testing for Assessing Risks to Bees during Registration and Registration Review* (USEPA 2016), for pesticides with Registration Review Data Call-In (DCI) orders issued before January 1, 2015, EPA will complete the risk assessment consistent with the existing schedule and available data. Specifically, this process indicates that the Agency risk assessors will calculate a risk quotient (RQ) for honey bees based on all available data, including pollinator data that may have been submitted in the absence of a DCI, according to the 2014 Bee Risk Assessment Guidance, even if the additional data described above have not yet been submitted.

The 2016 Guidance further states:

"If risks of concern are identified, various factors will be considered to determine the most appropriate regulatory determination. First, the EPA will evaluate the likelihood of exposure to bees considering whether the registered uses involve bee-attractive crops (based on the USDA list[1]), whether the directions for use allow application when bees may be present (e.g., application at bloom), whether expected usage in agriculture is likely to lead to problematic pollinator exposure scenarios, and whether suitable measures can be identified to mitigate exposure. As in every other registration decision, the EPA will also consider the benefits associated with the registration action to determine whether those benefits outweigh the risks of adverse effects. In order to facilitate the review and the FIFRA "no unreasonable adverse effects" determination, the EPA may request that the registrant submit additional information including efficacy data on key pest management claims, benefits and user alternatives assessments, and/or hazard comparison data to other registered pesticide alternatives…"

"After taking public comment on its proposed interim registration review decision, the EPA will consider the comments received and then issue an interim registration review decision that, after consideration of all risks and benefits, may include mitigation measures to address potential risks to pollinators. Depending upon the nature and extent of any required mitigation, the EPA may require, through a separate DCI, the additional pollinator data identified in the 2014 Guidance to adequately inform a useful refinement of risk estimates in the final registration review decision. If the risks can be appropriately mitigated, additional data may not be necessary."

For this Registration Review risk assessment with pyrethroids, only a Tier 1 risk assessment is being conducted. Furthermore, the Tier 1 risk assessment is focused on agricultural uses only, since these uses generally have the highest application rates and involve bee attractive crops.

2 BEE EXPOSURE POTENTIAL

Based on the use information presented in Part III for agricultural uses (Tables 15-29 of the PRA), the uses with the maximum application rates on bee attractive crops were identified. In many cases, the maximum application rate for a given pyrethroid corresponded to multiple bee-attractive crops. The attractiveness of crops to bees was evaluated using the USDA 2015 guidance document: *Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen.* The resulting uses and rates to be assessed are shown in **Table 1**.

[1] USDA 2015

Table 1. Uses and Maximum foliar application rates used in the Tier 1 risk assessment.

Chemical	Crop Group with Maximum Appl. Rate	Bee Attractiveness[1] and Agronomic Practices	Maximum Foliar Appl. Rate in lb ai/A (# apps, interval in days)
Bifenthrin	**Tree nuts**	**High** (requires managed pollination; almond)	0.2 (2, 15)
Cyfluthrins	**Citrus**	**High** (managed pollination for a few species; production of orange blossom honey)	0.1 (2, 7)
Cyhalothrins	**Citrus**	**High** (managed pollination for a few species; production of orange blossom honey)	0.04 (6, 3)
Cypermethrins	**Cucurbits**	**Moderate** (requires managed pollination)	0.05 (6, 4)
Deltamethrin	**Tree nuts**	**High** (requires managed pollination; almond)	0.033 (5, 7)
Esfenvalerate	**Tree nuts**	**High** (requires managed pollination; almond)	0.1 (4, 5)
Fenpropathrin	**Citrus**	**High** (managed pollination for a few species; production of orange blossom honey)	0.4 (2, 10)
Permethrin	**Tree nuts**	**High** (requires managed pollination; almond)	0.3 (3, 10)
Pyrethrins	**Citrus**	**High** (managed pollination for a few species; production of orange blossom honey)	0.05 (10, 3)

[1] USDA 2015

3 EFFECTS CHARACTERIZATION

Tier 1 (laboratory) toxicity data for the assessed pyrethroids are shown in **Table 2**. Among the pyrethroids, acute contact LD_{50} values for adult bees spanned two orders of magnitude, from 0.0015 µg a.i./bee (deltamethrin) to 0.13 µg a.i./bee (beta cypermethrin). No acceptable acute contact study was were submitted for fenpropathrin. Acute oral LD_{50} values for adult bees similarly ranged about two orders of magnitude (0.012 µg a.i./bee for beta-cyfluthrin to 1.26 µg a.i./bee for gamma cyhalothrin). Acceptable acute oral LD_{50} data were not submitted for bifenthrin, cyfluthrin, esfenvalerate, fenpropathrin, and pyrethrins. As discussed previously, acute oral toxicity data were not typically required at the time Registration Review was initiated for the pyrethroids.

In addition to the acute contact and acute oral toxicity data, submitted data on the residual toxicity on foliage (OCSPP Guideline 850.3030) are also compiled in Table 2. The goal of the residues on foliage studies is to estimate the amount of time that residues on foliage remain toxic to bees when bees come into contact with foliage when plants are treated at a specific application rate (*e.g.*, the RT_{25}). The RT_{25} is the residual time needed to reduce the toxicity of a pesticide formulated product and to bring mortality down to 25 percent (25%) for adult bees exposed by contact to field-weathered residues on the surfaces of the treated plants.

Table 2. Tier 1 toxicity data for pyrethroids considered in this assessment.

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./bee[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Bifenthrin				
Honey bee, *Apis mellifera* (0.8% EC)	LD_{50} (Adult acute contact)	**0.015**	00132538 (Atkins & Kellum, 1981)	Acceptable
(Capture 2 EC)	RT_{25}	Moderate to high toxicity for 1-2 days	00163104 (Atkins & Kellum, 1986)	Acceptable
Cyfluthrin				
Honey bee, *Apis mellifera* (TGAI)	LD_{50} (Adult acute contact)	**0.037**	00153638	Acceptable
Beta-cyfluthrin				
Honey bee, *Apis mellifera* (TGAI)	LD_{50} (Adult acute contact)	0.05	48350616	Acceptable
TGAI	LD_{50} (Adult acute oral)	**0.012**	48350616	Supplemental (Quantitative)
Cyhalothrin (Gamma)				
Honey bee, *Apis mellifera* (TGAI)	LD_{50} (Adult acute contact)	**0.0061** (0.005-0.007)	45464802	Acceptable (Sublethal effects occurred at $\geq$ 0.0013 µg ai/bee)
(TEP 14.7%)		0.030 (0.024-0.038)	45464803	Supplemental (nominal values; no effects $\leq$ 0.0063 µg ai/bee)
(TEP 14.7%)	LD_{50} (Adult acute oral)	1.26 (0.91-1.75)	45464804	Supplemental (Sublethal effects $\geq$ 0.025 µg ai/bee)
(TEP 14.7%; 17 g ai/ha)	RT_{25}	>24 hrs.	45464805	Supplemental
Cyhalothrin (Lambda)				

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./bee[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Honey bee, *Apis mellifera* (TGAI)	LD_{50} (48h Adult acute contact)	0.038	40052409	Acceptable
(TEP 5.04%)		0.098	40052409	Acceptable
(TGAI)	LD_{50} (48h Adult acute oral)	0.909	40052409	Acceptable
(TEP 5.04%)		**0.483**	40052409	Acceptable
(TEP, 0.013 lb ai/A)	RT_{25}	22-52 hrs.	40436402	Acceptable
Cypermethrin				
Honey bee, *Apis mellifera* (Cypermethrin)	LD_{50} (48h Adult acute contact)	**0.023**	155740	Acceptable
(Beta-cypermethrin)		0.13	44544208	Acceptable
(Cypermethrin)	LD_{50} (48h Adult acute oral)	**0.172**	00155740	Acceptable
(Beta-cypermethrin)		0.56	44544208	Acceptable
Deltamethrin				
Honey bee, *Apis mellifera* (99.7%)	**LD_{50} (48h adult acute contact)**	**0.0015**	42114815 (Hoxter & Lynn, 1991)	Acceptable (no observed effects ≤ 0.00063 µg a.i./bee)
(99.7%)	LD_{50} (72h adult acute contact)	0.11	49281401 (Schmitzer, 2013)	In Review (no observed effects ≤ 0.025 µg a.i./bee)
(99.7%)	LD_{50} (72h adult acute oral)	**0.19**	49281401 (Schmitzer, 2013)	In Review (no observed effects ≤ 0.091 µg a.i./bee)
Decis EC (0.02 lb ai/A)	RT_{25}	5.2 hrs	42773902 (Mayer 1992)	Acceptable
Esfenvalerate				
Honey bee, *Apis mellifera* (98.6%)	LD_{50} (adult acute contact)	**0.017**	41698402 (Hoxter & Smith 1990)	Acceptable
Fenpropathrin				
Honey bee, *Apis mellifera*	LD_{50} (Adult acute contact)	**0.0015**	Estimated value (no data submitted)	Estimated based on 5th percentile of pyrethroid acute contact LD_{50} (per latest new use assessment; USEPA 2013; D407810)
(Danitol 2.4 EC; 0.1, 0.2 and 0.4 lb ai/A)	RT_{25}	276 – 336 hrs.	00164240	Acceptable

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./bee[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Permethrin				
Honey bee, *Apis mellifera* (TGAI)	LD_{50} (adult acute contact)	0.05	00045044 (Clark 1976)	Supplemental
(NR)	LD_{50} (adult acute contact)	0.16	00045046 (1975)	Supplemental
(93.1%)	LD_{50} (48h adult acute contact)	**0.024**	42674501 (Gough *et al.* 1993)	Acceptable (no observed effects ≤ 0.005 µg a.i./bee)
(93.1%)	LD_{50} (48h adult acute oral)	**0.131**	42674501 (Gough *et al.* 1993)	Acceptable (no observed effects ≤ 0.02 µg a.i./bee)
Ambush 25W (0.2 & 0.4 lb ai/A)	RT_{25}	97-100% mortality @ 24 hour exposure to foliage with 24h-72h of aging	42009301 (Hoxter & Lynn, 1991)	Acceptable
Pyrethrins				
Honey bee, *Apis mellifera* (58% pyrethrins extract)	LD_{50} (48h adult acute contact)	**0.022**	41968803 (Lynn & Hoxter, 1991)	Acceptable

Bold values indicate toxicity data used to calculate Tier 1 risk quotients. RT_{25} is the residual time needed to reduce the toxicity of a pesticide formulated product and to bring mortality down to 25 percent (25%) for adult bees exposed by contact to field-weathered residues on the surfaces of the treated plants (https://www.epa.gov/pollinator-protection/residual-time-25-bee-mortality-rt25-data).

4 RISK CHARACTERIZATION

Tier 1 risk quotients are for acute contact and acute oral exposure based on default (screening-level) estimates of exposure according to the BeeRex model[2] (v. 1.0). Specifically, the acute contact exposure estimate is determined by multiplying the maximum application rate by the unit dose for acute contact (2.7 µg ai/bee). The acute oral exposure estimate for adult nectar foragers is determined by multiplying the maximum application rate by the oral unit dose (110 mg/kg-food per lb ai/A) and the estimated

[2] The Bee-REX model is a screening level tool that is intended for use in a Tier I risk assessment to assess exposures of bees to pesticides and to calculate risk quotients. This model is individual-based, and is not intended to assess exposures and effects at the colony-level (*i.e.*, for honey bees) https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#terrestrial

consumption rate of 292 mg/day for nectar and 0.041 mg/day for pollen. The adult forager bee was selected for RQ derivation since it has the highest overall consumption rate compared to other adult bees of different tasks. Details on the derivation of these default estimates of exposure are provided in the 2014 bee risk assessment guidance document. Lastly, acute contact and oral RQ values were determined by dividing the estimated dose (µg ai/bee) by the applicable acute contact or oral LD_{50} value (µg ai/bee). For pyrethroids with toxicity data for multiple isomers, the lowest toxicity value was selected for RQ calculation.

The resulting acute contact and acute oral RQ values for adult bees are shown in **Tables 3 and 4**, respectively. As expected given the high acute toxicity and conservative exposure assumptions of the default Tier 1 risk assessment, acute RQ values exceed the respective acute risk LOC (0.4) for all of the pyrethroid uses assessed. Acute contact RQs range from 6.1 (pyrethrins) to 59 (deltamethrin). Acute oral RQs range from 2.7 (cyhalothrins) to 270 (cyfluthrins). It is emphasized here that the risks indicated in Tables 3 and 4 reflect default (*i.e.*, high end) assumptions of exposure and pertain to acute risks to individual honey bees. Thus, these Tier 1 risk estimates can be subject to refinement both in terms of exposure and effects data. Such refinements would require additional data on exposure (*e.g.*, residues in pollen and nectar) and effects (*e.g.*, chronic Tier 1 and/or higher-tier data on effects at the colony level).

Table 3. Tier 1 (Default) Acute Contact RQ Values for Adult Nectar Foragers

Chemical	Assessed Use [1]	Max. Single Appl. Rate (lb ai/A)	No. Apps & Interval	Estimated Contact Dose (µg ai/bee) [2]	Acute Contact LD_{50} (µg ai/bee) [3]	Acute Contact RQ
Bifenthrin	Tree Nuts	0.2	2 @ 15d	0.54	0.015	**36**
Cyfluthrins	Citrus	0.1	2 @ 7d	0.27	0.037	**7.3**
Cyhalothrins	Multiple	0.04	6 @ 3d	0.108	0.0061	**18**
Cypermethrins	Multiple	0.05	6 @ 4d	0.135	0.023	**5.9**
Deltamethrin	Tree Nuts	0.033	5 @ 7d	0.0891	0.0015	**59**
Esfenvalerate	Tree Nuts	0.1	4 @ 5d	0.27	0.017	**16**
Fenpropathrin	Citrus	0.4	2 @ 10d	1.08	n.a.	n.a.
Permethrin	Tree Nuts	0.3	3 @ 10d	0.81	0.024	**34**
Pyrethrins	Multiple	0.05	10 @ 3d	0.135	0.022	**6.1**

[1] Bee-attractive agricultural use associated with the maximum single rate for foliar applications. Multiple indicates more than one 1 bee-attractive agricultural use at the maximum rate.
[2] Acute contact dose calculated for adult nectar foragers using a unit contact dose of 2.7 µg ai/bee per lb ai/A (BeeRex v. 1.0).
[3] Acute contact LD_{50} for adult honey bees from **Table 2**. For cyfluthrins, cyhalothrins and cypermethrins, lowest value among available data for isomers was selected.
n/a = no data available. Bold RQ values exceed the acute risk LOC of 0.4.

Table 4. Tier 1 (Default) Acute Oral RQ Values for Adult Nectar Foragers

Chemical	Assessed Use [1]	Max. Single Appl. Rate (lb ai/A)	No. Apps & Interval	Estimated EEC in Pollen and Nectar (mg ai/kg food) [2]	Estimated Oral Dose (µg ai/bee) [3]	Acute Oral LD_{50} (µg ai/bee) [4]	Acute Oral RQ
Bifenthrin	Tree Nuts	0.2	3 @ 15d	22	6.425	n.a.	n.a.
Cyfluthrins	Citrus	0.1	2 @ 7d	11	3.212	0.012	**270**
Cyhalothrin	Multiple	0.04	6 @ 3d	4.4	1.285	0.483	**2.7**
Cypermethrins	Multiple	0.05	6 @ 4d	5.5	1.606	0.172	**9.3**
Deltamethrin	Tree Nuts	0.033	5 @ 7d	3.63	1.060	0.19	**5.6**
Esfenvalerate	Tree Nuts	0.1	4 @ 5d	11	3.212	n.a.	n.a.
Fenpropathrin	Citrus	0.4	2 @ 10d	44	12.850	n.a.	n.a.
Permethrin	Tree Nuts	0.3	3 @ 10d	33	9.637	0.131	**74**
Pyrethrins	Multiple	0.05	10 @ 3d	5.5	1.606	n.a.	n.a.

[1] Bee-attractive agricultural use associated with the maximum single rate for foliar applications. Multiple indicates more than one 1 bee-attractive agricultural use at the maximum rate.
[2] Estimated concentration in nectar and pollen for foliar applications during bloom assuming a default unit concentration of 110 mg/kg-food per lb ai/A (BeeRex v. 1.0).
[3] Estimated oral dose for adult nectar foragers assuming nectar and pollen intake rates of 292 and 0.041 mg/day for nectar and pollen, respectively (BeeRex v. 1.0).
[4] Acute oral LD_{50} for adult honey bees from **Table 2**. For cyfluthrins, cyhalothrins and cypermethrins, lowest value among available data for isomers was selected.
n/a = no data available. Bold RQ values exceed the acute risk LOC of 0.4.

Other lines of evidence are also summarized here regarding the potential risks of the aforementioned pyrethroid uses to bees. Although pyrethroids are not systemically transported to pollen and nectar, information is available which indicates they may adsorb onto pollen (and reach nectaries) if applied to crops during bloom. Specifically, monitoring data reported by Mullins *et al.* (2010) indicate all of these pyrethroids have been detected in pollen and wax of honey bee colonies. In a survey of pesticides in stored pollen of managed hives from 11 states during 2011-2012, the USDA Animal and Plant Health Inspection Service (APHIS) reported detection frequencies from 1%-8% for bifenthrin, cypermethrin, cyfluthrin, cyhalothrins, esfenvalerate, fenpropathrin, and permethrin.[3] Similar frequencies of detection of multiple pyrethroids in bee-collected pollen were reported by Pettis *et al.* (2013) for nine hives placed next to seven crops including almond, apple, blueberry, cranberry, cucumber, pumpkin, and watermelon. Residues of pyrethroids reported in these studies were below 100 ppb and often below 10 ppb (average). These data suggest that the oral route of exposure is relevant to pyrethroid insecticides at least in terms of bee-collected pollen.

[3] https://www.aphis.usda.gov/plant_health/plant_pest_info/honey_bees/downloads/2011_National_Survey_Report.pdf

Another line of evidence includes information on ecological incidents involving bees and other beneficial arthropods. As reported in Attachment VII, the IDS and EISS databases contained 11 incidents for Bifenthrin, 12 incidents for Permethrin, 5 incidents for beta and zeta Cypermethrin, 12 incidents for Cyhalothrin (Lambda and Gamma), 9 incidents for Cyfluthrin (including Beta-cyfluthrin), 2 incidents for Esfenvalerate, 1 incident for Fenpropathrin, 1 incident for Pyrethrins and no pollinator incident reports for Deltamethrin. It should be noted that some of these incidents involved detection of multiple chemicals and are therefore repeated for more than one chemical. Importantly, many of these incidents were associated with multiple active ingredients. Among those incidents that were classified as "probable" or "highly probable" and were not considered accidental or intentional misuses, seven appeared to be associated with exposure to a single pyrethroid (I026996-001; I024129-001; I016728-010; I012515-005; I011527-002; I025673-001; I023061-001). Of these seven incidents, all but one involved residential/urban uses, several of which were for aerial mosquito control. Two of the seven uses were classified as registered uses, with the remaining classified as "unknown use".

5 REFERENCES

Mullin, C.A. et al., 2010. High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health. PLoS ONE. 5(3): e9754.

Pettis J.S. *et al.* 2013. Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema ceranae*. PLoS ONE 8(7): e70182. doi:10.1371/journal.pone.0070182

U.S. Department of Agriculture (USDA). 2015. *Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen.* http://www.ree.usda.gov/ree/news/Attractiveness_of_Agriculture_crops_to_pollinating_bees_Report-FINAL.pdf

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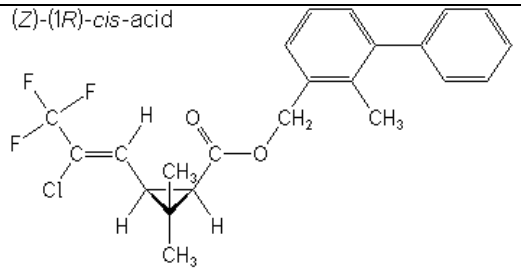
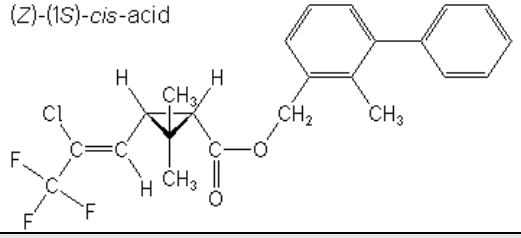
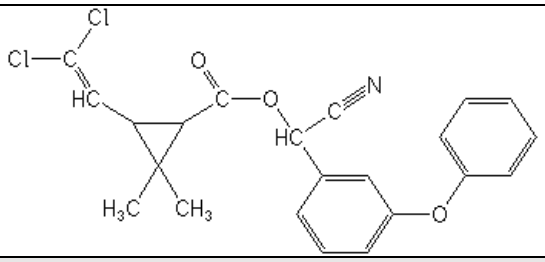
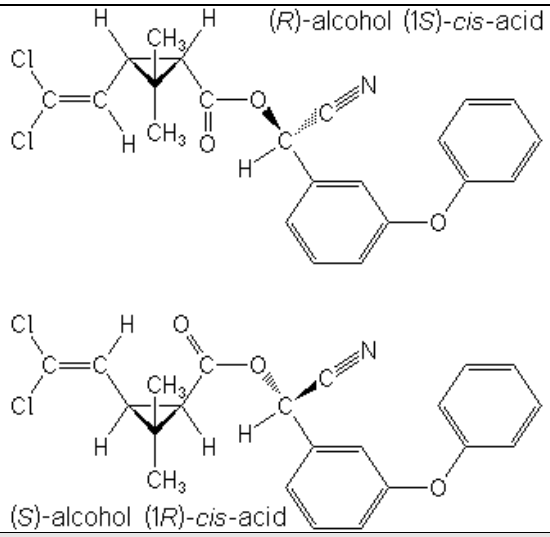
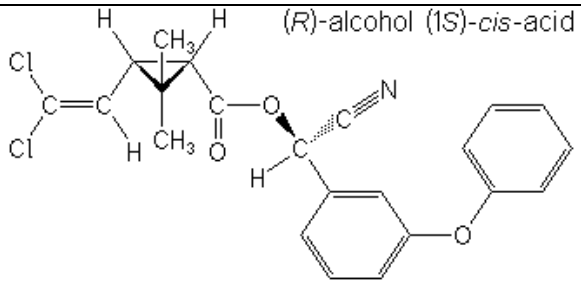
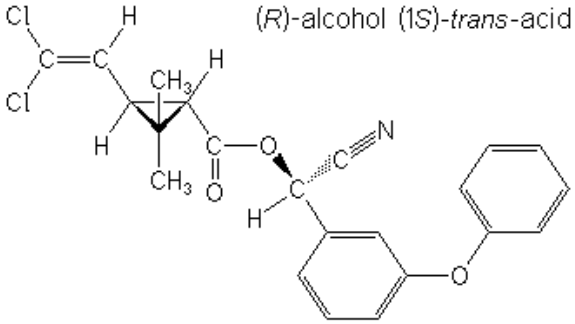
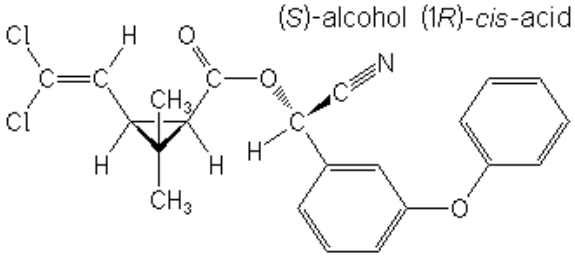
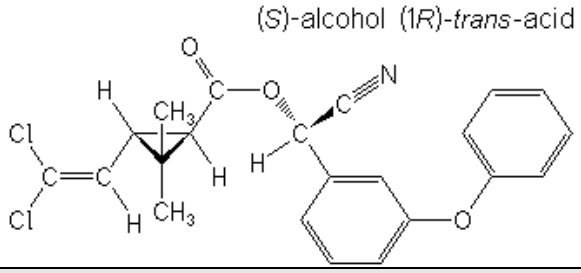
Attachment I. Structures, CAS Numbers and Nomenclature of Synthetic Pyrethroids and Pyrethrins

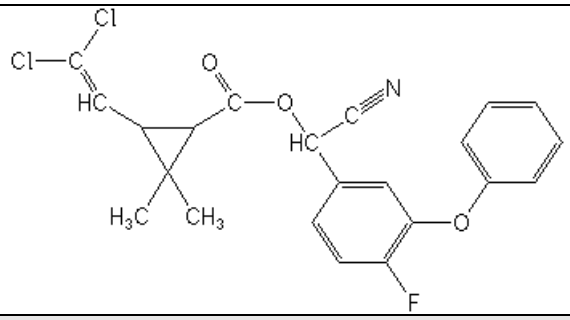
Chemical Names	**PC Codes**
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

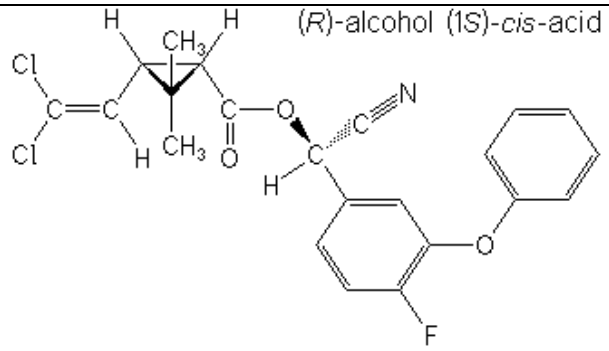
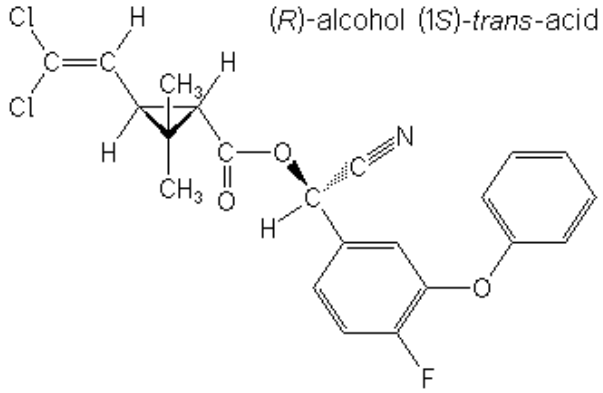
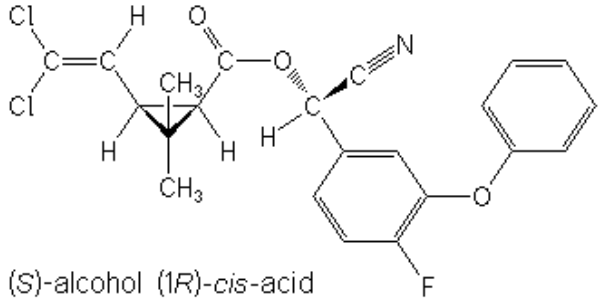
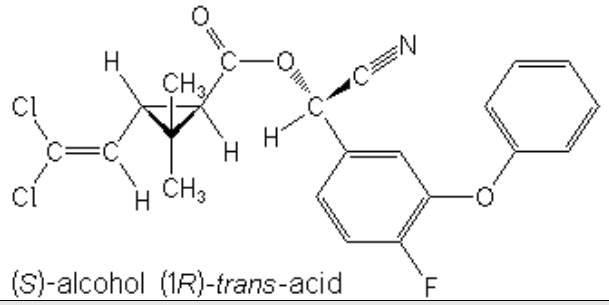
Table 1. Test Compound Nomenclature, CAS Number and Structures[1]

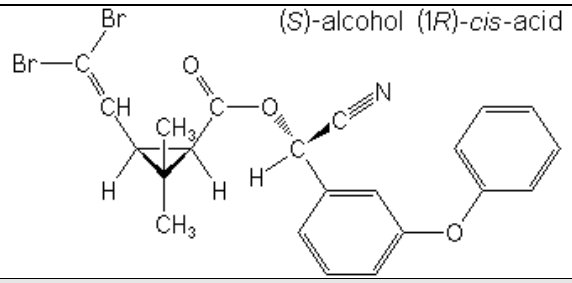
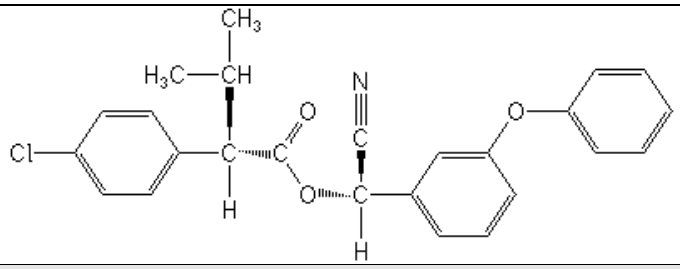
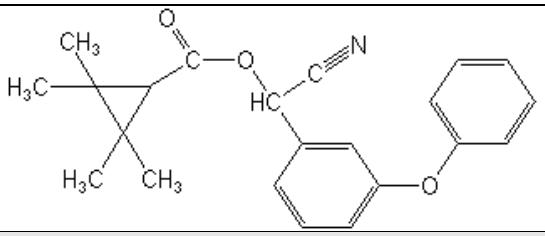
Common name	**Bifenthrin**
IUPAC name	2-Methylbiphenyl-3-ylmethyl (Z)-(1RS,3RS)-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate.
CAS Name	(2-Methyl [1,1'-biphenyl]-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate.
CAS #	82657-04-3.
Structure	 
Common name	**Cypermethrin.**
IUPAC name	(RS)-α-Cyano-3-phenoxybenzyl (1RS,3RS;1RS,3SR)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate.
CAS Name	Cyano (3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate.
CAS #	52315-07-8.
Structure	
Common name	**α-Cypermethrin**
IUPAC name	Racemate comprising (*R*)-α-cyano-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
CAS Name	(*R*)-cyano(3-phenoxyphenyl)methyl (1*S*,3*S*)-*rel*-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate
CAS #	67375-30-8

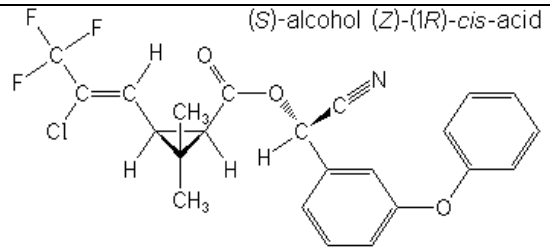
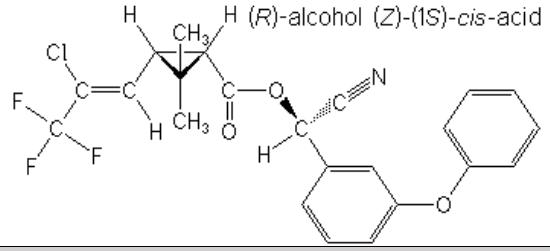
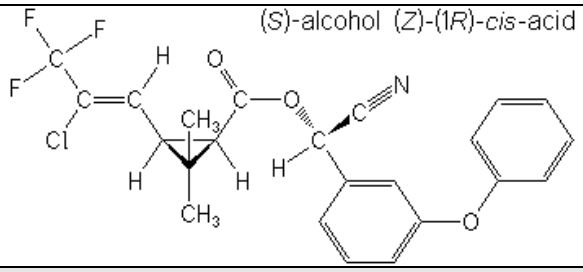
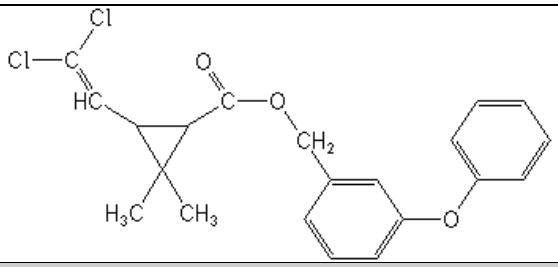
Structure	
Common name	**ß-Cypermethrin**
IUPAC name	Reaction mixture comprising the enantiomeric pair (*R*)-α-cyano-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate in ratio approximately 2:3 with the enantiomeric pair (*R*)-α-cyano-3-phenoxybenzyl (1*S*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
CAS Name	Cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate
CAS #	65731-84-2

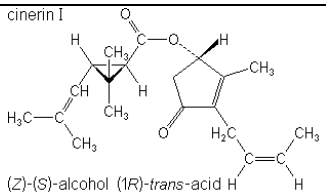
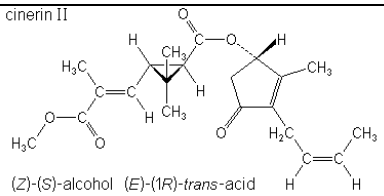
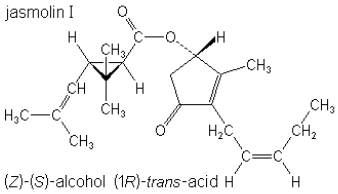
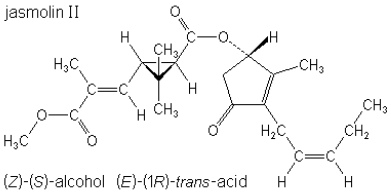
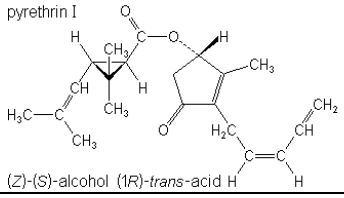
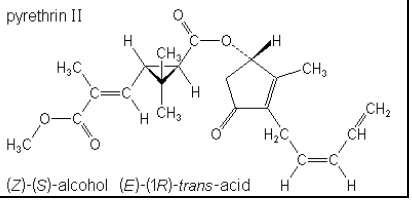
Structure	   
Common name	**Cyfluthrin.**
IUPAC name	(RS)-α-Cyano-4-fluoro-3-phenoxybenzyl (1RS,3RS;1RS,3SR)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylate.
CAS Name	Cyano (4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropancecarboxylate.
CAS #	68359-37-5.

Structure	
Common name	**ß-Cyfluthrin**
IUPAC name	Reaction mixture comprising the enantiomeric pair (*R*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate in ratio 1:2 with the enantiomeric pair (*R*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*S*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*R*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
CAS Name	Cyano(4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate
CAS #	68359-37-5

Structure	 (*R*)-alcohol (1*S*)-*cis*-acid  (*R*)-alcohol (1*S*)-*trans*-acid  (*S*)-alcohol (1*R*)-*cis*-acid  (*S*)-alcohol (1*R*)-*trans*-acid
Common name	**Deltamethrin.**
IUPAC name	(S)-α-Cyano-3-phenyoxybenzyl (1R,3R)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylate.
CAS Name	1-[R-[1-α-(S*),3α]]-Cyano(3-phenoxyphenyl)methyl 3-(2,2-dibromoethenyl)-2,2-dimethylcyclopropanecarboxylate.
CAS #	52918-63-5.

Structure	
Common name	**Esfenvalerate.**
IUPAC name	(S)-α-Cyano-3-phenoxybenzyl (S)-2-(4-chlorophenyl)-3-methyl-butyrate.
CAS Name	[S-(R*,R*)]-Cyano (3-phenoxyphenyl)methyl 4-chloro-2-(1-methylethyl) benzeneacetate.
CAS #	66230-04-4.
Structure	
Common name	**Fenpropathrin.**
IUPAC name	(RS)-α-Cyano-3-phenoxybenzyl 2,2,3,3,-tetramethylcyclopropance-carboxylate.
CAS Name	Cyano (3-phenoxyphenyl) methyl 2,2,3,3-tetramethylcyclopropane-carboxylate.
CAS #	64257-84-7.
Structure	
Common name	***Lambda*-cyhalothrin.**
IUPAC name	Reaction product of equal quantities of (S)- and (R)- α-cyano-3-phenoxybenzyl (Z)-(1R,3R)-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate.
CAS Name	[1α(S*),3α(Z)]-(±)-Cyano(3-phenoxyphenyl)methyl 3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclopropanecarboxylate.
CAS #	91465-08-6.

Structure	 
Common name	***Gamma*-cyhalothrin**
IUPAC name	(*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate or (*S*)-α-cyano-3-phenoxybenzyl (1*R*)-*cis*-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate
CAS Name	(*S*)-cyano(3-phenoxyphenyl)methyl (1*R*,3*R*)-3-[(1*Z*)-2-chloro-3,3,3-trifluoro-1-propen-1-yl]-2,2-dimethylcyclopropanecarboxylate
CAS #	76703-62-3
Structure	
Common name	**Permethrin.**
IUPAC name	3-Phenoxybenzyl (1RS,3RS;1RS,3SR)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate.
CAS Name	(3-Phenoxyphenyl) methyl 3-(2,2-dichloroethenyl)-2,2-dimethyl-cyclopropanecarboxylate.
CAS #	52645-53-1.
Structure	
Common name	**Pyrethrins**
IUPAC name	The components include cinerin I, cinerin II, jasmolin I, jasmolin II, pyrethrin I and pyrethrin II.
CAS Name	Pyrethrins

CAS #	8003-34-7
Structure	cinerin I  (*Z*)-(*S*)-alcohol (1*R*)-*trans*-acid cinerin II  (*Z*)-(*S*)-alcohol (*E*)-(1*R*)-*trans*-acid jasmolin I  (*Z*)-(*S*)-alcohol (1*R*)-*trans*-acid jasmolin II  (*Z*)-(*S*)-alcohol (*E*)-(1*R*)-*trans*-acid pyrethrin I  (*Z*)-(*S*)-alcohol (1*R*)-*trans*-acid pyrethrin II  (*Z*)-(*S*)-alcohol (*E*)-(1*R*)-*trans*-acid

1 Structures were obtained at http://www.alanwood.net/pesticides/index_cn_frame.html (accessed 04/06/2015).

Attachment II. Ecological Effects Summary Tables of Most Sensitive Endpoints for Synthetic Pyrethroids and Pyrethrins

Chemical Names	**PC Codes**
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

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In screening-level ecological risk assessments, effects characterization describes the types of effects a pesticide can produce in an aquatic (or terrestrial) organism. This characterization is based on registrant-submitted studies that describe acute and chronic effects toxicity information for various aquatic and terrestrial animals and plants. Toxicity testing reported in this section does not represent all species of aquatic organisms. Only a few surrogate species for freshwater fish are used to represent all freshwater fish (2000+) species in the United States. Estuarine/marine testing is usually limited to a crustacean, a mollusk, and a fish. Also, amphibians are not tested. The risk assessment assumes that freshwater fish serve as a surrogate for aquatic-phase amphibians.

Acute and chronic laboratory studies with pyrethroids and pyrethrins on aquatic organisms provide information regarding survival, growth, and reproduction. Data are available on the technical grade active ingredient (TGAI) and the effects on freshwater and estuarine/marine fish and invertebrates, aquatic vascular and nonvascular plants (algae), and freshwater and estuarine/marine sediment dwelling organisms. For species tested, MRID numbers, etc., refer to the subsequent tables.

Table 1. Toxicity Profile for Bifenthrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Assessment Endpoint	Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)	Acute	Rainbow Trout *Oncorhynchus mykiss* (88.4%).	**96-hr LC_{50} = 0.15 µg a.i./L** (C.L. 0.102-0.191 µg/L; slope 3.53)	00163156 (Hoberg, 1983)	Supplemental (Very highly toxic)
	Chronic	NA	Estimated Chronic **NOAEC = 0.004 µg a.i./L** [2]	NA	No valid chronic study is available
Freshwater invertebrates (Water column exposure)	Acute	Amphipod *Hyalella azteca* (93.6%)	**96-hr EC_{50} = 0.493 ng a.i./L** (C.L. 0.419-0.580)	49552201	Acceptable (Very highly toxic)
	Chronic	Water Flea *Daphnia magna* (97%)	21-d NOAEC = 0.0013 µg a.i./L 21-d LOAEC = 0.0029 µg a.i./L	41156501	Acceptable Based on significant effects on reproduction and growth
Freshwater invertebrates (Sediment exposure)	Sub-chronic	Amphipod *Hyalella azteca* (95.7%)	Based on Pore Water Concs: **10-d NOAEC = 0.050 ng a.i./L** 10-d LOAEC = 0.09 ng a.i./L Based on sediment dry weight concs: **10-d NOAEC= 0.25 µg a.i./kg-dw** 10-d LOAEC= 0.45 µg a.i./kg-dw	48593601	Acceptable Based on significantly reduced amphipod growth.
Estuarine/ marine fish	Acute	Sheepshead Minnow *Cyprinodon variegatus* (88.4%)	**96-hr LC_{50} = 17.8 µg a.i./L** (C.L. 14.6-21.1 µg/L)	ACC264646 (Battelle, 1987)	Acceptable (Very highly toxic)
	Chronic	Sheepshead Minnow *Cyprinodon variegatus* (93.6%)	**115-d NOAEC = 0.1 µg a.i./L** 115-d LOAEC = 0.14 µg a.i./L	49412101	Acceptable Based on significant reduction in fecundity and increase in F0 time to hatch

Assessment Endpoint	Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Estuarine/ marine invertebrates (water column exposure)	Acute	Mysid Shrimp *Americamysis bahia* (88.4%)	**96-hr LC_{50} = 0.00397 µg a.i./L** (C.L. 0.00309-0.00497 µg/L)	ACC264647 (Battelle, 1987)	Acceptable (Very highly toxic)
	Chronic	Mysid Shrimp *Americamysis bahia* (93.6%)	28-d NOAEC = 0.0016 µg a.i./L 28-d LOAEC = >0.0016 µg a.i./L	49412102	Supplemental No significant adverse effects at the highest test concentration
Estuarine/ marine invertebrates (sediment exposure)	Chronic	Amphipod *Leptocheirus plumulosus* (96.4%)	Based on Pore Water Concs: **28-d NOAEC <0.0006 µg a.i./L** 28-d LOAEC 0.0006 µg a.i./L Based on Sediment Concs: **28-d NOAEC = <5.4 µg a.i/kg-dw** 28-d LOAEC 5.4 µg a.i/kg-dw	46591501	Supplemental Significantly reduced amphipod reproduction
Aquatic plants	Vascular	Duckweed *Lemna gibba* (93.6%)	**7-d EC_{50} >330 µg a.i./L** **NOAEC = 330 µg a.i./L**	49134901	Acceptable (No significant effects observed at the limit concentration)
	Non-vascular	Marine Diatom *Skeletonema costatum* (93.6%)	**7-d EC_{50} >290 µg a.i./L** **NOAEC = 290 µg a.i./L**	49098202	Acceptable (No significant effects observed at the limit concentration)

Bolded and underlined endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.

[1] All test materials are TGAI unless otherwise noted.

[2] No acceptable data were submitted or found in the open literature on the chronic toxicity of bifenthrin to freshwater fish. The value used is based on the most sensitive chronic NOAEC reported for pyrethroids (tefluthrin; MRID 41705101).

[3] Concentrations in pore water estimated using mean K_{OC} of 236800 L/kg-OC

Table 2. Toxicity Profile for Cypermethrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute	*Beta*-Cypermethrin Rainbow Trout *Oncorhynchus mykiss* (98%)	**96-hr LC_{50} = 0.39 µg a.i./L** (C.L. 0.0.27-0.8 µg/L; slope – N/A Binominal test)	44546027 (Sousa, 1998)	Acceptable (Very highly toxic)
Chronic	Fathead Minnow *Pimephales promelas* *(92.9-93.2%)*	**30-d NOAEC = 0.051 µg a.i./L** 30-d LOAEC = 0.077 µg a.i./L	40641701 (Tapp, 1998)	Supplemental Significant reduced F_0-generation survivors (30-d post-hatch and number of larvae released)
Freshwater invertebrates (water column exposure)				
Acute	Amphipod *Hyalella azteca* (95.0%)	**96-hr EC_{50} = 0.00056 µg a.i./L** (C.L. 0.00045-0.00071 µg/L)	49274301 (Bradley, 2013)	Acceptable (Very highly toxic)
Chronic	Water flea *Daphnia magna*	**21-day NOAEC = 0.0041 µg/L** 21-day LOAEC = 0.0081	47885103 (Cafarella, 2008)	Acceptable Significant reduction in reproduction and dry weight
Freshwater benthic invertebrates (sediment exposure)				
Sub-chronic	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] **10-day NOAEC <0.00005 µg a.i./L** 10-D LOAEC = 0.00005 µg a.i./L Based on OC-normalized sediment concentrations: **10-day NOAEC <7.7 µg a.i./kg-TOC** 10-D LOAEC = 7.7 µg a.i./kg-TOC	48593603 (Picard, 2010)	Supplemental The survival NOAEC as the primary endpoint was not established, as treatment-related reductions in survival were indicated at all levels. Formulated sediment was used.

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
	Midge *Chironomus dilutus* (93%)	Based on Pore Water Concentrations:[2] 10-D NOAEC <0.006 µg a.i./L 10-D LOAEC = 0.006 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC <780 µg a.i./kg-TOC 10-D LOAEC = 780 µg a.i./kg-TOC	48593605 (Picard, 2010)	Supplemental The growth NOAEC was not established, as treatment-related reductions in growth were indicated at all levels. Growth is a required endpoint for this study type with midges. Formulated sediment was used.
Chronic	Midge *Chironomus tentans* (99.8%)	Based on Pore Water Concentrations:[2] **60-D NOAEC <0.0003 µg a.i./L** 60-D LOAEC = 0.0003 µg a.i./L Based on OC-normalized sediment concentrations: **60-D NOAEC <48 µg a.i./kg-TOC** 60-D LOAEC = 48 µg a.i./kg-TOC	48762903 amend to 46725701 (Putt, 2012)	Supplemental/Qualitative Significant reduction in female developmental rate and number of eggs per female. Was not upgraded to 'acceptable' from "supplemental' with the submission for reproduction data and replicate data for other endpoints since the NOAEC could not be established. National sediment was used.
Estuarine/marine fish (water column exposure)				
Acute	Sheepshead Minnow *Cyprinodon variegatus* 91.5 % a.i.	**96-hr LC_{50} = 0.95 µg a.i./L** (C.L. 0.48-1.9 µg/L)	90075 (Jaber, 1981)	Acceptable (Very highly toxic)
Chronic	NA	Estimated Chronic **NOAEC = 0.125 µg a.i./L**	Estimated from 90075	Estimated from a high uncertainty analysis using Sheepshead minnow acute data and ACR of 7.6 from freshwater fish acute and chronic data (MRIDs 44546027 and 40641701)
Estuarine/marine invertebrates (water column exposure)				
Acute	Mysid Shrimp *Americamysis bahia* (95.9%)	**96-hr LC_{50} = 0.0054 µg a.i./L** (C.L. 0.005-0.00607 µg/L)	42444601 (Ward *et al*, 1992)	Acceptable (Very highly toxic)

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Chronic	Mysid Shrimp *Americamysis bahia* (98.1%)	**28-d NOAEC = 0.000781 µg a.i./L** 28-d LOAEC = 0.00197 µg a.i./L	42725301 (Wheat, 1992)	Acceptable Significantly reduced female body weight
Estuarine/marine benthic invertebrates (sediment exposure)				
Chronic	Amphipod *Leptocheirus plumulosus* (99.8%)	Based on Pore Water Concs:[2] **28-d NOAEC = 0.0002 µg a.i./L** 28-d LOAEC = 0.0008 µg a.i./L Based on OC-normalized Sediment Concs: **28-d NOAEC = 34 µg a.i/kg-TOC** 28-d LOAEC = 110 µg a.i/kg-TOC	48762902 amend to 46591503 (Putt, 2012)	Acceptable Significantly reduced amphipod reproduction. Upgraded to 'acceptable' from 'supplemental' with the submission of reproduction raw data and replicate data for other endpoints. Natural sediment was used.
Aquatic plants				
Vascular	*Alpha*-Cypermethrin *Lemna gibba* (99.2)	**7-D EC50 >1.62 µg a.i./L** **7-D NOAEC = 1.62 µg a.i./L**	47944031 (Hoffmann, 2009)	Supplemental Numerous deviations impacted acceptability of the study.
Non-vascular	*Alpha*-Cypermethrin *Pseudokirchneriella subcapitata* (98.3 g/L)	**72-hr EC50= 25 mg a.i./L** **72-hr NOAEC = 0.06 mg a.i./L**	47944209 (Hoffmann, 2007)	Supplemental Test duration was not achieved
	CL912554 Metabolite of *Alpha*-Cypermethrin (99%)	**72-hr EC50= 28 mg a.i./L** **72-hr NOAEC = 12.7 mg a.i./L**	47944035 (Werner, 2002)	Supplemental Test duration was not achieved
	CL206128 Metabolite of *Alpha*-Cypermethrin (99%)	**72-hr EC50= 37 mg a.i./L** **72-hr NOAEC = 6.21 mg a.i./L**	47944036 (Werner, 2002)	Supplemental Test duration was not achieved

TGAI=technical grade active ingredient; LC_{50} = median lethal concentration; NOAEL=no observable adverse effect level; a.i. active ingredient; NA = Not applicable; ACR = acute to chronic ratio.

Bolded and underlined endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.

[1] All test materials are TGAI unless otherwise noted.

[2] Concentrations in pore water estimated using mean Koc of 141700 L/kg.

Table 3. Toxicity Profile for Esfenvalerate Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Acute/ Chronic	Species (% a.i.)[1]	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute	Bluegill *Lepomis macrochirus* (90.9% active isomer)	**96-hr LC_{50} = 0.142 µg a.i./L** (C.I. 0.106- 0.191)	48927403	Acceptable (Highly toxic)
Chronic	Fathead Minnow *Pimephales promelas* (90.9% active isomer)	**NOAEC = 0.017 µg a.i./L**	49289201	Acceptable Based on significantly reduced spawning frequency.
Freshwater invertebrates				
Acute	Amphipod *Hyalella azteca* (100%)	**96-hr LC_{50} = 0.848 ng a.i./L** (C.I. 0.797-0.903 ng a.i./L)	49209501	Acceptable (Very Highly Toxic)
Chronic	NA	**NOAEC = 0.0309 ng a.i./L**	Estimated from 49209501	Estimated from *Hyalella azteca* acute data and ACR of 27 from mysid data (MRIDs 49140405 and 49140407).
Freshwater benthic invertebrates				
Sub-chronic	Amphipod *H. azteca* (99.6%)	Based on Estimated Freely Dissolved Pore Water Concs: **10-d NOAEC = 0.70 ng a.i./L** Based on OC-normalized sediment concs: **10-d NOAEC = 176 µg a.i./kg OC**	48593610	Supplemental/Quantitative Based on significantly reduced (41%) survival; also had 64% reduction in growth.
Estuarine/marine fish				
Acute	NA	**96-hr LC_{50} = >19.3 µg a.i./L**	Estimated from 49212901[2]	Estimated from sheepshead TEP toxicity data, along with a rainbow trout adjustment factor for estimating TGAI toxicity from TEP data.
Chronic	Sheepshead minnow *Cyprinodon variegatus* (90.9% active isomer)	**NOAEC = 0.63 µg a.i./L**	49289202	Acceptable Based on significantly reduced F0 generation hatching success and 19-week length.

Acute/ Chronic	Species (% a.i.)[1]	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Estuarine/marine invertebrates				
Acute	Saltwater Mysid *Americamysis bahia* (90.9%)	**96-hr LC_{50} = <u>0.00466 µg a.i./L</u>** (C.I. 0.00394-0.00539; slope 7.15)	49140405	Acceptable (Very highly toxic)
Chronic	Saltwater Mysid A. *bahia* (96.3%)	**NOAEC = <u>0.00017 µg a.i./L</u>** LOAEC = 0.00025 µg a.i./L	49140407	Acceptable Based on significantly reduced offspring/ female.
Estuarine/marine benthic invertebrates				
Chronic	Amphipod *Leptocheirus plumulosus* (95.8%)	Based on Estimated Freely Dissolved Pore Water Concs: **28-d NOAEC = <u>0.003 µg a.i./L</u>** Based on OC-normalized Sediment Concs: **28-d NOAEC = <u>830 µg a.i/kg TOC</u>**	46620401	Supplemental/ Quantitative Based on significantly reduced growth.
Aquatic plants				
Vascular	Duckweed *Lemna gibba* (90.9%)	**7-day EC_{50} = <u>>8.6 µg a.i./L</u>** **NOAEC = <u>8.6 µg a.i./L</u>**	48831601	Acceptable Based on significantly reduced frond number yield, growth, final biomass and biomass growth rate.
Non-vascular	Freshwater Algae *Pseudokirchneriella subcapita* (90.9%)	**96-hr EC_{50} = <u>>5.6 µg a.i./L</u>** **NOAEC = <u>5.6 µg a.i./L</u>**	48927404	Acceptable Based on significantly reduced yield, growth rate and area under the curve.

TGAI=technical grade active ingredient; LC_{50} = median lethal concentration; NOAEL=no observable adverse effect level; a.i. active ingredient; NA = Not applicable; ACR = acute to chronic ratio.

<u>Bolded and underlined</u> endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.

[1] All test materials were TGAI unless otherwise noted.

[2] An estuarine/marine acute fish study was available only with TEP (typical end-use product, in this case 8.4% a.i.); in that study the sheepshead minnow LC_{50} was >9.23 µg a.i./L (MRID 49212901). TEP was twice (2.1x) as toxic as TGAI to the rainbow trout (MRIDs 48831602 and 43358311). If this toxicity enhancement factor is used to calculate sheepshead toxicity from TGAI, the LC_{50} estimate is >19.3 µg a.i./L. Two additional acute studies were available for TEP toxicity to saltwater fish (the Atlantic Silverside and the California Grunion, both from MRID 40228401); both had much lower LC_{50} estimates (0.29-0.31 µg a.i./L). Although these studies were classified as Supplemental/Qualitative and may not be used for risk calculation, they suggest that the sheepshead may not well represent sensitivity of other saltwater species with regard to esfenvalerate toxicity.

Table 4. Toxicity Profile for *Lambda*- and *Gamma*-cyhalothrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute	Golden orfe *Leuciscus idus* *Lambda*-cyhalothrin TGAI	96-hr LC_{50}: 0.078 µg ai/L (95% C.I.: 0.055-0.11 µg ai/L) Sublethal effects: quiescence, sounding, erratic swimming, spiraling, loss of balance, rapid respiration, labored respiration, swimming cessation, light discoloration, surfacing, irregular respiration, and gulping air.	44584001	Supplemental **(**Non-guideline species)
	Bluegill sunfish *Lepomis macrochirus* *Gamma*-cyhalothrin TGAI	**96-hr LC_{50} = 0.029 µg a.i./L** (95% C.I.: 0.021- 0.039 µg ai/L) Sublethal effects: lethargy and loss of equilibrium	45447215	Supplemental (20% mortality in negative control on the last day of the study and use of fish with mean weight less than the 0.5 to 5g guideline recommendation.)
Chronic	Fathead minnow *Pimephales promelas* *Lambda*-cyhalothrin TGAI	60 day - NOAEC = 0.031µg a.i./L 60 day - LOAEC = 0.062 µg a.i./L based on F1 survival at 28 days, F0 length at 56 days, male length and weigh at 300 days, and F1 weight and length at 31 days	41519001	Supplemental (Low-level contamination in the solvent and negative controls, use of lower number of eggs than guideline recommendations, and other guideline deviations.)
Freshwater invertebrates				
Acute	Amphipod *Hyalella azteca* *Gamma*-cyhalothrin TGAI	**96-hr EC_{50} = 0.00008 µg a.i./L** (C.I. 0.000046-0.000103 µg/L)	49463701	Supplemental/Quantitative (All test concentrations produced at least 50% mortality).
	Amphipod *Hyalella azteca* *Lambda*-cyhalothrin TGAI	96-hr EC_{50} = 0.0003 µg a.i./L (C.I. 0.00024-0.00037 µg/L) Sublethal effects: Lethargy, erratic swimming, immobility	49234301	Acceptable

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Chronic	Water Flea *Daphnia magna* *Lambda*-cyhalothrin TGAI	21-d NOAEC = 0.0020 µg/L 21-d LOAEC = 0.0035 µg/L Based on significant effects on reproduction and growth	41217501	Supplemental (Only the healthiest organisms in the source population were chosen for the test and there were only two replicates at each treatment level. Exposure concentrations also varied substantially within a treatment (approximately 3x), such that maximum and minimum values overlapped among treatments.)
	Water Flea *Daphnia magna* *Gamma*-cyhalothrin TGAI	NOAEC: 1.93 ng ai/L LOAEC: 5.01 ng ai/L Based on time to brood (no of young/surviving females)	49708801	Supplemental (quantitative) Replicate data were not provided for growth. Therefore, the reviewer could not verify if growth was statistically reduced at treatment levels where reproduction was also inhibited
Freshwater benthic invertebrates				
10-day Subchronic	Amphipod *Hyalella azteca* *Lambda*-cyhalothrin TGAI	Based on Estimated Pore Water Concs: **NOAEC: 0.00022 µg ai/L** LOAEC: 0.00031 µg ai/L Based on Sediment Concs: **NOAEC: 0.31 µg ai/kg-dw** LOAEC: 0.44 µg ai/kg-dw Endpoints based on survival.	48593612	Supplemental (Growth was the most sensitive endpoint; however, the study failed to determine a definitive NOAEC because effects were seen at all test concentrations.) No sublethal effects reported. Pore water estimated by normalizing sediment concentrations by TOC fraction (0.024) and then dividing by the Koc = 59677.28 L/kg-OC
	Midge *Chironomus dilutus* *Lambda*-cyhalothrin TGAI	Based on Estimated Pore Water Concs: NOAEC: 0.025 µg ai/L LOAEC: 0.050 µg ai/L Based on Sediment Concs: NOAEC: 31 µg ai/kg-dw LOAEC: 63 µg ai/kg-dw Endpoints based on survival	48593613	Acceptable No sublethal effects reported. Pore water estimated by normalizing sediment concentrations by TOC fraction (0.021) and then dividing by the Koc = 59677.28 L/kg-OC
42-day Life Cycle	Amphipod *Hyalella azteca*	TWA Sediment NOAEC: 0.45 µg ai/kg-dw	49469801	Supplemental (quantitative)

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Gamma-cyhalothrin TGAI	LOAEC: 1.6 µg ai/kg-dw TWA Pore water (estimated) NOAEC: 0.00015 µg ai/L LOAEC: 0.00054 µg ai/L Endpoints based on reproduction (cumulative egg production). Other affected endpoints: Male:Female and survival		Pore water estimated by normalizing sediment concentrations by TOC fraction (0.05) and then dividing by the Koc = 59677.28 L/kg-OC
Estuarine/marine fish				
Acute	Sheepshead minnow *Cyprinodon variegatus* *Lambda*-cyhalothrin TGAI	0.807 µg a.i./L (95% C.I.: 0.672 - 0.967) Sub-lethal effects included quiescence, loss of balance, weakness, hyper-excitability, and rapid respiration	00153506	Acceptable (Very highly toxic)
Chronic	Sheepshead minnow (*Cyprinodon variegatus*) *Lambda*-cyhalothrin TGAI	**NOAEC = 0.25 µg a.i./L** LOAEC =0.38 µg a.i./L Endpoints based on weight.	00152732	Acceptable
Estuarine/marine invertebrates				
Acute	Mysid Shrimp *Americamysis bahia* *Lambda*-cyhalothrin TGAI	**96-h LC50 = 0.00491 µg ai/L**	00152729	Acceptable (Very highly toxic)
Chronic	Mysid Shrimp *Americamysis bahia* *Lambda*-cyhalothrin TGAI	**28-day NOAEC = 0.0002 µg a.i./L** 28-day LOAEC = 0.0005 µg a.i./L Endpoints based on reductions in the number of young per reproductive day and number of young per treatment.	Acc 073989	Acceptable
Estuarine/marine benthic invertebrates				
10-day Subchronic	Amphipod L*eptocheirus plumulosus*	Based on Bulk Sediment: LC_{50}: 3.35 µg ai/kg-dw **NOAEC: <2.40 µg ai/kg-dw** LOAEC: 2.40 µg ai/kg-dw	49734102	Acceptable Pore water estimated by normalizing sediment concentrations by TOC fraction

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Gamma-cyhalothrin TGAI	Based on mean Measured Pore Water: **NOAEC: <0.0013 µg a.i./L** LOAEC: 0.0013 µg a.i./L Endpoints based on survival		(0.032) and then dividing by the Koc = 59677.28 L/kg-OC
Aquatic plants				
Vascular	Duckweed (*Lemna gibba*) *Lambda*-cyhalothrin TGAI	IC_{50}: >5.4 µg/L NOAEC: 5.4 µg/L No endpoints affected	49274205	Acceptable
	Duckweed (*Lemna gibba*) *Gamma*-cyhalothrin TGAI	**IC_{50}: >0.508 µg/L** NOAEC: 0.508 µg/L No endpoints affected	49734101	Acceptable
Non-vascular	Green Algae (*Selenastrum capricornutum*) *Gamma*-cyhalothrin TGAI	**EC_{50}:>310** NOAEC : ≥310	152731	Supplemental

* All test materials are TGAI unless otherwise noted.

Table 5. Toxicity Profile for Deltamethrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Assessment Endpoint	Species (% a.i.)[1]	Endpoint (Duration)	Toxicity Value (C.I.) in µg a.i./L[2]	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Freshwater fish*	Rainbow Trout, *Oncorhynchus mykiss* (99.3%)	LC_{50} (Acute, 96-h)	**0.15** (0.11 - 0.18)	48393201	Supplemental (Very highly toxic)
	Fathead minnow, *Pimephales promelas* (95%)	NOAEC LOAEC (Chronic, 280-d)	**0.017** 0.035	42786801	Acceptable (reduced growth - females)
Freshwater invertebrates (Water column exposure)	Amphipod, *Hyalella azteca* (99.5%)	LC_{50} (Acute, 96-h)	**0.2 ng a.i./L** (0.06-0.46)	49191301	In Review (Very highly toxic)
	Water flea, *Ceriodaphnia dubia*	NOAEC LOAEC (Chronic, 8-d)	0.0025 0.0050	Shen *et al.* 2012; [#157482]	Supplemental-quantitative (reduced growth)
Freshwater invertebrates (Sediment exposure)	Amphipod, *Hyalella azteca* (99.8%)	Pore Water: NOAEC LOAEC (Chronic, 10-d) Sediment, OC Normalized: NOAEC LOAEC (Chronic, 10-d)	**0.026 ng a.i./L** [3] 0.055 ng ai/L [3] **12 µg a.i./kg-$_{OC}$** 25 µg a.i./kg-$_{OC}$	48593608	Acceptable (reduced growth)
Estuarine/ marine fish	Sheepshead minnow, *Cyprinodon variegatus* (99.2%) (99.5%)	LC_{50} (Acute, 96-h)	**0.58** (0.35-0.90)	41651015	Acceptable (Very highly toxic)
		NOAEC LOAEC (Chronic, 35-d)	**0.024** 0.049	48988203	Acceptable (reduced growth)
Estuarine/ marine invertebrates (water column exposure)	Mysid shrimp, *Americamysis bahia* (>95%) (>99%)	LC_{50} (Acute, 96-h)	**0.0037** (0.0016-0.0049)	42114810	Acceptable (Very highly toxic)
		NOAEC LOAEC (Chronic, 35-d)	**0.47 ng ai/L** 0.73 ng ai/L	48988202	Acceptable (reduced survival day 0-35)
Estuarine/ marine invertebrates (sediment exposure)	NA	NA	NA	NA	No study was submitted.

Assessment Endpoint	Species (% a.i.)[1]	Endpoint (Duration)	Toxicity Value (C.I.) in µg a.i./L[2]	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Aquatic plants (vascular)	Duckweed *Lemna gibba* (99.5%)	EC_{50} NOAEC (7-d)	**>779** **779**	48988204	Acceptable
(Non-Vascular)	Freshwater Diatom *Navicula pelliculosa* (99.6%)	EC_{50} NOAEC (96-h)	**>3.1** **3.1**	49263802	Acceptable

* All TGAI are ≥ 95% purity.
(1) Surrogate for aquatic-phase amphibians
(2) C.I.= 95% confidence interval; units are in µg a.i./L unless otherwise specified.
(3) Pore water NOAEC estimated from sediment-OC NOAEC and mean Koc of 449,000 mL/g-$_{OC}$.

Table 6. Toxicity Profile for Permethrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Assessment Endpoint	Species (% a.i.)	Endpoint (Duration)	Toxicity Value (C.I.) in µg a.i./L[1]	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Freshwater fish*	Bluegill sunfish, *Lepomis macrochirus*	LC_{50} (Acute, 96-h)	**0.79**	00042128	Supplemental (Very highly toxic)
		NOAEC LOAEC (Chronic)	**0.052**[2] NA	NA	NA
Freshwater invertebrates (Water column exposure)	Amphipod, *Hyalella azteca*	LC_{50} (Acute, 96-h)	**0.0066** (0.0054-0.0089)	49513901	Acceptable (Very highly toxic)
	Water flea, *Daphnia magna*	NOAEC LOAEC (Chronic, 21-d)	0.039 0.084	43745701	Reduced growth and reproduction
Freshwater invertebrates (Sediment exposure)	Amphipod, *Hyalella azteca*	Pore Water: NOAEC LOAEC (Chronic, 10-d) Sediment (dry wt.): NOAEC LOAEC (Chronic, 10-d)	**0.0042**[3] 0.0074[3] **7.4 ug a.i./kg-dw** 13 ug a.i./kg-dw	48593614	Acceptable (reduced growth)
Estuarine/ marine fish	Atlantic Silverside (*Menidia menidia*)	LC_{50} (Acute, 96-h)	**2.2**	40228401	Supplemental (Very highly toxic)
		NOAEC LOAEC (Chronic)	**0.143** [4] NA	NA	NA
Estuarine/ marine invertebrates (water column exposure)	Stone crab (*Menippe mercenaria*)	EC_{50} (Acute, 96-h)	**0.018**	40228401	Supplemental (Very highly toxic)
	Mysid shrimp, *Americamysis bahia*	NOAEC LOAEC (Chronic, 28-d)	**0.0024** 0.0046	49554601	Acceptable

Assessment Endpoint	Species (% a.i.)	Endpoint (Duration)	Toxicity Value (C.I.) in µg a.i./L[1]	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Estuarine/ marine invertebrates (sediment exposure)	Amphipod *Leptocheirus plumulosus* (97.7%)	Pore Water: NOAEC LOAEC (Chronic, 28-d) Sediment (dry wt.): NOAEC LOAEC (Chronic, 28-d)	0.024 0.060 **38 µg a.i./kg-dw** 97 µg a.i./kg-dw	49063101	Acceptable
Aquatic plants	Duckweed, *Lemna gibba* (97.8%)	IC_{50} NOAEC (96-h)	**>3.2** **3.2**	49398801	Acceptable
	Freshwater Green alga (*Pseudokirch-neriella subcapitata)*	IC_{50} NOAEC (96-h)	**>4.4** **0.65**	49398804	Acceptable

[*] Surrogate for aquatic-phase amphibians
[(1)] C.I.= 95% confidence interval; units are in µg a.i./L unless otherwise specified
[(2)] NOAEC estimated for bluegill sunfish using an acute-chronic ratio of 15.34.
[(3)] Pore water concentrations estimated using K_{OC} of 76800 L/kg
[(4)] NOAEC estimated for Atlantic silverside using an acute-chronic ratio of 15.34.

Table 7. Toxicity Profile for Pyrethrins Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Assessment Endpoint	Species (% a.i.)	Endpoint (Duration)	Toxicity Value (C.I.) in µg a.i./L[1]	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Freshwater fish*	Rainbow Trout *Oncorhynchus mykiss* (57%)	LC_{50} (Acute, 96-h)	**5.1** (3.1 – 5.7)	43082303	Acceptable (Very highly toxic)
	Fathead minnow *Pimephales promelas*	NOAEC LOAEC (Chronic, ELS)	**1.9** 3.0	43252701	Acceptable (% hatch, growth)
Freshwater invertebrates (Water column exposure)	Amphipod, *Hyalella azteca*	LC_{50} (Acute, 96-h)	**0.76** (0.65 – 0.91)	49066401	Acceptable (Very highly toxic)
	Water flea, *Daphnia magna*	NOAEC LOAEC (Chronic, 21-d)	0.86 2.0	43252702	Acceptable (Reduced # offspring)
Freshwater invertebrates (Sediment exposure)	Midge, *Chironomus dilutus* (52.2%)	(Chronic, 63d LC) Pore Water: NOAEC LOAEC Sediment, dry wt. NOAEC LOAEC	**0.04 µg ai/L [2]** **0.10 µg ai/L [2]** **41 µg ai/kg-dw** **95 µg ai/kg-dw**	49508202 (Bradley, 2014)	Acceptable (significant reduction in % emergence)
Estuarine/ marine fish	Sheepshead minnow, *Cyprinodon variegatus*	LC_{50} (Acute, 96-h)	**16** (14.5-17.7)	43082307	Acceptable (Very highly toxic)
		NOAEC LOAEC (Chronic, 33-d)	**0.7** 1.7	48931401	In Review (reduced growth)
Estuarine/ marine invertebrates (water column exposure)	Mysid shrimp, *Americamysis bahia*	EC_{50} (Acute, 96-h)	**1.4** (1.1 – 1.8)	43082311	Acceptable (Very highly toxic)
		NOAEC LOAEC (Chronic, 28-d)	**0.25** 0.64	49233202	In Review (reduced growth, reproduction)
Estuarine/ marine invertebrates (sediment exposure)	NA	NA	NA	NA	NA

Assessment Endpoint	Species (% a.i.)	Endpoint (Duration)	Toxicity Value (C.I.) in µg a.i./L[1]	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Aquatic plants (Vascular)	Duckweed (*Lemna gibba*) (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (7-d, SR/M)	1,230 (928-1620) 480	48874201 (Softcheck, 2012)	Acceptable (Reduced frond number, biomass)
(Nonvascular)	Freshwater Green Alga, (*Pseudokirch-neriella subcapitata)* (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (96-h, S/M)	105 (94-116) 29	48874204 (Softcheck, 2012)	Acceptable (significant reduction in area under the curve)

[*] Surrogate for aquatic-phase amphibians
[(1)] C.I.= 95% confidence interval; units are in µg a.i./L unless otherwise specified
[(2)] Pore water concentrations estimated using K_{OC} of 35200 L/kg-OC

Table 8. Toxicity Profile for Cyfluthrin and *beta*-Cyfluthrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)	Acute (cyfluthrin)	Rainbow Trout *Oncorhynchus mykiss* (97.6%).	LC_{50} = 0.209 [slope = 6.7 (C.I.: 4.0 – 9.4)]	45426708	Supplemental due to unexplained variability in recovery of the parent compound (Very highly toxic)
	Acute (*beta*-cyfluthrin)	Rainbow Trout *Oncorhynchus mykiss* (99.4%).	**LC_{50} = 0.068** [slope = 7.6 (C.I.: 4.7 – 10.5)]	45375002	Supplemental due to a very high level of variability in the measured concentrations (at all levels) (Very highly toxic)
	Chronic (cyfluthrin)	Rainbow Trout *Oncorhynchus mykiss* (96%).	NOAEC = 0.010 LOAEC = 0.018	00155898	Supplemental. LOAEC based on reduced growth and behavioral effects
	Chronic (*beta*-cyfluthrin)	Rainbow Trout *Oncorhynchus mykiss* (N/A).	**NOAEC = 0.0042** LOAEC = 0.008	N/A	N/A. Based on a '*beta*-cyfluthrin equivalent' using chronic data for cyfluthrin (0.010 x 0.42 = 0.0042)
Freshwater invertebrates	Acute (cyfluthrin; TEMPO 2EC)	Water Flea *Daphnia magna* (2%)	**EC_{50} = 0.025** (slope could not be calculated)	41558003	Acceptable. (Very highly toxic)
	Acute (*beta*-cyfluthrin)	Water Flea *Daphnia magna* (Tech)	EC_{50} = 0.29 (slope could not be calculated)	45426701	Supplemental because the purity of the test material was not specified. (Very highly toxic)
	Chronic (cyfluthrin)	Water Flea *Daphnia magna* (94.7%)	NOAEC = 0.0074 LOAEC = 0.0157	00151442	Acceptable. LOAEC based on reduced growth, survival, and number of young.
	Chronic (*beta*-cyfluthrin)	Water Flea *Daphnia magna* (N/A).	**NOAEC = 0.003** LOAEC = 0.006	N/A	N/A. Based on a '*beta*-cyfluthrin equivalent' using chronic data for cyfluthrin (0.0074 x 0.42 = 0.003)
		Water Flea *Daphnia magna* (2.9%)	NOAEC = 0.10 LOAEC = 0.30	48350610	INVALID
Freshwater benthic invertebrates	Sub-chronic (10-day cyfluthrin)	Midge *Chironomus tentans* (99% a.i.)	Pore water: NOAEC: 0.009 LOAEC: 0.018 LC_{50}: 0.039	46591507	Acceptable

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
	Sub-chronic (10-day; cyfluthrin)	Amphipod *Hyalella azteca* (95.8%)	Mean-measured (survival in µg ai/kg) NOAEC: 0.53 LOAEC: 1.1 LC_{50}: 4.8 OC-normalized mean-measured (survival in µg ai/kg TOC) **NOAEC: 22** LOAEC: 46 LC_{50}: 200 Freely dissolved pore water concentrations (survival in µg a.i./L): **NOAEC: 0.00012** LOAEC: 0.00025 LC_{50}: 0.0011	48593606	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.
	Sub-chronic (10-day; cyfluthrin)	Amphipod *Hyalella azteca* (95.8%)	Mean-measured (survival in µg ai/kg) NOAEC: 61 LOAEC: 130 LC_{50}: 116 OC-normalized mean-measured (survival in µg ai/kg OC) NOAEC: 1967 LOAEC: 4194 LC_{50}: 3742 Freely dissolved pore water concentrations (survival in µg a.i./L): NOAEC: 0.011 LOAEC: 0.023 LC_{50}: 0.02	49209503	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
	Sub-chronic (10-day; cyfluthrin)	Midge *Chironomus dilutus* (94.1%)	Mean-measured (survival in µg ai/kg) NOAEC: <14 LOAEC: 14 LC_{50}: 88 OC-normalized mean-measured (survival in µg ai/kg OC) NOAEC: <609 LOAEC: 609 LC_{50}: 3,826 Freely dissolved pore water concentrations (survival in µg a.i./L): NOAEC: <0.003 LOAEC: 0.003 LC_{50}: 0.02	48593607	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.
	Chronic (42-day; cyfluthrin)	Amphipod *Hyalella azteca* (95.8%)	TWA, bulk sediment (µg ai/kg) NOAEC: 8.0 LOAEC: 20 TWA, OC-normalized (µg ai/kg-OC) NOAEC: 260 LOAEC: 630 TWA, Freely dissolved pore water concentrations (survival in µg a.i./L): NOAEC: 0.0014 LOAEC: 0.0034	49272613	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
	Chronic (Life-cycle; cyfluthrin)	Midge *Chironomus dilutus* (95.8%)	Mean-measured (multiple* in µg ai/kg) NOAEC: 1.6 LOAEC: 3.1 OC-normalized mean-measured (multiple* in µg ai/kg OC) NOAEC: 70 LOAEC: 135 Freely dissolved pore water concentrations (multiple* in µg a.i./L): NOAEC: 0.0004 LOAEC: 0.0007	49272612	Acceptable. *multiple endpoints: male development rate (a growth endpoint, equivalent to emergence rate), combined development rate, male-to-female ratio For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.
	Acute (^{14}C-cyfluthrin)	*Gammarus pulex* (*radiolabeled ^{14}C-cyfluthrin EC 050 Xylol, a.i.-content 54.2g/L)	Initial measured overlying water (ng a.i./L) 7d-LC_{50}: >118	48350611	INVALID
	Chronic (28-day; *beta*-cyfluthrin)	Larvae of *Chironomus riparius* (11.5%)	Overlying water TWA (emergence rate in µg a.i./L) NOAEC: 0.035 LOAEC: 0.087	48350612	INVALID
Estuarine/ marine fish	Acute (cyfluthrin)	Sheepshead Minnow *Cyprinodon variegatus* (87% a.i.)	**LC_{50} = 4.05** (slope could not be calculated)	00146485	Acceptable. (Very highly toxic)
	Acute (*beta*-cyfluthrin)	No data available			
	Chronic (cyfluthrin)	Sheepshead Minnow *Cyprinodon variegatus* (90.5% a.i.)	**NOAEC = 0.025** LOAEC = 0.084	00158781	Supplemental. LOAEC based on reduced juvenile survival.
	Chronic (*beta*-cyfluthrin)	No data available.			

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
Estuarine/ marine invertebrates	Acute (cyfluthrin)	Mysid Shrimp *Mysidopsis bahia* (92% a.i.).	LC_{50} = 0.0024 (slope could not be calculated)	40069501	Acceptable (Very highly toxic)
	Acute (*beta*-cyfluthrin)	Mysid Shrimp *Mysidopsis bahia* (>98% a.i.).	**LC_{50} = 0.0022** [slope = 5.5 (C.I.: 3.7 – 7.3)]	45426709	Acceptable (Very highly toxic)
	Chronic (cyfluthrin)	Mysid Shrimp *Mysidopsis bahia* (97% a.i.).	**NOAEC = 0.00017** LOAEC = 0.00040	00158785	Supplemental. LOAEC based on reduced growth and survival; this study is supplemental due to fluctuations in the test concentrations throughout the study.
	Chronic (*beta*-cyfluthrin)	Mysid Shrimp *Mysidopsis bahia* (NA)	**NOAEC = 0.00007** LOAEC = 0.00017	N/A	N/A. Based on a '*beta*-cyfluthrin equivalent' using chronic data for cyfluthrin (0.00017 x 0.42 = 0.00007)
		Mysid Shrimp *Mysidopsis bahia* (97% a.i.).	NOAEC = 0.00041 LOAEC = 0.00083	49272611	Acceptable. LOAEC based on number of offspring produced per female.

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
Estuarine/ marine benthic invertebrates	28-day (chronic ^{14}C-cyfluthrin)	Amphipod *Leptocheirus plumulosus* (99%)	Mean-measured (survival in µg ai/kg) NOAEC: 13 LOAEC: 35 LC_{50}: 16.7 OC-normalized mean-measured (survival in µg ai/kg OC) **NOAEC: 317** LOAEC: 854 LC_{50}: 407 Freely dissolved pore water concentrations (survival in µg a.i./L): **NOAEC: 0.0026** LOAEC: 0.0069 LC_{50}: 0.0033 ---------- Mean-measured (repro. in µg ai/kg) NOAEC: <1.4 LOAEC: 1.4 LC_{50}: 13.7 OC-normalized mean-measured (repro. in µg ai/kg OC) **NOAEC: <34** LOAEC: 34 LC_{50}: 334 Freely dissolved pore water concentrations (repor. in µg a.i./L): **NOAEC: <0.00018** LOAEC: 0.00018 LC_{50}: 0.0018	46591506 48762904	Supplemental. Reproduction endpoint was not reported. Acceptable. Reproduction addendum to previous study (MRID 46591506), which is now upgraded to acceptable.
Aquatic plants	Vascular (cyfluthrin)	Duckweed (*Lemna* sp.)	NA	NA	No study was submitted.
	Vascular (*beta*-cyfluthrin)	Duckweed (*Lemna* sp.)	NA	NA	No study was submitted.

Assessment Endpoint	Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)	Citation or MRID #	Study Classification/ Comment
	Non-vascular (cyfluthrin)	Green algae (*Pseudokirchneriella subcapita*) (98.7% a.i.)	EC_{50} >181	43984901	Acceptable. No effects at any concentration tested (Highly toxic)
		Algae (*Scenedesmus subspicatus* CHODAT, 95.8% a.i.)	EC_{50} >2	48350623	Supplemental. No effects up to the limit of solubility (0.002 mg/L) (Very highly toxic)
	Non-vascular (*beta*-cyfluthrin)	NA	NA	NA	No study was submitted.

*All test materials are TGAI unless otherwise noted.

[1]Used Koc = 184,864 (185,000) to calculate freely-dissolved pore water concentrations: ug ai/kg-OC / Koc = freely-dissolved pore water concentration, ug ai/L.

Table 9. Toxicity Profile for Fenpropathrin Summarizing Most Sensitive Endpoints for Aquatic Organisms for Use in Risk Assessment

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute (Fenpropathrin)	Bluegill sunfish *Lepomis macrochirus* (91.4%)	LC_{50} = 2.2 (C.I.: 1.3 – 3.6)	00127791	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Fathead Minnow (*Pimephales promelas*) (93.7%)	NOAEC = 0.06 LOAEC = 0.091	41525901	Supplemental due to incomplete submission of raw test data.
Freshwater invertebrates				
Acute (Fenpropathrin)	Water Flea *Daphnia magna* (91.4%)	LC_{50} = 0.53 (C.I.: 0.46 – 0.63)	00127795	Acceptable (Very highly toxic)
Acute (4'-OH-Fenpropathrin)	Water Flea *Daphnia magna* (99.4%)	LC_{50}: = 27.3 (C.I.: 23.1 – 32.5)	49604601	Acceptable (Very highly toxic)
Acute (TMPA[2])	Water Flea *Daphnia magna* (99.7%)	LC_{50}: > 72,000 (C.I.: NA)	49604602	Acceptable (Slightly toxic)
Chronic (Fenpropathrin)	Water Flea *Daphnia magna* (98.0%)	NOAEC = 0.064 LOAEC = 0.35	00153801	Acceptable
Freshwater benthic invertebrates				
Acute (Fenpropathrin)	Amphipod *Hyalella azteca* (91.7%)	LC_{50}: 3.05 ng ai/L (C.I.: 2.38 – 3.38 ng ai/L)	49209502	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Amphipod *Hyalella azteca* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **42-d NOAEC**: 4.0 ng ai/L **42-d LOAEC**: 10.1 ng ai/L Based on OC-normalized sediment concs: **42-d NOAEC**: 0.83 µg ai/g_{oc} **42-d LOAEC**: 2.1 µg ai/g_{oc}	49243301	Acceptable. The NOAEC/LOAEC are based on Day 28 survival.

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Chronic (Fenpropathrin)	Midge *Chironomus dilutus* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **59-d NOAEC**: 5.78 ng ai/L **59-d LOAEC**: 14.94 ng ai/L Based on OC-normalized sediment concs: **59-d NOAEC**: 0.32 µg ai/g_{oc} **59-d LOAEC**: 1.2 µg ai/g_{oc}	49316005	Acceptable. The NOAEC/LOAEC are based on Day 59 overall emergence rate.
Sub-chronic (Fenpropathrin)	Amphipod *Hyalella azteca* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **10-d NOAEC**: <1.5 ng ai/L or <0.0015 µg a.i./L **10-d LOAEC**: 1.5 ng ai/L Based on OC-normalized sediment concs: **10-d NOAEC**: <0.31 µg ai/g_{oc} = <310 µg a.i./kg_{oc} **10-d LOAEC**: 0.31 µg ai/g_{oc}	49368102	Supplemental-qualitative. A non-definitive "less than" (<) value for amphipod length was reported. This information is needed to characterize the effects of fenpropathrin on other freshwater amphipods. Pore water concentrations were not reported in the study. However, the estimated fenpropathrin in the pore water could still be estimated using the OC-normalized sediment concentrations.
Estuarine/marine fish				
Acute (Fenpropathrin)	Sheepshead Minnow *Cyprinodon variegatus* (91.4%)	LC_{50} = 3.1 (C.I.: 2.4 – 4.0)	00127793	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Sheepshead minnow *Cyprinidon variegatus* (91.7%)	NOAEC = 0.81 LOAEC = 2.0	48536801	Supplemental due to high analytical variation (>20%) for all treatment levels. NOAEC based on Normal fry at hatch and post-hatch survival
Estuarine/marine invertebrates				
Acute (Fenpropathrin)	Mysid shrimp *Americamysis bahia* (90.0%)	LC_{50} 0.021 (C.I.: 0.018 – 0.025)	40974404	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Mysid shrimp *Americamysis bahia* (98.6%)	NOAEC = 0.012 LOAEC = 0.024	40974407	Acceptable. NOAEC based on reduced survival and reproductive success.

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Estuarine/marine benthic invertebrates				
Sub-chronic (Fenpropathrin)	Amphipod *Leptocheirus plumulosus* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **10-d NOAEC**: 15.42 ng a.i./L = 0.0154 µg a.i./L **10-d LOAEC**: 32.76 ng ai/L Based on OC-normalized sediment concs: **10-d NOAEC**: 3.2 µg a.i./g_{oc} = 3,200 µg ai/kg_{oc} **10-d LOAEC**: 6.8 µg ai/g_{oc}	48536802	Acceptable. The NOAEC/LOAEC are based on mortality.
Aquatic plants and algae				
Vascular (Fenpropathrin)	Duckweed *Lemna gibba* (91.7%)	IC_{50}>1.0 mg a.i./L NOAEC=1.0 mg a.i./L	49055601	Acceptable. No effects were reported.
Nonvascular (Fenpropathrin)	Green algae *Pseudokirchneriella subcapitata* (91.7%)	IC_{50}>0.85 mg a.i./L NOAEC=0.85 mg a.i./L	48983501	Acceptable. No effects were reported.
Nonvascular (Fenpropathrin)	Blue-green alga *Anabaena flos-aquae* (91.7%)	IC_{50}>1.0 mg a.i./L NOAEC=1.0 mg a.i./L	449055603	Acceptable. No effects were reported.
Nonvascular (Fenpropathrin)	Freshwater diatom *Navicula pelliculosa* (91.7%)	IC_{50}=1.33 mg a.i./L (yield) NOAEC=0.14 mg a.i./L Area under the curve (AUC)	49076502	Acceptable. Endpoints effected: yield, growth rate, AUC
Nonvascular (Fenpropathrin)	Marine diatom *Skeletonema costatum* (91.7)	IC_{50}=0.063 mg a.i./L NOAEC=0.024 mg a.i./L	49055602	Acceptable. Endpoints effected: Area under the curve (AUC)

*All test materials are TGAI unless otherwise noted.
[1] Values based on the most sensitive toxicity estimates which are used for RQ calculations.
[2] TMPA=2,2,3,3-tetramethylcyclopropanecarboxylic acid

Attachment III. Environmental Fate Assessments for Eight Synthetic Pyrethroids plus the Pyrethrins

Chemical Names	**PC Codes**
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

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Cyfluthrin and *Beta*-Cyfluthrin 93
Fenpropathrin 108

Bifenthrin

An environmental fate assessment was provided in the Problem Formulation (DP Barcode D384352, dated December 22, 2010). Additionally, in late 2012, an endangered species assessment for a number of California species was issued[1]. The environmental fate assessment is being updated here with several newly submitted studies.

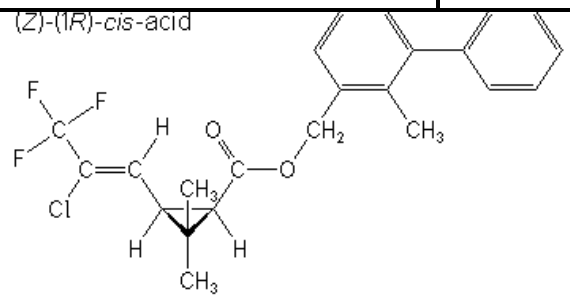
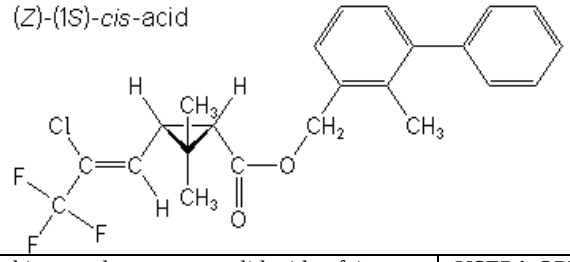
Physical and Chemical Properties

Bifenthrin (**Table 1**) is a synthetic pyrethroid insecticide and acaricide. Its structure has three rings, two phenyl rings attached to each other, and a cyclopropyl ring. It is a Type I synthetic pyrethroid (*i.e.*, it is not cyano-substituted in the *alpha* position). The chemistry of bifenthrin may be dictated by its ester moiety. It would be expected to hydrolyze as the pH increases; however, in the available hydrolysis study, the chemical was stable at all three pHs (5, 7 and 9). The structure of the molecule has two chiral centers and a double bond that could result in a total of 8 isomers. Chemically, bifenthrin contains the Z, *cis*-isomers (includes the 1R and 1S configurations) [(Z)-(1R)-*cis*-acid and (Z)-(1S)-*cis*-acid] out of eight isomeric esters. Bifenthrin has a (*Z*)-2-chloro-3,3,3-trifluoropropene (or 2-trifluoromethyl-2-chloro-ethene) substitution in the cyclopropyl ring. A summary of physicochemical properties of bifenthrin is included in **Table 1**.

Table 1. Summary of physicochemical properties of bifenthrin.

PARAMETER	VALUE(S) (units)	SOURCE
CAS Chemical Name	(2-methyl[1,1′-biphenyl]-3-yl)methyl (1*R*,3*R*)-*rel*-3-[(1*Z*)-2-chloro-3,3,3-trifluoro-1-propenyl]-2,2-dimethylcyclopropanecarboxylate	Bifenthrin data sheet: http://www.alanwood.net/pesticides/bifenthrin.html accessed 04/28/2015
IUPAC Chemical Name	2-methylbiphenyl-3-ylmethyl (1*RS*,3*RS*)-3-[(*Z*)-2-chloro-3,3,3-trifluoroprop-1-enyl]-2,2-dimethylcyclopropanecarboxylate or 2-methylbiphenyl-3-ylmethyl (1*RS*)-*cis*-3-[(*Z*)-2-chloro-3,3,3-trifluoroprop-1-enyl]-2,2-dimethylcyclopropanecarboxylate	
PC Code	128825	OPP Databases

[1] Available at http://www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html (accessed 05/05/2015).

PARAMETER	VALUE(S) (units)	SOURCE
Chemical Structure (from chemical's data sheet)	 	
Appearance	It is an off-white to pale tan waxy solid with a faint, slightly sweet smell.	USEPA OPPTS. 1988. Fact Sheet No.177 Bifenthrin[1]
CAS Reg. No.	82657-04-3	Laskowski, 2002[2]
Molecular Weight	422.9	Laskowski, 2002[2]
Melting Point	68-70.6ºC	USEPA OPPTS. 1988. Fact Sheet No.177 Bifenthrin[1]
Solubility (22ºC)	0.0000140 mg/L *or* 1.40×10^{-5} ppm *or* 0.0140 ppb 'Not Soluble' according to FAO solubility classification.	Laskowski, 2002[2] FAO, 2000[3]
Vapor Pressure (25ºC)	1.80×10^{-7} mmHg (by extrapolation) 'Non-volatile under field conditions.'	MRID 132518 or Acc No.251725 (Laskowski, 2002[2]) USEPA, 2008[4]
Henry's Law Constant	7.2×10^{-3} atm-m^3/mol (from vapor pressure and water solubility)	Laskowski, 2002[2]
Octanol-Water Partition Coefficient (20ºC) (log K_{OW} and K_{OW})	6.4 and 3.00×10^6	Laskowski, 2002[2]
Octanol-Air Partition Coefficient, K_{OA}	$K_{OA} = \frac{K_{OW}}{K_{AW}} = \frac{K_{OW} RT}{\text{Henry's Law Constant}} = 9.4 \times 10^9$	Calculated Value
C_{water}/C_{air}	$\frac{C_{water}}{C_{air}} = \left(\frac{S \times T \times R \times 760}{P \times GMW \times 10^6}\right) = 3133$ (unitless) Volatile from a water surface.	Calculated USEPA, 2008[4]
$C_{water+soil}/C_{air}$[5]	$C_{water+soil}/C_{air} = (C_{water}/C_{air})(1/r + K_d) =$ $(3133)(1/6 + 3591) = 1.13 \times 10^7$ Classified as 'non-volatile from a moist soil.'	Calculated USEPA, 2008[4]
OH Radical Reaction Half-life	0.361 days	EPISuite v.4.0 Estimate
UV/Visible Light Absorption	λ_{max} = 250 nm in neutral, acidic and alkaline solutions; at $\lambda \geq 290$ nm, the tail of the peak at 250 nm results in significant absorption in the range 290 to *ca.* 300 nm.	*EFSA Scientific Report* (2008) 186, 1-109; Conclusion on the peer review of bifenthrin.
Biomagnification Potential	Presumption: If log K_{OA} > 5, log K_{OW} >2 and the rate of chemical transformation is low, the chemical may biomagnify in terrestrial food chains.** For bifenthrin, log K_{OA}> 5, log K_{OW}>2 and rate of	**Gobas *et al.* 2003[6] and Armitage & Gobas, 2007[7] support this presumption utilized here only as a broad reference to determine the

PARAMETER	VALUE(S) (units)	SOURCE
	transformation is slow in the environment and appears to be relatively slow in fish, with slow depuration; it appears that bifenthrin has *a potential to biomagnify* in terrestrial food chains.	potential for biomagnification.

1 As cited in the EXTOXNET database.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
3 Food and Agriculture Organization of the United Nations. FAO PESTICIDE DISPOSAL SERIES 8. Assessing Soil Contamination: A Reference Manual. Appendix 2. Parameters of pesticides that influence processes in the soil. Editorial Group, FAO Information Division: Rome, 2000. http://www.fao.org/DOCREP/003/X2570E/X2570E00.htm (accessed 04/28/2015).
4 USEPA. 2008. *OPPTS 835.6100 Terrestrial Field Dissipation*. EPA 712-C-08-020. October 2008. Office of Prevention, Pesticides, and Toxic Substances. United States Environmental Protection Agency. Available at http://www.epa.gov/ocspp/pubs/frs/publications/Test_Guidelines/series835.htm (accessed 04/28/2015). Also, USEPA 2010: http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (accessed 05/12/2015).
5 Assuming 2% organic carbon, soil to soil water ratio (w/w) = 6, and soil water to soil air (v/v) = 1.
6 Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.
7 Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

Bifenthrin has a high molecular weight of 422.9 g/mol. With an extremely small water solubility (only 0.0140 ppb) and a high octanol/water partition coefficient (K_{OW} = 3.00x10^6). Based on its octanol/water partition coefficient, it appears that bifenthrin has the potential to bioaccumulate/ bioconcentrate. With a vapor pressure of 1.80 x 10^{-7} mmHg, and due to its very small solubility (0.0140 ppb), its calculated Henry's Law Constant is moderately high (7.2 x 10^{-3} atm-m^3/mol). In addition, its C_{water}/C_{air} is 3133, which classifies it as "volatile from a water surface" (USEPA 2008). Bifenthrin has the potential to volatilize from wet surfaces. The potential to volatilize may be attenuated by its tendency to bind to organic matter (*e.g.*, soils, sediments, or organic matter and particulate in natural water).

For bifenthrin, the log K_{OA} range is 7.01 – 12.5 (calculated and EPISuite v.4.0 estimate), the log K_{OW} is 6.4 and the rate of transformation is slow in the environment and appears to be relatively slow in fish, with slow depuration; it appears that bifenthrin may have *a potential* to biomagnify in terrestrial food chains, based on the presumption made by Gobas *et al.* and Armitage & Gobas, in 2003 and 2007 articles, respectively[2]. Even though the EFED has not adopted an official reference or guideline to distinguish chemicals that biomagnify, Gobas *et al.* and Armitage & Gobas' presumption was utilized here as a general or broad reference to identify the potential for biomagnification in terrestrial food chains.

Environmental Fate

A summary of environmental fate/transport properties of bifenthrin is included in **Table 2**. Bifenthrin is a persistent pyrethroid in the environment, stable to hydrolysis and slow to biodegrade. This Type 1 pyrethroid that has a (*Z*)-2-chloro-3,3,3-trifluoropropene (or 2-

[2] Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.

trifluoromethyl-2-chloroethene) group attached to the cyclopropane moiety appears to be stable to sunlight, as opposed to other early Type 1 pyrethroids like allethrin or resmethrin. The very low water solubility and hydrophobic (lipophilic) nature of bifenthrin leads to strong soil adsorption and a tendency to partition to sediment in aquatic systems. The high octanol/water partition coefficient suggests that bifenthrin will bioconcentrate in aquatic organisms. This is confirmed by the bioaccumulation in fish study, where the bioconcentration factors (BCFs) ranged from 2110x for edible portion to 8720x for the non-edible portion. Lower BCFs for bifenthrin in a bioaccumulation in aquatic non-target organisms study (screened only) may be a result of chemical metabolism (biotransformation) by organisms. Bifenthrin has a low vapor pressure and a moderate Henry's law constant. Given the fact that bifenthrin adsorbs strongly to soil particles and to organic matter, volatilization from water and soil surfaces may be reduced. The hydroxyl radical reaction half-life for bifenthrin is 0.4 days (EPISUITE v.4.0 estimate), which appears to preclude the potential for long term transport.

Studies conducted on bifenthrin indicate that it is persistent under most conditions and bioaccumulative. It appears that a major route of degradation is aerobic metabolism. Bifenthrin is stable to hydrolysis at all pH values. It is relatively stable to aqueous and soil photolysis. It degrades slowly under both aerobic and anaerobic soil metabolism conditions (half-life range 97-250 days in four aerobic soils using two radiolabels; and, stable in two anaerobic soils). In aquatic sediments it degrades somewhat faster in aerobic than anaerobic sediments (87-455 days in five aerobic sediments, and 267-9391 days in five anaerobic sediments). Bifenthrin is immobile in four soils tested (K_{OC} > 100,000, FAO classification); it was also found to be immobile in four additional soils and two sediments in studies submitted more recently. Field studies show a pattern consistent with the laboratory studies, with relatively high persistence (half-lives ranging from 78 to 345 days in 10 field trials) and low mobility of the chemical in soil. In aquatic environments, it appears that residues of bifenthrin persist in pond water and sediment for extended periods (at least 12 months of monitoring). No major metabolites were observed (>10% of the applied) in any of the laboratory studies. Bifenthrin was highly bioaccumulative in fish with relatively slow depuration.

Bifenthrin can be spray applied by ground or aerially on agricultural settings. A buffer region is label recommended (150 ft for aerial applications that do not use ULV); however, under a high end drift scenario (*e.g.* small droplets and/ or high wind speed), substantial amounts of the chemical can reach adjacent bodies of water via spray drift. In addition, substantial fractions of the applied bifenthrin should be available for runoff for several weeks to several months after application. Due to its low solubility (0.0140 ppb) and high level of binding (K_{OC} values ranging from 131,000 to 302,000) it appears that bifenthrin would remain bound to the soils during run-off events, and that the chemical would reach surface waters if the run-off event is accompanied by erosion; however, transport of the chemical when dissolved in water is not precluded. A recent study suggests that dissolved organic carbon (DOC) present in sediments may facilitate the desorption of sediment-sorbed pyrethroids (forming dissolved pyrethroid-DOC complexes). Such enhanced desorption in the presence of DOC may enhance the mobility of pyrethroids in streams and by extension, in soils via runoff containing high amounts of DOC (e.g., Delgado-Moreno et al 2010).

Once bifenthrin reaches surface water, the fate of the chemical is of concern since bifenthrin is very toxic to fish and aquatic invertebrates. The Agency believes that bifenthrin, due to its high

level of binding, would remain bound to the sediments and would dissolve only very slowly into the water column. Organisms that live near the sediments may be particularly at risk. The sediments may serve as reservoirs or repositories of bifenthrin, where it appears that it will persist, as shown in an aquatic field dissipation study.

Bifenthrin is not likely to reach subsurface soil environments or ground waters. Various terrestrial field dissipation studies confirm that bifenthrin remains mostly in the upper soil level.

Table 2. Summary of Bifenthrin Environmental Fate Properties (MRIDs for new studies are bolded)

Study	**Value and unit**	**Major Degradate** ***Minor Degradates***	**MRID # (or Citation)**	**Study Classification, Comment**
Abiotic Hydrolysis	No evidence of degradation, relatively stable at all three pHs (5, 7, 9) and in unbuffered (pH 7.5) solution (25°C).	N/A	MRID 00132539	Supplemental. The study was conducted in the presence of 7% of the cosolvent acetonitrile.
	Relatively stable at pH 4 and 7 at 50°C, with <15% AR degraded after 5 days. Stable at pH 9 at 20°C.		MRID **49138403**	Supplemental. The cosolvent acetonitrile was 10% of the buffer solution.
Atmospheric Degradation	Half-life[1] = 0.36 days (hydroxyl) 7.04 days (ozone)	N/A	N/A	Estimated EPISUITE v.4.1[3]
Direct Aqueous Photolysis	No evidence of degradation, relatively stable. Natural sunlight was used.	N/A	MRID 00163084	Supplemental. In unbuffered solution, and conducted in the presence of a very high concentration of the cosolvent acetonitrile.
	Half-life = 49 days (SFO) for <u>total</u> bifenthrin, cyclopropyl and phenyl labels	*Trans*-bifenthrin (58.8% AR) Bifenthrin alcohol (22.5% AR) CO_2 (10.5% AR) *cis*-TFP acid (6.1% AR) *trans*-TFP-acid (5.4% AR)	MRID **48882501**	Supplemental. The study was conducted at >70X the solubility limit of bifenthrin. Recoveries of total residues from the samples were extremely variable (range >20%).

[3] In order to make these estimates, there are certain assumptions made by the module of EPISUITE, which represent a typical hydroxyl and ozone reaction in the atmosphere (refer to AOPWIN module at http://www.epa.gov/opptintr/exposure/pubs/episuite.htm accessed 04/28/2015).

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # (or Citation)	Study Classification, Comment
Soil Photolysis	$t_{1/2}$ = 147 days cyclopropyl $t_{1/2}$ = 98.5 days phenyl labels Silt loam. Corrected $t_{1/2}$'s are 147 days and 106 days, respectively (No significant degradation in dark control for cyclopropyl label.)	*Trans*-bifenthrin reached up to around 3.1% of the applied	MRID 00163085	Acceptable. Natural sunlight in Princeton, New Jersey on August to October, 1985.
Aerobic Soil Metabolism	Half-life[1] = 132 days, SL, cyclopropyl label 116 days, SL, phenyl label 250 days, SiL, cyclopropyl label 155 days, SiL, phenyl label 128 days, SiCL, cyclopropyl label 97 days, SiCL, phenyl label	$^{14}CO_2$ was 6-29% and unextracted residues were 14-25% AR	Acc No: 073174, 073225, 141502, 251278, 251728, 254401, 254411, 264642, 532540; MRID 00132540, 00141202, 00152266	Acceptable. There is a discrepancy between labels (phenyl label degraded faster in all instances). The studies were conducted separately.
	Half-life = 111 days (IORE), SiL, combined cyclopropyl and phenyl labels	CO_2 (47.0% AR) Unextracted residues (18.6% AR) 4'OH 54800 (4.0% AR); TFP acid (0.5% AR) BP alcohol (0.5% AR) BP acid (0.7% AR)	MRID **48882502**	Supplemental. High levels of unextracted radioactivity were observed in the latter intervals.
Anaerobic Soil Metabolism	Relatively stable. Slow metabolism was observed after anaerobic conditions were established. 75-79% of the recovered was bifenthrin at 61 days, sandy loam.	N/A	MRID 00163088	Supplemental. Samples were harvested only a few times: 0 (29 days after aerobic incubation and flooding), 31, and 61 days.
	Half-life = 2,061 days (SFO), LS, cyclopropyl and phenyl labels		MRID **48882503**	Acceptable.

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # (or Citation)	Study Classification, Comment
Aerobic Aquatic Metabolism	Half-life = 276 days (SFO), SiL sediment from the UK 92.9 days (SFO), sand sediment from the UK	UERs (10-15% AR) 4'-OH-Bifenthrin (11.1% AR) CO_2 (27.3% AR) TFP Acid (1.5% AR) BP Acid (1.9% AR) BP Alcohol (1.4% AR)	MRID **48882504**	Supplemental. Test duration was insufficient (only 99 days). Unextracted radioactivity reached up to 14.7% AR at 99 days posttreatment.
	Half-life = 104 days (SFO), sand 455 days (SFO), clay 114 days (SFO), sandy clay loam 98.7 days (SFO), sand 275 days (SFO), clay 87.3 days (SFO), sandy clay loam	N/A	MRID **48762908**	Supplemental. Water and sediment were extracted together. The runs were conducted for a period of up to only 108 days. Non-radiolabeled material was used in this study.
Anaerobic Aquatic Metabolism	Half-life = 587 days (SFO), ClL sediment from ND 618 days (SFO), sand sediment from ND	Biphenyl acid (11.5% AR) TFP acid (8.2% AR)	MRID **49364001**	Supplemental. Data for the time 0 and day 14 were reported from a repeat experiment using different batches of sediment from the original experiment. Many of the sampling intervals had recoveries below guideline requirements. Study lasted only 132 days.
	Half-life = 992 days (SFO), sand 330 days (SFO), clay 307 days (SFO), sandy clay loam 9391 days (SFO), sand 269 days (SFO), clay 267 days (SFO), sandy clay loam	N/A	MRID **48762908**	Supplemental. Water and sediment were extracted together. The runs were conducted for a period of up to only 108 days. Non-radiolabeled material was used in this study.
Solid-water distribution coefficient (K_d)	K_d = 992 L/kg, sand (0.76% OC) 4192 L/kg, sandy loam (1.76% OC) 5430 L/kg, silty loam (1.80% OC) 3690 L/kg, clay loam (1.34% OC)	N/A	Acc. No. 254411 or MRID 00141203	Supplemental. Study was performed at only one concentration. No Freundlich correlations are available. The K_{OC} model represents the mobility better than the K_d model (binding correlated to organic carbon content and the coefficient of variation for the K_{OC} dataset is lower than for the K_d dataset).
Organic-carbon normalized distribution coefficient (K_{OC})	Mean K_{OC} = 236,750 L/kg$_{OC}$ 131,000 L/kg$_{OC}$, sand 239,000 L/kg$_{OC}$, sandy loam 302,000 L/kg$_{OC}$, silty loam 275,000 L/kg$_{OC}$, clay loam			

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # (or Citation)	Study Classification, Comment
Solid-water distribution coefficient (K_d)	Mean K_d = 3104 L/kg 3,966 L/kg, sandy clay loam 3,823 L/kg, clay 2,458 L/kg, sandy loam 2,384 L/kg, loam 2,744 L/kg, marine sediment 3,250 L/kg, freshwater sediment	N/A	MRID **49175401**	Supplemental. Binding is not correlated to organic carbon content and the coefficient of variation for the K_d dataset is lower than for the K_{OC} dataset. The four highest test substance concentrations, were higher than limit of solubility of bifenthrin although the test substance concentration in water at equilibrium were below the solubility limit. The test substance degraded during the study.
Organic-carbon normalized distribution coefficient (K_{OC})	152,547 L/kg_{OC}, sandy clay loam 476,912 L/kg_{OC}, clay 446,881 L/kg_{OC}, sandy loam 58,138 L/kg_{OC}, loam 109,742 L/kg_{OC}, marine sediment 95,594 L/kg_{OC}, freshwater sediment			
Mobility TLC	In TLC studies, the R_f values reported for bifenthrin were as follows: Leon fine sand - 0.3; Cosad sandy loam (low OM) - 0.03; Dunkirk silt loam - 0.08; Hagerstown clay loam - 0.07; The data indicates that bifenthrin is immobile in non-sandy soils.	N/A	Acc. No. 251728 MRID 132541	Provides minimal supplemental information; studies do not fill guideline requirements. Study 00163089 is a mobility study of aged soil using TLC methodology. It was only screened to check if it provided suitable mobility information.
Volatility from Soil (Laboratory)	The mean volatility for day 14 was 5.07×10^{-5} µg/cm^2-hr at 25ºC and 1.48×10^{-4} µg/cm^2-hr at 40ºC, soil texture sand.	N/A	MRID 41220601	Supplemental. The maximum volatiles were 1.1% at 25ºC and 5.1% at 40ºC, of the recovered, after 14 days.
Leachability from Treated Wood	Test material was Bistar® WT Insecticide (23.4 % A.I.) at 0.14 kg/m^3. Maximum leaching rate was 0.64 µg/cm^2/day at 1 day. The median was 0.12 µg/cm^2/day (days 1-14). The cumulative was 1.85 µg/cm^2/day (days 1-14).	N/A	MRID **47454101**	Acceptable, it satisfies the AWPA E11-06 data requirement.
	Test material was 3% Bifenthrin ME over a period of 60 days. Maximum leaching rate was 0.0068 µg/cm^2/day at 7, 14, 28 days. The median was 0.0004 µg/cm^2/day (days 7-60). The cumulative was 0.0691 µg/cm^2/day (days 7-60).		MRID **47454102**	Acceptable, it satisfies the OECD 313 data requirement

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # (or Citation)	Study Classification, Comment
Terrestrial Field Dissipation	Dissipation Half-life[1,2] = Site Half-lives Champaign, IL 192 days Fresco, CA 345 Madera, CA 155 Imperial County, CA 228 Tifton, GA 122 Marion, AR 78 Fresno, CA 193 Champaign, IL 118 Champaign, IL 126 Marion, AR 121 Fresno, CA DT_{50} = 35 days	N/A	Acc No 264642 or MRID 00163091; MRIDs 42339203, 42339201, 42334167, 41673103, 41673101, 41671302	Acceptable
Aquatic Field Dissipation	Pond study was conducted, due to the high toxicity demonstrated for bifenthrin, in Dallas County, Orville, AL: Residues of bifenthrin were found in the sediment and water of the pond during the 12 months period after application; in the sediment, there was no clear discernible pattern of decay.	N/A	MRIDs 40981803, 40981805, 40981808, 40981812, 40981814, 40981815, 40981816, 40981817, 40981818, 40981819.	Supplemental. Residues in fish tissues were orders of magnitude higher than the concentration in water. The study provides useful qualitative information.
Bioconcentration Factor (BCF) – Bluegill Sunfish	Steady State BCF= 6,090 L/kg wet wt whole fish 2,140 L/kg wet wt edible tissue 8,720 L/kg wet wt non-edible tissue Depuration half-lives 32.3 and 38.0 days, for the edible and inedible tissues, respectively.[1]	Parent 66.8-70.2% TRR; 4'-OH-bifenthrin 3.2-3.6% TRR; Unextracted 21.4-23.4% TRR;	Acc. No. 264642 or MRID: 163094, 163095	Supplemental. Depuration was slow with 43-53% of the residues still remaining in the fish tissue after 42 days of depuration. Around 39% *trans*-bifenthrin, which the registrant argues might be a photoproduct.
Bioaccumulation in Aquatic Non-Target Organisms	BCFs seemed to be independent of the application rates: *Daphnia magna* – 270-440x; *Asellus* (water exposure) – 71-82x; *Asellus* (water and soil exposure) – 120-180x; *Pimephales promela* – 45-63x; *Corbicula* (aqueous phase) – 41-74x; *Corbicula* (soil phase) – 92-140x.	Not Available	MRID 42529902	Supplemental. It was noted that the water concentrations greatly exceeded the limit of solubility of bifenthrin, suggesting that dissolved organic matter might have been present in the water.
Bioaccumulation in Aquatic Non-Target Organisms	*Daphnia magna* BCFs ~ 2,500-4,600 L/kg (water) BCFs ~ 800-4,300 L/kg (water plus suspended solids at 0-200 mg/L)	Not Available	Yang *et al.* 2006[3]	Supplemental.
Bioconcentration in Aquatic Non-Target Organisms	*Hyalella azteca* BCF = 1180 ± 542 L/kg	Not Available	Holzer 2011[4]	Supplemental Ref. No. 156712

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # (or Citation)	Study Classification, Comment
POTW Treatability Study	Removal percent for bifenthrin: Primary Settling LR Aerobic Chamber 51.9% Anaerobic Digestion 32.1% Ultrafiltration 91.7%	Not Available	MRID **48762906**	Supplemental; POTW treatability study of eight pyrethroids.

Abbreviations: wt=weight, TRR=total residue recovered, OC=organic carbon, SL=sandy loam; SiL=silt loam; SiCL=silty clay loam; LR=limited removal.
1 Half-lives were calculated using the single-first order (SFO) equation and nonlinear regression, unless otherwise specified. 2 The value may reflect both dissipation and degradation processes.
3 Yang, W., J. Gan, W. Hunter, and F. Spurlock (2006). Effect of Suspended Solids on Bioavailability of Pyrethroid Insecticides. *Environ. Toxicol. Chem.*, 25 (6) 1585–1591, 2006.
4 Holzer, B.R. 2011. Determination of Critical Body Residue Values for Three Current Use Pesticides in *Hyalella azteca* Predictive Techniques Versus Direct Tissue Residue Measurement. ECOTOX Reference Number 156712. Thesis submitted in partial fulfillment for the degree of Masters in Science at Oklahoma State University.

Metabolism and Abiotic Degradation

Bifenthrin, is stable to hydrolysis at a pH range of 5 to 9, as shown in one laboratory study. This was confirmed in a new study, conducted at pH's of 4, 7 and 9. Bifenthrin, was also stable in unbuffered solutions exposed to natural summer sunlight in New Jersey. In a new aqueous photolysis study, a half-life of 49 days was calculated for the total bifenthrin residues (*trans*-bifenthrin was the major transformation product at ~59% AR; another major product was bifenthrin alcohol). Due to the low solubility of this chemical, both studies were conducted in the presence of high concentrations of acetonitrile. Bifenthrin did not appear to degrade substantially for a period of 30 days on a silt loam soil following irradiation with natural sunlight (New Jersey).

The reported half-life of ^{14}C-bifenthrin in three soils under aerobic conditions, using two radiolabels, ranged from 96.8 to 250 days. A newly submitted study yielded a half-life of 111 days in a silt loam, which is within the range of the former study. In an anaerobic soil metabolism study, a sandy loam soil was flooded. The rate of degradation of bifenthrin was very slow when the anaerobic conditions were established. The very slow degradation under the conditions was confirmed in a new anaerobic soil metabolism study. No individual degradation products accounted for more than 10% of the applied in any of the above mentioned studies.

At the time of the Problem Formulation, the Agency did not have aerobic or anaerobic aquatic metabolism studies, but the Agency identified an open literature study. Gan *et al.* (2005)[4] determined the aerobic and anaerobic aquatic metabolism of bifenthrin to be >250 days. Since then, three studies have been submitted, one aerobic aquatic, one anaerobic aquatic, and one study that supplied aerobic and anaerobic aquatic metabolism results. Of the new studies, the combined study used three California sediments and tested them both under aerobic and anaerobic aquatic metabolism conditions. Each sediment was tested twice (*i.e.*, two aerobic and two anaerobic aquatic metabolism half-lives were derived for each sediment, for a total of six aerobic and six anaerobic half-lives). Non-radiolabeled material was used in this study. This study was deemed

[4] Gan, J., S.J. Lee, W.P. Liu, D.L. Haver, and J.N. Kabashima. 2005. Distribution and Persistence of Pyrethroids in Runoff Sediments. J. Environ. Qual. 34:836–841 (2005).

supplemental since the water and sediments were extracted together. It yielded aerobic half-lives in the range of 87-455 days and anaerobic half-lives of 267-9391 days. In an aerobic aquatic metabolism study that used radiolabeled material, half-lives of 93 and 276 days were calculated in two sediments. In an anaerobic aquatic metabolism study, which also used radiolabeled material, bifenthrin was more persistent, with half-lives of 587 and 618 days. All three studies were performed for a short period of time, compared to the derived half-lives.

Transpot, Mobility, Sorption

Bifenthrin was immobile in four soils tested (K_{OC} >100,000, FAO mobility classification FAO 2000). Using a sand, sandy loam, silty loam, and silty clay loam, adsorption experiments resulted in K_{OC} values of 131,000, 239,000, 302,000, and 275,000 L/kg$_{OC}$, respectively. The desorption K_{OC} values were 439,000, 634,000, 645,000, and 765,000 L/kg$_{OC}$, respectively. All these values were obtained at a single concentration. Freundlich correlation coefficients could not be established for bifenthrin. The solutions contained 2% acetonitrile as a cosolvent. In a new study, four soils, a freshwater and an estuarine/marine sediment were tested. The study confirms that bifenthrin is immobile (mean K_{OC} >100,000, FAO 2000). In the study, binding did not appear to be correlated to organic carbon and the mean K_d was 3,104 L/kg. The range of K_{OC}'s was 58,138 to 476,912 L/kg$_{OC}$.

Bifenthrin has a low vapor pressure of 1.8×10^{-7} mmHg, a very low water solubility of 0.014 ppb, and a moderate calculated Henry's law constant of 7.2×10^{-3} atm-m^3/mol. Based upon its Henry's law constant, bifenthrin would be expected to have a moderate potential for volatilization from water surfaces. A laboratory volatility study showed a maximum volatility at 40°C of 5.07×10^{-4} µg/cm^2 hr (average at 14 days). The maximum recovered volatiles were 1.1% at 25ºC (and 5.1% at 40ºC). Although the vapor pressure is marginally low, the Henry's Law Constant suggests that there could be exposure during irrigation events. On the other hand, bifenthrin does not seem to be persistent in air. As indicated in **Table 1**, the hydroxyl radical reaction half-life for bifenthrin is ~0.4 days (EPISuite v.4.0 estimate). Therefore, chronic atmospheric exposure, or transport are precluded, and any concerns would likely be restricted to acute exposures. Bifenthrin's potential for volatilization may be reduced significantly because it adsorbs strongly to soils, suspended solids, particulate, sediment, and organic matter in the water column.

The theoretical maximum concentration of bifenthrin in air[5], based on its vapor pressure, is 4.1 µg/m^3. One air monitoring study for bifenthrin, performed by the California Air Resources Board (CARB 2001), is available. The maximum air concentration from the CARB monitoring results was only 0.270 µg/m^3 (270 ng/m^3), which was "observed at the east sampling site, during the 1st sampling period (application) of 2.7 hours." For the ambient monitoring, "the highest bifenthrin concentration, 17 ng/m^3 (0.97 pptv), was observed at the Helm Elementary School (HES) sampling site in Helm on July 15, 1999."

The Health Effects Division (HED) waived the rat inhalation data requirement based on bifenthrin's low vapor pressure (1.8×10^{-7} mmHg), which is over 400 times below the threshold

[5] Calculated using the equation $Cs = (VP)(MW)(10^3\ L/m^3)(10^6\ \mu g/g)/[(760)(V_m)]$, where Cs is the air concentration at saturation (µg/m^3), VP is the vapor pressure in mmHg, MW is the molecular weight (g/mol), and V_m is the volume occupied by a gas at 25°C, and a pressure of 1 atm, according to the ideal gas constant, which is 24.45 L/mol.

value of $7.5x10^{-5}$ mmHg for low volatility (inhalation waiver criteria 2).

Numerous terrestrial field dissipation studies are available in various states and counties of the nation. They show that bifenthrin degrades in the field with half-lives ranging from 78 to 345 days. These studies appear to confirm the findings of the laboratory studies. They use different formulations and application rates. A supplemental aquatic field dissipation study employing a site in Alabama showed that bifenthrin in aquatic environments (a pond) persists for extended periods of time. It was found throughout the 12 months of monitoring after the last pesticide application, that residues were present in the water column and in the sediment, with no clear pattern of decline.

Bioaccumulation

Bifenthrin appears to be highly bioaccumulative. Fish bioaccumulation studies showed that bifenthrin bioaccumulated with BCF of 2,110 L/kg in edible portion, 8,720 L/kg in the non-edible portion, and 6,090 L/kg in whole fish exposed to 0.0006 to 0.001 ppb of the chemical for 42 days. Depuration was slow with 43-53% of the residues still remaining in the fish tissue after 42 days of depuration. To characterize the residues, fish were exposed to a higher concentration of bifenthrin; the parent comprised 66.8-70.2% of the total radiocarbon, and 4'-OH-bifenthrin was 3.2-3.6%. Unextractable radioactivity was 21.4-23.4%. The following was reported in a screened bioaccumulation in aquatic non-target organisms study: BCFs were independent of the application rates: *Daphnia magna* – 270-440x; *Asellus* (water exposure) – 71-82x; *Asellus* (water and soil exposure) – 120-180x; *Pimephales promela* – 45-63x; *Corbicula* (aqueous phase) – 41-74x; *Corbicula* (soil phase) – 92-140x. In Yang *et al.* 2006[6], the BCFs in *Daphnia magna* were ~2500-4600 L/kg in water and ~800-4300 L/kg in water containing 0-200 mg/L suspended solids. In another study by Holzer (2011)[7], the bioconcentration factor was 1180±542 L/kg in *Hyalella azteca*. These studies confirm bifenthrin's potential to bioconcentrate.

Other Studies (POTW Treatability and Wood Leaching)

In a POTW treatability study, bifenthrin showed limited removal upon primary settling, and nearly 52% removal in the aerobic chamber. In the anaerobic digester only 32.1% of the parent compound was removed. Under ultrafiltration, nearly 92% of the bifenthrin was removed.

In a leachability from treated wood study, using test material was Bistar® WT Insecticide (23.4 % A.I.) at 0.14 kg/m^3, the maximum leaching rate was 0.64 $\mu g/cm^2/day$ at 1 day. The median was 0.12 $\mu g/cm^2/day$ (days 1-14). The cumulative was 1.85 $\mu g/cm^2/day$ (days 1-14). The testing was conducted according to the American Wood Preservers Association (AWPA E11-06) data requirement.

Uncertainties

[6] Yang, W., J. Gan, W. Hunter, and F. Spurlock (2006). Effect of Suspended Solids on Bioavailability of Pyrethroid Insecticides. *Environ. Toxicol. Chem.*, 25 (6) 1585–1591, 2006.

[7] Holzer, B.R. 2011. Determination of Critical Body Residue Values for Three Current Use Pesticides in *Hyalella azteca* Predictive Techniques Versus Direct Tissue Residue Measurement. ECOTOX Reference Number 156712. Thesis submitted in partial fulfillment for the degree of Masters in Science at Oklahoma State University.

The major uncertainties with respect to the environmental fate studies on bifenthrin are related to the extremely low solubility of bifenthrin and the problems found when the registrant performed these studies. The hydrolysis, aqueous photolysis, and batch equilibrium studies were performed in unusually high concentrations of acetonitrile. For example, one of the aqueous photolysis studies was performed in the presence of 30% acetonitrile; nonetheless, it should be acknowledged that no substantial photolysis was observed. Furthermore, one of the batch equilibrium studies was performed at a single concentration (a Freundlich isotherm was not developed). Both, new aqueous photolysis and batch equilibrium studies were submitted to the Agency and included in this report.

Transformation Products

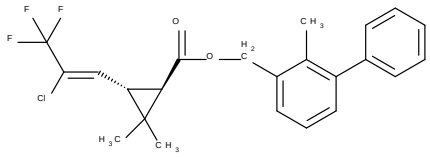
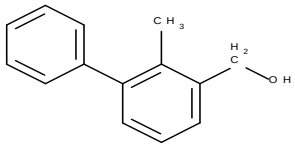
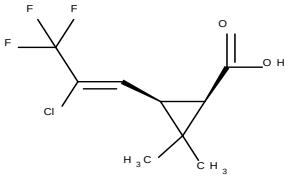
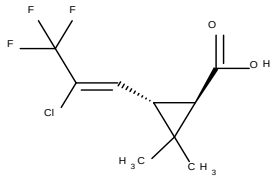
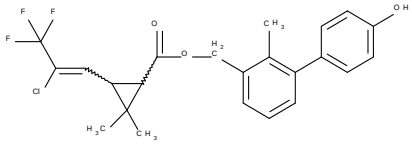
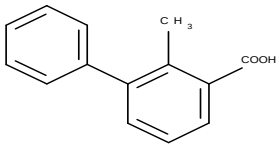
Table 3 is a summary of degradate formation for bifenthrin. **Table 4** provides the structures of these degradates. Note that, because bifenthrin is relatively stable or dissipates very slowly in most studies, in general no major transformation products (≥10% of the applied) were observed. At the time, no degradates were flagged for further quantitation in the terrestrial field dissipation study; however, 4'-OH-bifenthrin was monitored and detected in some of the sites. After the initial studies were reviewed, newly submitted studies show the formation of major degradates under certain conditions, as described in **Table 3**.

Table 3. Summary of degradate formation from degradation of bifenthrin.

STUDY TYPE	SOURCE	DEGRADATE and MAXIMUM CONCENTRATION
Hydrolysis	ACC: 251728, MRID: 132539.	NO hydrolysis product exceeded 10% of the applied during the study.
	MRID: 49138403	
Aqueous Photolysis	ACC: 264642.	NO aqueous photolysis product exceeded 10% of the applied during the study.
	MRID: 48882501	*trans*-bifenthrin (58.8% AR); bifenthrin alcohol (22.5%); *cis*-TFP acid (6.1% AR); *trans*-TFP-acid (5.4% AR); CO_2 (10.5% AR)
Soil Photolysis	ACC: 264642 or MRID: 00163085	NO soil photolysis product exceeded 10% of the applied during the study.
Aerobic Soil Metabolism	MRIDs: 141202, 254411, 532540, 251728, 254401, 073225, 073174, 251278.	NO aerobic soil metabolism product exceeded 10% of the applied in the studies. The most significant metabolite (Met I) at 3-5.6% of the applied radioactivity was identified as 4'-OH-bifenthrin. $^{14}CO_2$ was 6-29% and unextracted residues were 14-25% AR.
	MRID 48882502	CO_2 (47.0% AR); unextracted residues (18.6% AR); 4'OH 54800 (4.0% AR); TFP acid (0.5% AR); BP alcohol (0.5% AR); BP acid (0.7% AR)
Anaerobic Soil Metabolism	Acc. No. 264642 or MRID: 163088	NO anaerobic soil metabolism product exceeded 10% of the applied in the study. The following metabolites were observed at low concentrations: 4'-OH-bifenthrin, TFP acid, BP-alcohol, BP-acid and BP-aldehyde.
	MRID: 48882503	NO anaerobic soil metabolism product exceeded 10% of the applied in the study.
Aerobic Aquatic Metabolism	MRID: 48882504	Unextracted residues (10-15% AR); 4'-OH-Bifenthrin (11.1% AR); CO_2 (27.3% AR); TFP Acid (1.5% AR); BP Acid (1.9% AR); BP Alcohol (1.4% AR)
	MRID: 48762908	Degradates were not identified in this study. It was conducted using non-radiolabeled test material.

STUDY TYPE	SOURCE	DEGRADATE and MAXIMUM CONCENTRATION
Anaerobic Aquatic Metabolism	MRID: 49364001	Biphenyl acid (11.5% AR); TFP Acid (8.2% AR)
	MRID: 48762908	Degradates were not identified in this study. It was conducted using non-radiolabeled test material.
Terrestrial Field Dissipation	MRIDs: 40981803, 40981805, 40981808, 40981812, 40981814, 40981815, 40981816, 40981817, 40981818, 40981819.	4'-OH-bifenthrin detected in certain studies.

Table 4. Structures of Transformation Products of Bifenthrin

Common Name	Chemical Name	Structure
trans-bifenthrin	2-Methylbiphenyl-3-ylmethyl (1R,3S)-3-[(Z)-2-chloro-3,3,3-trifluoroprop-1-enyl]-2,2-dimethylcyclopropanecarboxylate	
bifenthrin alcohol (BFA); Biphenyl alcohol; BP alcohol)	2-Methyl-3-phenylbenzyl alcohol	
cis-TFP acid	(1R,3R)-3-[(Z)-2-chloro-3,3,3-trifluoro-prop-1-enyl]-2,2-dimethyl-cyclopropanecarboxylic acid	
trans-TFP acid	(1R,3S)-3-[(Z)-2-chloro-3,3,3-trifluoro-prop-1-enyl]-2,2-dimethyl-cyclopropanecarboxylic acid	
4'-OH-bifenthrin, 4'OH 54800, 4'-Hydroxy-bifenthrin	4'-Hydroxy-2-methyl-biphenyl-3-ylmethyl (Z)-(1RS,3RS)-3-[2-chloro-3,3,3-trifluoroprop-1-enyl]-2,2-dimethylcyclopropanecarboxylate	
BP-acid, Biphenyl acid	2-Methyl-3-phenylbenzoic acid	
BP-aldehyde	2-Methyl-3-phenylbenzaldehyde	Structure not available

Deltamethrin

An environmental fate assessment was provided in the Problem Formulation (DP Barcode D373622, dated March 23, 2010). Additionally, in March 2013, an endangered species assessment for a number of California species was issued[8]. The environmental fate assessment is being updated here with around seven newly submitted studies. **Table 5** lists the physical-chemical properties of deltamethrin. **Table 6** lists the other environmental fate properties of deltamethrin, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

Physical-Chemical Properties

Deltamethrin has two phenyl rings attached through an oxygen atom (*i.e.*, phenyl and phenoxy), and a cyclopropyl ring with a dibromoethenyl group. It is a Type II synthetic pyrethroid (*i.e.*, it is cyano-substituted in the *alpha*-position). The structure of the molecule has three chiral centers that could result in a total of 8 stereoisomers. Chemically, it is the [1R, *cis*; *alpha* S]-isomer [alternatively, (1S)-alcohol (1R)-*cis*-acid], out of eight stereoisomeric esters of the dibromo analogue of chrysanthemic acid.

Table 5. Physical-chemical Properties of Deltamethrin

Property	Value and units	MRID or Source
Molecular Weight	505.2 g/mole	Laskowski, 2002
Chemical Formula	$C_{22}H_{19}Br_2NO_3$	EPI Suite v.4.1
CAS No.	52918-63-5	EPI Suite v.4.1
Relative Density Bulk Density	1.59 g/cm^3 at 20^{0}C (CV = 0.4%; technical grade) 0.550 g/cm^3 (technical grade)	MRID 47866503 European Commission [(1)]
Vapor Pressure	9.32 x 10^{-11} torr @ 25ºC Classified as 'Non-volatile under field conditions.' [(2), (4)]	Laskowski, 2002
Henry's Law Constant	3.1 x 10^{-7} atm-m^3/mole	Estimated from water solubility and vapor pressure
Water Solubility	0.000200 mg/L = 0.200 ppb @ 20ºC	Laskowski, 2002
Solubility in Organic Solvents	All at 20^{0}C: 5.13±0.18 mg/mL in n-octanol 292.6±3.5 mg/mL in acetone 176.7±8.5 mg/mL in o-xylene	MRID 47866503
Octanol – water partition coefficient (K_{OW})	3.42 x 10^4 @ 25ºC (log K_{OW} = 4.53) 9.12 x 10^6 @ 20ºC (log K_{OW} = 5.96)	Laskowski, 2002 MRID 47866503
Air-water partition coefficient (K_{AW})	$K_{AW} = C_{air}/C_{water}$ = Henry's Law Constant/(RT) = 1.27x10^{-5} (unitless) Classified as 'Slightly volatile from a water surface.'[(2)]	Calculated
Octanol-air partition coefficient (K_{OA})	$K_{OA} = K_{OW}/K_{AW}$ = 2.7 x 10^9 (unitless)	Calculated
$C_{water+soil}/C_{air}$	$C_{water+soil}/C_{air} = (C_{water}/C_{air})(1/r + K_d)$ = (78700) (1/6 + 3113) = 2.45x10^6 (3) Classified as 'Non-volatile from a moist soil.' [(2)(3)(4)]	Calculated

[8] Available at http://www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html (accessed 05/05/2015).

Property	Value and units	MRID or Source
UV/visible light absorption	Maxima at 267, 271 and 278 nm Low to very low absorption at 290-300 nm; Maxima at 205, 268 and 290 nm in methanol Lower absorption coefficient (ε) at 290 nm.	European Commission (1); MRID 47866503

(1) Review report for the active substance deltamethrin, European Commission, 6504/VI/99-final, October 17, 2002, Appendix I, Identity, physical and chemical properties (July 4, 2002). Bulk density also available in Material Safety Data Sheet (MSDS) at http://www.chemicalbook.com/ProductMSDSDetailCB5266265_EN.htm (accessed 05/05/2015).
(2) For classification scheme, see USEPA, 2008. See also "Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in Problem Formulations," available at (accessed 05/05/2015): http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm. Additionally see USEPA 2010 (accessed 05/12/2015): at:http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm.
(3) Assuming 2% organic carbon, soil to soil water ratio (w/w) = 6, and soil water to soil air (v/v) = 1.
(4) Note that all chemicals may volatilize to some extent; this classification simply indicates that the volatility potential is very low.

Deltamethrin has a very low solubility (only 0.200 ppb) and a high octanol/water partition coefficient (K_{OW} = 34,200). Based on K_{OW} alone, it would appear that deltamethrin has the potential to bioconcentrate or bioaccumulate. However, many of the pyrethroids, such as deltamethrin, undergo substantial biotransformation *in vivo* (refer to **Table 6**). With a small vapor pressure (9.32 x 10^{-11} torr) a relatively small Henry's Law Constant (3.1 x 10^{-7} atm-m^3/mol), deltamethrin is not expected to volatilize substantially from dry/wet surfaces.

For deltamethrin, the log K_{OA} is 9.89 and the log K_{OW} is 4.53. For chemicals that are not readily metabolized in vivo, a log K_{OA} and log K_{OW} in this range (K_{OA} > 5, log K_{OW} >2) have been associated with biomagnification in terrestrial-based food webs based on information presented in articles by Gobas *et al.* and Armitage & Gobas (2003 and 2007, respectively). However, pyrethroids, such as deltamethrin, undergo substantial biotransformation *in vivo*. Even though the EFED has not adopted an official reference to distinguish chemicals that biomagnify, their presumption was utilized here as a general or broad reference to detect the biomagnification potential in terrestrial food chains.

Table 6. Deltamethrin Environmental Fate Properties (MRIDs for new studies are bolded)

Study	Value and unit	Major Degradate *Minor Degradates**	MRID # or Citation	Study Classification, Comment
Abiotic Hydrolysis	Half-life[1] = Stable, pH 5 **Stable**, pH 7 2.5 days, pH 9	Major: BR_2CA, 3-PB Aldehyde	MRID 41651038	Supplemental
Atmospheric Degradation	[Include when an air photolysis study is not available] Half-life[1] = 51.4 days, estimated for ozone reaction; 0.46 days, estimated for OH radical reaction	Not Available	EPI Suite v.4.10 Estimates	Ozone reaction @ 25^0C and $7x10^{11}$ mol/cm^3; Hydroxyl radical reaction @ 25^0C and 12-hr day; $1.5x10^6$ OH/cm^3
Direct Aqueous	Half-life[1] =	Major:	MRID	Acceptable

Study	Value and unit	Major Degradate *Minor Degradates**	MRID # or Citation	Study Classification, Comment
Photolysis	64 days, pH 5 (benzyl label) **84** days, pH 5 (gem label)	3-PBA *Minor*: *cis*-BR_2CA	42114818	
Soil Photolysis	Half-life[1] = Stable, sandy loam	Reported R/S epimerization; *cis* and *trans*-Br_2CA & 3-PBA observed	MRID 42114819	Acceptable Test material degraded both in the irradiated samples and controls.
Aerobic Soil Metabolism	Half-life[1] = Dubbs fine sandy loam (acidic) was tested at two application rates and with two radiolabels, first order half-lives as follows: for cyano and phenoxy labels, respectively: at 0.02 lb/A: **52.5**, **54.6** days, at 0.20 lb/A 50.2, 55.0 days. Memphis silt loam (acidic) was tested at two application rates and with two radiolabels, first order half-lives as follows: for cyano and phenoxy labels, respectively: at 0.02 lb/A **46.2**, **50.2** days, at 0.20 lb/A 45.6, 52.5 days. Additional study conducted with Dubbs fine sandy loam at 10-40ºC, the half-lives obtained at 25ºC were 19.7 and 24.6 days for the cyano and vinyl labels, respectively. Alkaline Arizona sandy loam (pH 8.1) half-lives **22** and **26** days	Major: BR_2CA	MRID 41677404, 41677405, 42114820	Acceptable
Anaerobic Soil Metabolism	Half-life[1] = **34** days combined labels (benzyl and gem), alkaline loam	Major: BR_2CA *Minor*: 3-PBA	MRID 42114821	Acceptable
Aerobic Aquatic Metabolism	Half-life[1] sum of deltamethrin + the *alpha*-R-deltamethrin = Loam sediment from the Netherlands (ditch): 6.0 days in water 62.2 days in sediment **25.9** days in total system Sandy loam sediment from the Netherlands (river): <1 days in water 132 days in sediment	Major: α-R-deltamethrin, *Minor*: 3-PBA	MRID 44977005	Supplemental

Study	Value and unit	Major Degradate *Minor Degradates**	MRID # or Citation	Study Classification, Comment
	120 days in total system			
	Half-life[1] = Hoenniger Weiher loam sediment (20°C): $t_{R\ IORE}$ = 8.55 days Parent + α–R-deltamethrin $t_{R\ IORE}$ = **21.2** days; Germany Anglersee sand sediment (20ºC): $t_{R\ IORE}$ = 6.28 days Parent + α–R-deltamethrin $t_{R\ IORE}$ = **9.29** days Half-lives do not include UERs.	Major: α-R-deltamethrin; BR_2CA; BrCA isomers 1 & 2; BrCA isomers 1 & 2; Serinyl-BrCA; CO_2; Unextracted residues	MRID **48988201**	Supplemental; Material balances decreased to 81.5-84.0% AR at 73-99 days. Unextracted residues totaled maximums of 35.3-37.0% AR.
	Half-life = 9.74 days (SFO), sand 91.2 days (IORE), clay 37.3 days (IORE), sandy clay loam	N/A	MRID **48762908**	Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used in this study.
Anaerobic Aquatic Metabolism	Half-life[1] = Kansas, USA silty clay loam sediment (20°C): Slow $t_{1/2}$ = **98.9** days (DFOP) North Dakota, USA silt loam sediment (20°C): Slow $t_{1/2}$ = **60.7** days (DFOP)	Major: 3-PBA; Monobromo acid isomers 1& 2; *Minor*: CO_2; Unextracted residues	MRID **49114109**	Supplemental; Both sediments had "fine textures" with percent clay plus silt above 50%.
	Half-life = 162 days (DFOP), sand 327 days (IORE), clay 59.8 days (SFO), sandy clay loam	N/A	MRID **48762908**	Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used in this study.
Freundlich solid-water distribution coefficient (K_F)	K_F; 1/n = 3,000 mL/g AK silt loam; 1.00 4,750 mL/g GA silt loam; 1.13 960 mL/g TX sandy loam; 1.18 3,790 mL/g MS silt clay loam; 1.01	N/A	MRID 41651039, 42976501	Acceptable
Organic-carbon normalized distribution coefficient (K_{OC})	K_{OC} = 317,000 mL/g_{OC} AK silt loam 255,000 mL/g_{OC} GA silt loam 516,000 mL/g_{OC} TX sandy loam 708,000 mL/g_{OC} MS silt clay loam Mean K_{OC} = **449,000** ml/g_{OC}	N/A	MRID 41651039, 42976501	Acceptable Immobile (FAO 2000) K_{OC} model is appropriate to describe sorption better than K_d.
Terrestrial Field Dissipation	Dissipation Half-life[1,2] = 231 days, bare ground and cotton, LS (low organic matter) 37 days, bare ground, CA 40 days, cotton, CA 69 days, bare ground, MN 14 days, corn, MN	BR_2CA and α-R-deltamethrin detected; 3-PBA not monitored	MRID 42137505, 42773903, 42114822	Acceptable

Study	Value and unit	Major Degradate *Minor Degradates**	MRID # or Citation	Study Classification, Comment
Bioconcentration Factor (BCF)- Bluegill Sunfish (*Lepomis macrochirus*)	Steady State BCF= 698 L/kg wet wt whole fish 198 L/kg wet wt edible tissue 3630 L/kg wet wt non-edible tissue; 50% depurated between 3-7 days, and 70-75% after 2 weeks; calculated $t_{1/2}$ = 3.55 days	The majority of the radioactivity was parent material.	MRID 41651040, 43072701, 43072702	Acceptable
Deposition of deltamethrin adulticide using ground ULV sprayer	Test substance applied at ~0.0005, 0.0010 & 0.0015 lb a.i./A using ground ULV. The maximum depositions were: Manatee County, FL 17.9% Chambers County, TX 34.2% Merced County, CA 20.8% Caswell County, NC 25.1%	N/A	MRID **49114102**, **49114103**, **49114104**, **49114105**	Final study review classification is issued by the Registration Division.
WWTP Treatability Study	Removal percent deltamethrin: Primary Settling LR Aerobic Chamber 59.1% Anaerobic Digestion 77.1% Ultrafiltration 92.6%	N/A	MRID **48762906**	Supplemental; POTW treatability study of eight pyrethroids.

Abbreviations: wt=weight; LR= Limited Removal; Bolded values are used in risk assessment.
*For additional information about the transformation products of deltamethrin, see **Tables 7 to 9**.
[1] Half-lives were calculated using the single-first order equation and nonlinear regression, unless otherwise specified.
[2] The value may reflect both dissipation and degradation processes.

Metabolism and Abiotic Degradation

When applied to the field, deltamethrin is likely to partition to the soil (solid) phase and organic matter, though binding is not instantaneous (K_{OW} = 34,200 and K_{OC}>>100,000 mL/g_{OC}; immobile, FAO 2000). It is not expected to leach into subsurfaces. It may reach aquatic environments via spray drift or in runoff events accompanied by erosion. Deltamethrin appears to be moderately to highly persistent in terrestrial environments (aerobic soil metabolism 20-55 days; terrestrial field dissipation 14-231 days). It has the potential to persist in aquatic environments, where it may partition with the sediment and to affect benthic and epibenthic organisms (aerobic aquatic metabolism ~9-120 days for the residues in the total system of parent + α-R-deltamethrin; anaerobic aquatic metabolism 60.7-98.9 days for the residues in the total system).

Deltamethrin is relatively stable at pH 5 and 7. However, it rapidly degraded (half-life of 2.5 days) at an alkaline pH of 9, to form Br_2CA and 3-PB aldehyde (refer to **Table 7**). It does not appear to photodegrade substantially in aqueous solutions (half-lives 64 & 84 days). In the soil photolysis study, considerable degradation was occurring both in the irradiated and dark controls samples. Soil photodegradation was not considered as an important route of dissipation.

Based on acceptable aerobic soil metabolism data, deltamethrin in Dubbs fine sandy loam and Memphis silt loam soil, tested at two application rates and with two radiolabels, degraded at moderate rates (first order half-lives 19.7-55.0 days) to form DBVA (or Br_2CA) (<10%) and CO_2. Over the l28 day incubation period, 62-77% and 52-60% of the ^{14}C-cyano- and the ^{14}C-phenoxy-

labelled parent evolved as $^{14}CO_2$. The proposed routes of degradation are ester hydrolysis and microbial-mediated mineralization to CO_2. An additional aerobic soil metabolism study was submitted for an alkaline Arizona sandy loam (pH 8.l), which yielded somewhat lower half-lives of 22 and 26 days. For the gem label study, Br_2CA was formed, which peaked at 23-26% on day 30 and 14, respectively. Given the fact that the pH of the latter study was higher, the half-lives were lower, which is what was expected from the hydrolysis study.

In an anaerobic soil metabolism study, deltamethrin degraded in an Arizona sandy loam (pH 8.l) with a half-life of 32-36 days for the benzyl and gem labels, respectively. For the gem label experiment, only l metabolite, Br_2CA or decamethrinic acid, was found at 49% of the applied radioactivity by day 30 and remained at about this level on days 59 (52%) and 90 (48%). For the benzyl label, the only metabolite identified was m-PB Acid, which was only detected in a day 30 sample, accounting for only 3% of the applied radioactivity. This study is not representative of a neutral or acidic pH soil, which is expected to yield higher half-lives.

In a new aerobic aquatic metabolism study, consisting of a loam or a sandy loam test systems from the Netherlands, the half-lives for the whole systems were 26 and 120 days, respectively. The major transformation product was the α-R-isomer of deltamethrin, at up to 24% in the sandy loam. In a new aerobic aquatic metabolism study, the half-lives for the whole systems were 21.2 and 9.29 days for a loam and a sand sediments at 20°C, respectively. In this study, α-R-deltamethrin was also a major product. The above half-lives are for the decay of parent plus α-R-deltamethrin. In another new aerobic aquatic metabolism study, using non-radiolabeled material, the calculated representative half-lives were 9.74, 91.2 and 37.3 days, for a sand, clay and sandy clay loam, respectively. In the study, water and sediment were extracted together and non-radiolabeled test substance was used. It is unclear whether these half-lives included the α-R-deltamethrin transformation product observed in previous studies.

A new anaerobic aquatic metabolism study was submitted. In the study, the half-lives were 98.9 and 60.7 days, in a KS silty clay loam and a ND silt loam, respectively. Major degradates included 3-PBA and monobromo acid isomers 1 and 2. Another new anaerobic aquatic metabolism study, using non-radiolabeled material, the calculated representative half-lives were 162, 327 and 59.8 days, for a sand, clay and sandy clay loam, respectively. This is a study, which included both aerobic and anaerobic aquatic metabolism evaluation. In the study, the water and sediment were extracted together.

Transport, Mobility, Sorption

In batch equilibrium studies, deltamethrin was found to be immobile (K_{OC}>100,000 mL/g_{OC}), FAO classification, FAO 2000) and had Freundlich K_d's of 3,790 mL/g for a Mississippi silty clay loam, 3000 mL/g for an Arkansas silty loam, 4750 mL/g for a Georgia silty loam, and 960 mL/g for a Texas sandy loam. K_{OC}'s ranged from 204000 to 577000 mL/g_{OC}. Although deltamethrin is tightly bound, adsorption was not immediate, because equilibrium times were 4-24 hours.

Field Dissipation Studies

In three terrestrial field dissipation studies parent appeared not to be mobile in soil and degraded

in l-2 months, except the Louisiana study, where the half-life was almost 8 months. The longer half-life could fall within the range of normal field variability and the Louisiana soil was the lowest in organic matter, which could result in the lowest amount of soil binding and soil microbial degradation. No clear pattern of degradate formation and decline was seen, possibly because the low application rate and 6" sampling intervals resulted in soil dilution. Ten applications were performed at up to 0.1 lb a.i./A.

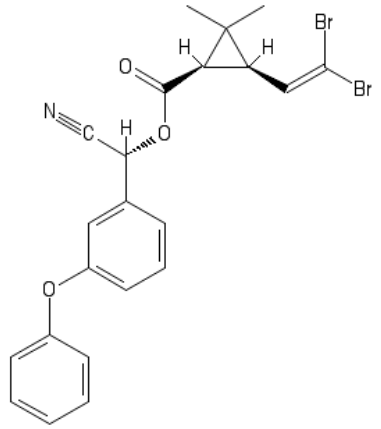
Bioconcentration

In a fish bioconcentration study, a whole body BCF of 698x was calculated from edible and visceral fish tissue results. The majority of the radioactive residue found in fish was parent, accounting for 78 and 83% of the total radioactive residue in edible and visceral fish tissues, respectively. In a study, the depuration was about 50% between days 3-7 and 70-75% after 2 weeks. The depuration results were obtained from a separate study that had been conducted prior to the final bioconcentration study.

Transformation Products

Even though various degradates were observed in the laboratory studies (*e.g.* 3-PBA and tetramethrinic acid), it was found that they were the result of the rupture of the ester bond of the parent molecule. It is believed that the resulting molecules are not as toxic as the parent because they presumably have lost the neurotoxic mode of action. **Table 7** shows the chemical structures of deltamethrin's major degradation products. At this time, except for *alpha*-R-deltamethrin, they are not considered stressors. The latter degradate was 24% of the applied radioactivity in the aerobic aquatic metabolism study. The half-lives calculated for the test systems included the parent compound and the major degradate. Thus, the degradate *alpha*-R-deltamethrin is considered a stressor in this assessment.

Table 7. Major Transformation Products of Deltamethrin

Common Name	Chemical Name/CAS	Structure
alpha-R-deltamethrin	(*R*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-carboxylate Major product in the aerobic aquatic metabolism studies; for the aerobic aquatic metabolism study, the half-lives for the total residue were calculated. [R-S epimerization was reported in the soil photolysis study.]	(*R*)-alcohol (1*R*)-*cis* acid of deltamethrin 

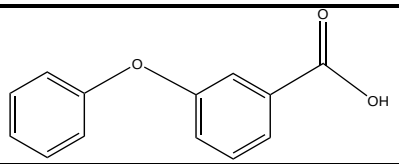
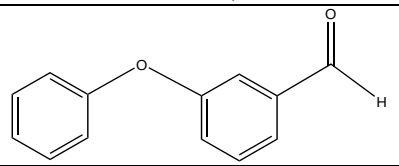
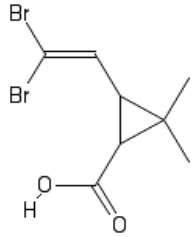
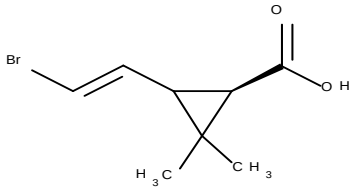
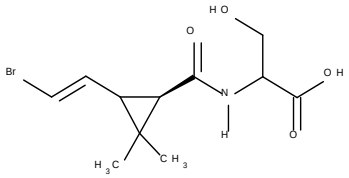
Common Name	Chemical Name/CAS	Structure
m-PBA or *m*-PBAc or 3-PBA or 3-PBAc	3-phenoxybenzoic acid/ (CAS No. 3739-38-6) Major product in aqueous and soil photolysis studies, and the anaerobic aquatic metabolism study.	
3-PB Aldehyde	3-phenoxybenzaldehyde/ (CAS No. 39515-51-0) Major product in the hydrolysis study.	
Decamethrinic Acid or *cis*-Br_2CA presented	(lR-*cis*)-3(2,2-dibromoethyl)-2,2-dimethylcyclopropanecarboxylic acid/ (CAS No. 53179-78-5) Major product in soil photolysis, aerobic soil metabolism, anaerobic soil, and aerobic aquatic metabolism studies.	
BrCA isomers 1 and 2	(1R)-3-[(E)-2-bromovinyl]-2,2-dimethyl-cyclopropanecarboxylic acid Major product in one aerobic aquatic metabolism study and in the anaerobic aquatic metabolism study.	
Serinyl-BrCA	2-[[(1R)-3-[(E)-2-bromovinyl]-2,2-dimethyl-cyclopropanecarbonyl]amino]-3-hydroxy-propanoic acid Major product in one aerobic aquatic metabolism study.	

Table 8 provides a summary of the various degradation products formed by each process in the studies reviewed for deltamethrin.

Table 8. Summary of degradate formation from degradation of deltamethrin

STUDY TYPE	DEGRADATE and MAXIMUM CONCENTRATION			SOURCE
	Br_2CA or BrCA derivatives (% applied)	**Deltamethrin Isomers (% applied)**	**m-PBAc <u>or</u> m-PBald (% applied)**	
Hydrolysis	Br_2CA <0.15 µg/L (*vs.* app. rate 10.0 µg/L)	--	m-PBald: 3.37 µg/L at 30 days (*vs.* app. rate 10.0 µg/L)	MRID 41651038
Aqueous Photolysis	Br_2CA 3% at day 21	--	m-PBAc 11% at day 21	MRID 42114818

STUDY TYPE	DEGRADATE and MAXIMUM CONCENTRATION			SOURCE
	Br_2CA or BrCA derivatives (% applied)	**Deltamethrin Isomers (% applied)**	**m-PBAc or m-PBald (% applied)**	
Soil Photolysis	Br_2CA 40% at 21 days (samples contained more *cis*- than *trans*-Br_2CA; it was present also in dark control)	R-S epimerization was reported, but no *trans*-deltamethrin observed	m-PBAc 11% at 14 days in preliminary study	MRID 42114819
Aerobic Soil Metabolism	Br_2CA 23-26% at 14-30 days	--	--	MRID 41677404, 41677407, 42114820
Anaerobic Soil Metabolism	Br_2CA 49% by day 30, and remained at that level through day 90 (48-52% during the period)	--	m-PBAc 3% at 30 days	MRID 42114821
Aerobic Aquatic Metabolism	Br_2CA at up to 45.4% at 7 days and decreased to 12.0% at 99 days. BrCA isomer 1 at up to 33.7 at 30 days and isomer 2 at up to 10.1% at 50-73 days. They were ≤0.6% at 99 days. Serinyl-BrCA was up to 11.2% at 73-99 days.	α-R-deltamethrin was up to 36.7% at 1 day, decreasing to 2.7% at 99 days	m-PBAc (≤7%)	MRID 44977005, 48988201
Anaerobic Aquatic Metabolism	BrCA was up to 69.9% at 103 days or last test interval.	--	m-PBAc was up to 69.6% at 103 days or last test interval.	MRID 49114109
Terrestrial Field Dissipation	Br_2CA detected in one study.	2-4 ppb detected sporadically. *trans*-deltamethrin detected in one study.	Not monitored	MRID 42114822, 42137505, 42773903

It appears that m-PB-Acid and m-PB-aldehyde are not very persistent in the environment (an exception was the anaerobic aquatic metabolism study). However, Br_2CA appears to persist much more than the former compounds. It was observed in laboratory studies and in the field. These degradates are the result of the ester rupture in the parent molecule. Another transformation product that was monitored in some of the studies (soil photolysis and aerobic aquatic metabolism) was the α-R-deltamethrin, an isomer of deltamethrin. It appears that it was not measured or could not be distinguished from the parent in other laboratory studies.

Table 9 provides a summary of batch equilibrium data for 3-PB-acid and decamethrinic acid (*cis*-Br_2CA).

Table 9. Summary of mobility data for deltamethrin degradates

PARAMETER	VALUE(S) (units)	SOURCE
Organic Carbon Partition Coefficient, 3-PB-Ac (K_{OC})	288, 190, 105, 50.7 mL/g_{OC} (for Cl, SiClL, SL & ClL)	MRID 44977006, Acceptable, Partial (*m*-Phenoxybenzoic Acid, *m*-PBA or 3-PBA)
Soil Partition Coefficient, 3-PB-Ac (K_d)	0.668, 1.54, 2.68, 1.34 mL/g (for Cl, SiClL, SL & ClL)	
Organic Carbon Partition Coefficient, *cis*-Br_2CA, (K_{OC})	38.2, 46.8, 43.7, 23.0, 10.1 mL/g_{OC} for AZ SL#2, AZ SL#3, SiClL, SL, ClL	MRID 42475908, Acceptable, Partial (Decamethrinic acid, RU 23441 or *cis*-Br_2CA)
Soil Partition Coefficient, *cis*-Br_2CA (K_d)	0.09, 0.11, 0.36, 0.59, 0.27 mL/g for AZ SL#2, AZ SL#3, SiClL, SL, ClL	

Cl=clay; SiClL=silty clay loam; SL=sandy loam; ClL=clay loam

A major degradate of deltamethrin, *cis*-Br_2CA or decamethrinic acid, appeared to be mobile in 5 soils (Freundlich K_ds <l, and K_{OC}'s=10.1-46.8, FAO mobility classification, FAO 2000). In addition, for the degradate m-PB-Acid, K_d's were in the range of 0.7-2.7 while the K_{OC}'s were in the range of 51-288 (mobile to moderately mobile according to FAO mobility classification, FAO 2000). Of these degradates, Br_2CA has the potential to leach to subsurfaces, or to reach adjacent bodies of water via runoff events, most likely dissolved in the water.

Other Studies

Deposition studies were submitted to support the applications of deltamethrin as an adulticide using ground ULV methodology, conducted in four sites. In these studies, the levels of deposition showed some variability from site to site. The maximum deposition was observed in Chambers County, TX at 34.2%.

In a POTW treatability study, deltamethrin showed limited removal upon primary settling, and nearly 60% removal in the aerobic chamber. In the anaerobic digester 77.1% of the parent compound was removed. Under ultrafiltration, nearly 93% of the deltamethrin was removed.

Permethrin

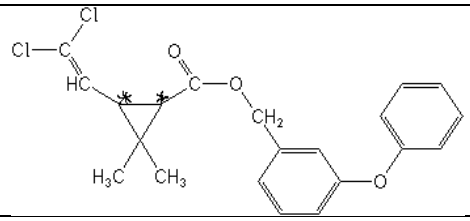
An environmental fate assessment was provided in the Problem Formulation (DP Barcode D384703, dated June 20, 2011). Additionally, in 2008 and 2010 endangered species assessment for a number of California species were issued[9]. The environmental fate assessment is being updated here with around two newly submitted studies.

Physical and Chemical Properties

Permethrin (**Table 10**) has a structure with three rings, two phenyl rings attached to each other by an oxygen atom (phenyl and phenoxy), and a cyclopropyl ring. It is a Type I synthetic pyrethroid (meaning that it is not cyano substituted in the *alpha* position). The chemistry of permethrin may be dictated by its ester moiety. It would be expected to hydrolyze as the pH increases. This is confirmed from the hydrolysis study, where permethrin was stable at pH 3 and 6 and hydrolyzed slowly at pH 9. The structure of the molecule has two chiral centers which raise the number of possible isomers to $2^2 = 4$. Permethrin consists of a mixture of these isomers (see below). Permethrin has a 2,2-dichloroethenyl group in the cyclopropane ring. **Table 10** provides some identification information for permethrin, and its structure.

According to the International Programme on Chemical Safety (IPCS INCHEM), Environmental Health Criteria 94, Permethrin, of the World Health Organization (1990):[10] "Technical products are a mixture of four stereoisomers with the configurations [1R,*trans*], [1R,*cis*], [1S,*trans*], and [1S,*cis*] in the approximate ratio of 3:2:3:2. The ratio of *cis*:*trans* is around 2:3 and the ratio of 1R:1S is 1:1 (racemic). The [1R,*cis*] isomer is the most insecticidally active of the isomers, followed by the [1R,*trans*] isomer."

Table 10. Identification information for permethrin

PARAMETER	VALUE(s) units (chemical name)	SOURCES
CAS Chemical Name	(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate	Chemical's data sheet[a]
PC Code	109701	OPP Databases
Case Number	2510	OPP Databases
IUPAC Chemical Name	3-phenoxybenzyl (1*RS*,3*RS*;1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate or 3-phenoxybenzyl (1*RS*)-*cis*-*trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate	Chemical's data sheet[a]
CAS Reg. No.	52645-53-1	Chemical's data sheet[a]
Chemical Structure (unspecified stereochemistry, chiral centers are marked with asterisks)		Chemical's data sheet[a]

[9] Available at http://www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html (accessed 05/05/2015).
[10] Available at http://www.inchem.org/documents/ehc/ehc/ehc94.htm accessed 05/12/2015.

PARAMETER	VALUE(s) units (chemical name)	SOURCES
Molecular Formula	$C_{21}H_{20}Cl_2O_3$	Chemical's data sheet[a]
Molecular Weight	391.30	EXTOXNET (see below)

a. The chemical's data sheet is available at http://www.alanwood.net/pesticides/permethrin.html, accessed 05/12/2015.

In the environment, permethrin is slow to hydrolyze and biodegrade. Pyrethroids such as permethrin, that have the 2,2-dichloroethenyl group attached to the cyclopropane moiety, are more stable to sunlight than earlier pyrethroids like allethrin or resmethrin. Permethrin has a low water solubility (0.0055 mg/L, Laskowski, 2002), and its hydrophobic nature leads to strong soil adsorption and a tendency to partition to sediment in aquatic systems ($K_{FOC} \geq 28{,}200$ L/kg, Hardly Mobile to Immobile, according to FAO Mobility Classification, FAO 2000). The reported value of log octanol/ water partition coefficient of 6.1 ($K_{OW} = 1.3 \times 10^6$) suggests that permethrin has the potential to bioaccumulate in aquatic organisms, assuming that chemical metabolism is negligible. However, the measured bioconcentration factor in fish (570-610 L/kg wet wt for whole fish, **Table 13**) is much lower than that expected based on K_{OW} alone, which suggests that permethrin metabolism by fish is substantial. Permethrin has a high molecular weight of 391.30 g/mol and a vapor pressure of 1.48×10^{-8} mm Hg. Due to its very low solubility, the calculated Henry's Law Constant is moderately low (1.4×10^{-6} atm-m^3/mol). Permethrin's air/water partition coefficient (K_{AW}) is 5.7×10^{-5}, which classifies it as 'slightly volatile from a water surface' (see USEPA 2010[11]), and the $C_{water+soil}/C_{air} = 4.4 \times 10^6$, which classifies the chemical as 'non-volatile from moist soil' (USEPA 2010). Based on these properties, permethrin would have a slight potential to volatilize from wet surfaces, but not from moist soil. The slight potential to volatilize of permethrin is attenuated by its tendency to bind to organic matter (*e.g.*, soils, sediments, or organic matter and particulate in natural water). **Table 11** lists various important physicochemical characteristics of the chemical. **Table 13** lists the other environmental fate properties of permethrin, along with information on the major and minor degradates detected in the submitted environmental fate and transport studies.

Table 11. Physicochemical Properties of Permethrin

Property	Value[1]	MRID or Source
Density/ Specific Gravity	1.19 – 1.27 g/cm^3	Tomlin, C.D.S. (ed.). The Pesticide Manual – 11th ed., British Crop Protection Council, Surrey, England 1997, p. 944 [4]
Melting Point (^{0}C)	34-35; *cis*-isomers, 63-65; *trans*-isomers, 44-47	Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997, p. 944[4]
Boiling Point (^{0}C)	200 at 0.1 mmHg; >290 at 760 mmHg	Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium. 10th ed. Surrey, UK: The British Crop Protection Council, 1994., p. 784[4]
Solubility in Organic Solvents	In xylene and hexane >1000, methanol 258 (all in g/kg at 25^{0}C)	Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997, p. 944[4]

[11] http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (accessed 05/12/2015).

Property	Value[1]	MRID or Source
Vapor Pressure (mmHg)	**1.48×10^{-8}** (Average of two values) (at 25ºC)	MRID No. 42109801 & Laskowski 2002[5]
	2.18×10^{-8} (at 25ºC)	USDA, Agric. Res. Service 1995 [4]
	1.9×10^{-8} (*cis*), and 1.1×10^{-8} (*trans*)	Wells *et al*., 1986
Henry's Law Constant (atm-m^3/mole at 20-25ºC)	**1.4×10^{-6}**	Calculated using solubility of 0.0055 mg/L and VP of 1.5×10^{-8} mmHg
	1.6×10^{-7}	Calculated using solubility of 0.0055 mg/L and VP of 2.18×10^{-8} mmHg
Water Solubility (mg/L)	**0.0055** at 20°C	Wollerton, 1987 [5]
	0.175 (Average of 0.22, and 0.13)	MRID No. 42109801
Octanol – water partition coefficient (log K_{OW})	6.1 at 20ºC	Wollerton, 1987 [5]
Dissociation Constant (pK_a and/or pK_b)	Not available	PPDB [6]
Air-water partition coefficient (K_{AW})	$K_{AW} = C_{air}/C_{water} = HLC/RT$ $= 5.7 \times 10^{-5}$ 'Slightly volatile from a water surface'	Calculated Value, USEPA, 2010 [8]
Octanol-air partition coefficient (K_{OA})	$K_{OA} = \frac{K_{OW}}{K_{AW}} = \frac{K_{OW} RT}{\text{Henry's Law Constant}}$ $= 2.2 \times 10^{10}$	Calculated Value
C_{water}/C_{air}	$\frac{C_{water}}{C_{air}} = \left(\frac{S \times T \times R \times 760}{P \times GMW \times 10^6}\right) = RT/HLC$ $= 1/K_{AW} = 17{,}534$ (unitless) 'Slightly volatile from a water surface'	Calculated USEPA, 2010 [8]
UV/visible light absorption	Peaks at approximately 200 and 275 nm, with some tailing (in acetonitrile). λ_{max} at 207 and 273 nm at pH 7.	MRID 40242801 RD D274107[7]
Volatilisation Flux	Not available	Not available
$C_{water+soil}/C_{air}$	$C_{water+soil}/C_{air} = (1/K_{AW})(1/r + K_d) =$ 4.4×10^6 'Non-volatile from moist soil'	Calculated Value USEPA, 2010 [8]
OH Radical Reaction Half-life	0.467 days (at 12-hr days; 1.5×10^6 OH/cm^3)	EPIWEB v.4.0 Estimate
Ozone Reaction Half-life	49.3 days	EPIWEB v.4.0 Estimate

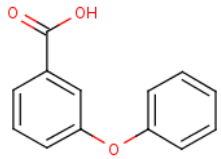
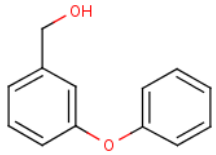
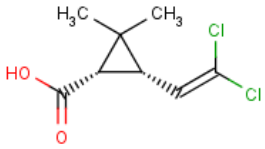
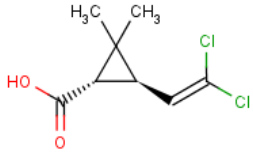
Property	Value[1]	MRID or Source
Biomagnification Potential	Presumption: If log K_{OA} > 5, log K_{OW} > 2 and the rate of chemical transformation is low, the chemical may biomagnify in terrestrial food chains** For permethrin, log K_{OA}> 5, log K_{OW}> 2 and therefore is identified as having a potential to biomagnify in terrestrial food chains. However, its rate of biotransformation is moderate in the environment, and it appears to be moderate in fish. Specifically, bioconcentration factors for permethrin are 570-610x, which are much lower than would be expected if biotransformation was minimal. Further, it is depurated relatively rapidly in fish (depuration half -life ~4.7 days). Additionally, the potential of permethrin to biomagnify in terrestrial food chains will be reduced substantially should it be similarly biotransformed by terrestrial organisms	**Gobas *et al.* 2003 and Armitage & Gobas, 2007 support this presumption, utilized here only as a broad reference to determine the potential for biomagnification.

[1] When more than one value for a property was available, the **bolded** one is the one that was deemed the best, based on professional judgment (see also Laskowski, 2002, for further details).
[2] http://www.alanwood.net/pesticides/permethrin.html (accessed 05/12/2015)
[3] http://extoxnet.orst.edu/pips/permethr.htm (previously accessed 08/20/2010)
[4] Information taken from the Hazardous Substances Data Bank (HSDB) at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (previously accessed 01/07/2011)
[5] As cited in Laskowski, 2002.
[6] http://sitem.herts.ac.uk/aeru/iupac/Reports/515.htm (previously accessed 08/25/2010)
[7] As cited by HED in its RED document D357566, 4/1/09 (USEPA 2009).
[8] http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (accessed 05/12/2015).

Transformation Products

Various degradates were observed in the laboratory studies (*e.g. m*-PBA, *m*-PBAlc, and *cis*- and *trans*-DCVA). These studies indicate that all of the identified degradates were the result of the rupture of the ester bond of the parent molecule. It is believed that the resulting molecules are not as toxic as the parent because they presumably have lost the neurotoxic mode of action. **Table 12** shows the chemical structures of permethrin's major degradation products. At this time, the degradates will not be considered stressors of concern in the forthcoming environmental fate and ecological risk assessment.

Table 12. Permethrin Major Breakdown Products

Common Name	Chemical Name/ CAS #	Structure
m-PBA, 3-PBA	*m*-phenoxybenzoic acid CAS # 3739-38-6	
m-PB-alc or *m*-PB-alcohol	*m*-phenoxybenzyl alcohol CAS # 13826-35-2	
cis-DCVA	*cis*-permethric acid or *cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid CAS # 59042-49-8	
trans-DCVA	*trans*-permethric acid or *trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid CAS # 59042-50-1	

Permethrin's structure has three rings, two phenyl rings attached to each other by an oxygen atom, and a cyclopropyl ring. The structure of the molecule has two chiral centers which raise the number of possible isomers to $2^2 = 4$. Permethrin consists of a mixture of these four isomers with the configurations [1R,*trans*], [1R,*cis*], [1S,*trans*], and [1S,*cis*]. The ratio of *cis*:*trans* is around 2:3 and 1R:1S is 1:1 (racemic). The [1R,*cis*] isomer is the most insecticidally active of the isomers.

Table 13 summarizes the environmental fate/transport properties of permethrin.

Table 13. Summary of Environmental Fate Properties for Permethrin

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Abiotic Hydrolysis	Half-life[1] = Stable, pH 3 Stable, pH 6 125-350 days, pH 9	Major: *m*-PB-alcohol (15.5%), Minor: *cis*-/*trans*-DCVA (6.5%)	00102043	Acceptable
Atmospheric Degradation	Half-life[1] = 0.467 days, estimated for hydroxyl radical	N/A	EPISuite v.4.0	N/A
Direct Aqueous Photolysis	Half-life[1] = 80 days, pH = 5	Major: None; Note: In the supplemental article, *cis*- and *trans*-DCVA and *m*-PBalc are major products with UV light ($\lambda > 290$ nm).	40242801	Supplemental[3]
Soil Photolysis	Half-life[1] = 106 days, loam soil	Major: None, Minor: *m*-PBA (1.5%), and *m*-PBAlc (4.8%)	40190101	Acceptable
Aerobic Soil Metabolism	Half-life[1] = 37 days, sandy loam soil	Major: CO_2 (34-40% after 6 months), *trans*-DCVA (10% at 14 DAT), and *m*-PBA (12-15% at 30 DAT) Minor: (3-(2,2-dichloro vinyl)-2-methylcyclo propane-l,2-dicarboxylic acid) (8% at 60 days)	42410002	Acceptable[4]
Anaerobic Soil Metabolism	Half-life[1] = 204 days, sandy loam soil	Major: *trans*-DCVA (13% at 60 days) and *m*-PBA (12% at 60 days)	41970601	Acceptable[5]
	Half-life[1] = 124 days (DFOP), ND loam 515 days (DFOP), IL silt loam 526 days (SFO), FL sand	Major: 3-PBA, 3-PB alcohol, *cis*-DCVA, *trans*-DCVA Minor: *cis*-4' OH-permethrin, *trans*-4' OH-permethrin	MRID **49728101**	Supplemental
Aerobic Aquatic Metabolism	Half-life[1] = Pond water test system from Wilson, NC: 38.2 days (acid label) total system 42.9 days (alcohol label) total system	Major: *trans*-DCVA (20% at 21 DAT) Minor: *cis*-DCVA (3.7%) and *m*-PBA (5.7%)	43938201	Acceptable[6]
	Half-life = 5.93 days (IORE), sand 77.4 days (DFOP), clay 6.37 days (IORE), sandy clay loam	N/A	MRID **48762908**	Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used.

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Anaerobic Aquatic Metabolism	Half-life[1] = Pond water/sediment system from Lucama, NC: **144 days** for the combination of acid and alcohol labels total system Overall half-life for the isomers *cis*-permethrin 179 days *trans*-permethrin 114 days	Major: *trans*-DCVA (20.8% at 90 days), CO_2 (33.8-43.6% by 367 DAT) Minor: *cis*-DCVA (6.6%), *m*-PBA (3.2% at 30 days), *m*-PBalc (0.45% at 30 days)	43982001	Supplemental[7]
	Half-life = 204 days (DFOP), sand 229 days (IORE), clay 66.2 days (SFO), sandy clay loam	N/A	MRID **48762908**	Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used.
Solid-water distribution coefficient (K_d)	K_d, soil texture 140 L/kg, sand 217 L/kg, sandy loam 236 L/kg, silty loam 246 L/kg, clay loam 401 L/kg, sandy loam sediment	N/A	41868001	Supplemental[8]
Freundlich solid-water distribution coefficient (K_F)	K_F, 1/n, soil texture 446 L/kg, 1.32, sand 355 L/kg, 1.12, sandy loam 344 L/kg, 1.09, silty loam 378 L/kg, 1.10, clay loam 1,517 L/kg, 1.29, sandy loam sediment	N/A	41868001	Supplemental
Organic-carbon normalized distribution coefficient (K_{OC})	K_{OC}, soil texture 60,900 L/kg, sand 20,900 L/kg, sandy loam 19,300 L/kg, silty loam 20,500 L/kg, clay loam 25,500 L/kg, sandy loam sediment	N/A	41868001	Supplemental
Freundlich organic-carbon normalized distribution coefficient (K_{FOC})	K_{FOC}, 1/n, soil texture 194,000 L/kg, 1.32, sand 34,100 L/kg, 1.12, sandy loam 28,200 L/kg, 1.09, silty loam 31,500 L/kg, 1.10, clay loam 96,600 L/kg, 1.29, sandy loam sediment	N/A	41868001	Supplemental
Terrestrial Field Dissipation	Dissipation Half-life[1,2] = Bareground plots 17 days, NC silt loam soil, and 43 days IL silty clay soil	Observed: *trans*-DCVA and *m*-PBA at both NC and IL sites	42359109	Acceptable

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Aquatic Field Dissipation	Dissipation Half-life[1,2] = Pond water, California 1.8/ 1.4 days from the pond water for *cis*-/ *trans*-permethrin; 118/ 18 days from the sediment top 2" for *cis*-/ *trans*-permethrin	Observed: *cis*-DCVA, *trans*-DCVA and *m*-PBA dissipated from the water with half-lives of 28, 22 & 7.5 days, respectively. Not detected in sediment.	44030501	Acceptable
	Dissipation Half-life[1,2] = Pond water, North Carolina 3.1/ 1.4 days from the pond water for *cis*-/ *trans*-permethrin; 156/ 62 days from the sediment top 2" for *cis*-/ *trans*-permethrin	Observed: *cis*-DCVA, *trans*-DCVA and *m*-PBA dissipated from the water with half-lives of 33, 23 & 14 days, respectively. Not detected in sediment.	44034101	Acceptable
Bioconcentration Factor (BCF) – Bluegill Sunfish (*Lepomis macrochirus*)	Steady State BCF= 570-610 L/kg wet wt whole fish 180-230 L/kg wet wt edible tissue 950-1,100 L/kg wet wt nonedible tissue Depuration: 4.7 days for 50% depuration	Only *trans*-DCVA was identified, at 4-10% of the total radioactivity	41300401, 41300402, 41300403	Acceptable
WWTP Treatability Study	Removal percent for permethrin: Primary Settling LR Aerobic Chamber 86.6% Anaerobic Digestion 43.5% Ultrafiltration 96.9%	N/A	MRID **48762906**	Supplemental; POTW treatability study of eight pyrethroids.

Abbreviations: wt=weight; NA=Not Available; N/A=Not Applicable.

1 Half-lives were calculated using the single-first order equation and nonlinear regression, unless otherwise specified.

2 The value may reflect both dissipation and degradation processes.

3 Additional information evaluated from Holmstead, R.L., J.E. Casida, L.O. Ruzo, and D.G. Fullmer. 1978. Pyrethroid photodecomposition: Permethrin. *J. Agric. Food Chem.* 1978, 26 (3), 590-595; and Ruzo, L.O., R.L. Holmstead, and J.E. Casida. 1976. Photochemical Reactions of Pyrethroid Insecticides. Tett. Lett. 35, 3045, 1976. However, the available study was conducted at a concentration of 0.05-0.06 ppm (solubility of permethrin in water 0.0055 ppm), and up to 91% of AR was in the walls of the test vials during the study. A new study addressing the above mentioned deficiencies is being required.

4 Partially fulfills the data requirement. Only one soil system was tested. Data on three other soil systems was required as per current guidelines.

5 Partially fulfills the data requirement. Study only lasted 60 days anaerobic incubation, at which time, 65-72% AR was parent permethrin. Furthermore, it was conducted using only one soil. Data on three other soil systems was required as per current guidelines.

6 Partially fulfills the data requirement. Treatment rate was 1 ppm, which greatly exceeds the solubility limit of permethrin; furthermore, the study lasted only 30 days, at which time 56-59% AR was permethrin (sum of *cis* and *trans*). Data for two additional water/ sediment systems, one of marine origin was required. The new studies should address the above mentioned deficiencies besides fulfilling current guidelines which indicate that at least two water/sediment systems are required.

7 Partially fulfills the data requirement. The study was performed at a concentration that greatly exceeded the solubility limit of permethrin (1 ppm v. 0.0055 ppm). In order to promote anaerobicity, glucose was added to the sediment/water system; however, no redox potential was measured to confirm that the system was fully anaerobic. Furthermore, only one sediment system was evaluated while current guidelines require at least two. A new study is required; since there is the potential to use permethrin near marine/estuarine areas, one of the test systems should be conducted with water/sediment of marine origin. The new studies should address the above mentioned deficiencies besides fulfilling current guidelines which indicate that at least two water/sediment systems are required.

8 Study was performed at concentrations of 0.05 to 0.55 ppm, compared to a solubility limit of 0.0055 ppm in water. Furthermore, a cosolvent concentration of 5% (acetonitrile) was used, compared to a recommended ≤0.1%. Even though correlations were good ($r^2 \geq 0.966$), the 1/n values varied from 1.09 to 1.32, with only one of them within the recommended range of 0.9-1.1. Extensive degradation occurred particularly for the aquatic sediment. In another study, considered supplemental (MRID No. 45170102, not reported in the **Table 13**), the adsorption coefficients were much higher than for the supplemental study. For the later study, for three of the soils the texture was the same (sandy loam), the soils were sterilized using gamma irradiation, and the test was performed at above the solubility limit. However, the cosolvent used was also acetonitrile at a lower concentration of 0.25% (recommended ≤0.1%). And the highest test concentration was 0.2 ppm (solubility in water of 0.0055 ppm), which may promote adsorption. A new study addressing all the above mentioned deficiencies is being required for permethrin.

Metabolism and Abiotic Degradation

As shown in **Table 13**, permethrin is stable to hydrolysis at pHs 3-6, and it degrades at a slow rate ($t_{½}$ = 125-350 days) in alkaline solutions (pH 9) at 25°C in the dark. The hydrolysis products were *m*-PB-alcohol and *cis*-DCVA/*trans*-DCVA. In contrast, permethrin did not appear to degrade substantially for a period of 30 days (extrapolated half-life 106 days) on a loam soil following irradiation with a xenon arc lamp at 25°C.

The reported half-life of ^{14}C-permethrin in soil under aerobic soil conditions was 37 days, with $^{14}CO_2$, *trans*-DCVA and *m*-PBA being the major degradation products. It was noted that the *trans*-isomer of permethrin degraded at a faster rate when compared to the *cis*-isomer. Furthermore, the degradation of permethrin was biphasic, with faster degradation from 0-90 days; however, a half-life for the second phase was not provided. A separate supplemental aerobic biodegradation study showed that of three factors: application rate, moisture percent and application volume, the first one had the greatest effect on the rate of dissipation of permethrin (in the review, it was speculated that possibly the microbial activity was inhibited due to toxicity or the solubility may have been exceeded) when permethrin was applied to aerobic soil at fortification levels similar to the maximum application rate for terrestrial non-food uses (MRID No. 41970602, results not shown in **Table 13**). The study lasted a short time (32 days) and only three sampling points were taken (0, 14 and 32 days). The half-life in the anaerobic soil metabolism study was 204 days (in a study that lasted 30 aerobic and 60 anaerobic days) and major degradates were *trans*-DCVA and *m*-PBA. In a newer study, three soils were tested. In the study, the representative half-lives were 124, 515 and 526 days, in a ND loam, IL silt loam, and FL sand soils, respectively. Major degradates included cis/trans-DCVA, m-PBA and m-PB alcohol.

In an aerobic aquatic metabolism study, the reported half-life ranged from 38 to 43 days (the study lasted only 30 days). In this study, *trans*-permethrin yielded shorter half-lives than the *cis*-permethrin. There is also a study in which three sediments were tested. Half-lives for the total system were 5.93, 77.4 and 6.37 days for a sand, clay and sandy clay loam sediments from California, respectively. In this study, sediments and water were extracted together.

The half-lives reported for permethrin in an anaerobic aquatic study ranged from 113 days to 175 days (the combined half-life for two radiolabels was 144 days), which indicates that the degradation in soil and water/sediment systems is slower as the oxygen levels are reduced. Also, there is a study in which three sediments were tested. Half-lives for the total system were 204, 229 and 66.2 days for a sand, clay and sandy clay loam sediments from California, respectively.

In this study, sediments and water were extracted together.

Inspection of the available metabolism studies shows that high levels of non-extracted residues were observed in some studies (*e.g.* non-extracted residues reached ~15-35% in the aerobic soil metabolism study at or after 30 days posttreatment; however, adequate attempts were made to extract the residues in such instance).

Transport, Mobility, Sorption

Permethrin was hardly mobile to immobile (according to the FAO mobility classification) in several soils tested, both sterile and viable (K_{FOC} > 10,000 L/kg). K_{FOC} values in the range of 28,000 to 194,000 L/kg were measured in four soils and one sediment sample. Even though the study was found to be acceptable, several deficiencies were found upon a cursory inspection and it was downgraded to supplemental (see footnote in **Table 13**). Various literature articles document the possibility of desorption of pyrethroids from impervious surfaces despite pyrethroids strong sorption (*e.g.* see Jiang *et al*. (2010), Jorgenson and Young (2010), and Jiang *et al.* (2011)[12]). In the latter article, the model pyrethroid permethrin was used on concrete surfaces. Among their findings, the authors reported that the permethrin desorption from such surfaces decreases with sorption time. This was attributed to the possible alkaline decomposition of the test substance on the concrete surface. The authors indicated that there is the potential for extended contamination due to permethrin treated surfaces.

Based upon its low Henry's Law constant and vapor pressure, permethrin is expected to have a relatively low potential for volatilization from soil and water surfaces.

Potential transport mechanisms for a pesticide include surface water runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. Surface water runoff and spray drift are expected to be the major routes of exposure for permethrin to non-target organisms. The magnitude of transport via secondary drift depends on the permethrin's ability to be mobilized into air and its eventual removal through wet and dry deposition of gases/ particles and photochemical reactions in the atmosphere. Therefore, physicochemical properties of permethrin that describe its potential to enter the air from water or soil (*e.g.*, Henry's Law constant and vapor pressure), pesticide use data, modeled estimated concentrations in water and air, and available air monitoring data are considered in evaluating the potential for atmospheric transport of permethrin. Permethrin has a low vapor pressure (1.48×10^{-8} torr) and Henry's Law constant (1.4×10^{-6} atm-m^3/mol); thus, volatilization from water and soil surfaces is expected to be very low. Permethrin's potential for volatilization is also reduced significantly because it adsorbs strongly to soils. Permethrin's estimated atmospheric half-life is short (~0.5 days for the hydroxyl radical reaction), indicating a low potential for transport via volatilized active substance (as opposed to present in suspended solids).

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[12] Jiang, W., K. Lin, D. Haver, S. Qin, G. Ayre, F. Spurlock, and J. Gan. 2010. Wash-off Potential of Urban Use Insecticides on Concrete Surfaces. Environ. Tox. Chem. 29(6), pp. 1203–1208, 2010.
Jiang, W., J. Gan and D. Haver. 2011. Sorption and Desorption of Pyrethroid Insecticide Permethrin on Concrete. *Environ. Sci. & Technol.* **2011**, 45, 602-607.
Jorgenson, B., and T. Young. 2010. Formulation Effects and the Off-Target Transport of Pyrethroid Insecticides from Urban Hard Surfaces. *Environ. Sci. Technol.* **2010**, *44*, 4951–4957.

Limited atmospheric monitoring in California[13] was conducted in Butte, Monterey and Santa Barbara Counties. Application air monitoring was conducted in Butte County and ambient air monitoring was conducted in Monterey County (both in 1997). Of 24 application samples in Butte County, three were above the LOQ (LOQ = 0.33 µg/sample, equivalent to 0.015 µg/m^3 for 24 hour sampling at 15 L/min). The highest concentration was 0.57 µg/m^3. Ambient samples were taken in populated areas of Monterey County that coincided with the use of permethrin on lettuce and celery. Of the 115 samples collected, six were reported as "detected" and 109 samples were below the LOD (LOD = 0.10 µg/sample). Monitoring samples were taken in Lompoc, an agricultural city in Santa Barbara County in 2000, for a total of 31 pesticides. Permethrin was detected at trace levels to 4.3 ng/m^3 (highest 1-day air concentration).

Table 14. Summary of mobility data for permethrin degradates

Study	Value and unit	MRID # or Citation	Study Classification
***m*-PBA**, Freundlich solid-water distribution coefficient and organic carbon normalized distribution coefficient (K_F and K_{FOC})	K_F = 0.98 to 3.11 L/kg K_{FOC} = 118 to 215 L/kg In sand, silt clay, clay, sandy loam, and another sandy loam soils	43424901	Acceptable, Partial
***trans*-DCVA**, Freundlich solid-water distribution coefficient and organic carbon normalized distribution coefficient (K_F and K_{FOC})	K_F = 0.16 to 0.54 L/kg K_{FOC} = 18 to 48 L/kg In sand, silt clay, clay, sandy loam, and another sandy loam soils	43424901	Acceptable, Partial

The main degradates of permethrin, *m*-PBA and *trans*-DCVA were shown to have a much higher potential for mobility in the soils tested [K_{FOC}s for *m*-PBA range = 118 to 215 L/kg (moderately mobile) and for *trans*-DCVA range = 18 to 48 L/kg (mobile)]. Compared to the results in **Table 9** for *m*-PBA under MRID 44977006, they resemble each other, as expected.

Terrestrial and Aquatic Field Dissipation Studies

Acceptable terrestrial field dissipation studies showed that permethrin degraded in the field with half-lives ranging from 17 days in a North Carolina field to 43 days for a field located in Illinois. These studies were conducted at the terrestrial food use rate of 0.4 lb a.i./A. Neither parent nor its two principal soil degradates (*trans*-DCVA and *m*-PBA) were detected (detection limits 2.5 µg/kg) below a depth of 6-inches at either site. More rapid dissipation rates of permethrin were reported in a study measuring permethrin concentrations in environmental components of a boreal plantation forest in Ontario, Canada treated with an aerial spray of permethrin. Permethrin concentrations in soil and forest floor litter ranged from 25 to 7 µg/kg and 33 to 18 µg/kg, respectively, during the 4 days after application (Sundaram, *et al.*, 1992)[14]. These concentrations represent measurements taken 1 hour to 4 days after the application of 0.06 lb of permethrin per acre (detection limits 2 µg/kg) Permethrin appeared to persist in forest litter longer than in soil. Ten days after application, permethrin was not detected in soil while 8 µg/kg of permethrin were detected in forest litter.

[13] http://www.cdpr.ca.gov/docs/emon/pubs/tac/permthrn.htm (accessed 02/04/11).
[14] Sundaram, K, Helson BV, and NJ Payne. 1992. Distribution and persistence of aerially sprayed permethrin in some terrestrial components of boreal plantation forest. Journal of Agriculture and Food Chemistry 40:2523-2529.

An acceptable aquatic field dissipation study employing a site in North Carolina, and a second site in California showed that permethrin dissipated (moved) rapidly from the water column by binding to suspended solids and sediment. At both sites *cis*-/*trans*-permethrin appeared to be immobile and remained in the uppermost layer (0-2-inch fraction) of the sediment. There were no detects of metabolites in sediment. In North Carolina, *cis*- and *trans*-permethrin were removed from the water surface with half-lives of 3.1 and 1.9 days, respectively. In sediment the reported degradation half-lives for *cis*- and *trans*-permethrin were 256 and 62 days, respectively. In California, *cis*- and *trans*-permethrin were removed from the water surface with half-lives of 1.8 and 1.4 days, respectively. In sediment the reported degradation half-lives for *cis*- and *trans*-permethrin were 118 and 18 days, respectively.

Bioconcentration

Acceptable fish bioconcentration studies, conducted in bluegill sunfish, showed that permethrin bioconcentrated with factors of 950 – 1100x in viscera, 570 – 610x in the whole fish, and 180 – 230x in the fillet. Depuration occurred at a moderate rate, with 73-83% depuration occurring after 14 days and 4.7 days for 50% depuration.

Other Studies – POTW Treatability

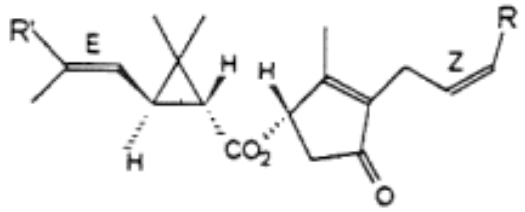
In a POTW treatability study, permethrin showed limited removal upon primary settling, and nearly 87% removal in the aerobic chamber. In the anaerobic digester only 43.5% of the parent compound was removed. Under ultrafiltration, nearly 97% of the permethrin was removed.

Pyrethrins

An environmental fate assessment for pyrethrins was provided in the Problem Formulation (DP Barcode D391619, dated November 30, 2011). Additionally, in 2006, a Reregistration Eligibility Decision document was issued for pyrethrins (USEPA 2006[15]). The environmental fate assessment is being updated here with one newly submitted study.

Physical and Chemical Properties

The pyrethrins are a mixture of naturally occurring insecticides derived from the flowers of *Chrysanthemum cinerariaefolium* and *Chrysanthemum cineum*. The six individual pyrethrins are pyrethrin 1, pyrethrin 2, cinerin 1, cinerin 2, jasmolin 1, and jasmolin 2. The technical grade active ingredient (FEK-99) is commonly referred to as pyrethrum extract, which is the sum of pyrethrins I (the esters of chrysanthemic acid - pyrethrin 1, cinerin 1 and jasmolin 1) and pyrethrins II (the esters of pyrethric acid - pyrethrin 2, cinerin 2, and jasmolin 2), and this mixture constitutes 45 to 55% of pyrethrum extract. In addition to pyrethrins, the extract contains "23-25% other phytochemical extracts containing triglyceride oils, terpenoids, and carotinoid plant colours. The extracts usually contain 20-25% light isoparaffins and 3-5% butylated hydroxytoluene, which may be added during and after processing, respectively, for extraction or as antioxidants" (Solecky 1999[16]).



R = $-CH_4$ (for cinerin), $-CH_3CH_4$ (for jasmolin) or $-CH=CH_2$ (for pyrethrin)
R'= $-CH_3$ (for pyrethrins I) $-CO_2CH_4$ (for the pyrethins II)

Figure 2. The general structure and stereochemistry of the pyrethrins

All six pyrethrins have the same backbone molecular structure with different substituents at two sites. In the United States, the pyrethrum extract is standardized as 45-55% w/w total pyrethrins. The typical proportion of Pyrethrins I to II is 1:14, while the ratio of pyrethrins: cynerins: jasmolins is 71:21:7 (Tomlin 1997[17]). Since all the structures at the two sites are similar, they are expected to have similar environmental fate properties.

[15] USEPA. 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006.
[16] Solecky, R. 1999. Pyrethrum Extract (Pyrethrins) (addendum). Journal of Medicinal Plants Research or JMPR 1999, 273-291 [Same information was obtained from IPCS INCHEM Toxicological Evaluations at http://www.inchem.org/documents/jmpr/jmpmono/v99pr11.htm accessed 09/27/2011]
[17] Tomlin CDS; The Pesticide Manual. 11th Ed. Crop Protection Publ: British Crop Protection Council 49 Downing St, Farnham United Kingdom (1997).

Table 15. Identification information for pyrethrins[1]

PARAMETER	VALUE(s)	SOURCES
Nomenclature of Pyrethrins (IUPAC Names)	pyrethrin 1: (Z)-(S)-2-methyl-4-oxo-3-(penta-2,4-dienyl)cyclopent-2-enyl (1R,3R)-2,2dimethyl-3-(2-methylprop-1-enyl) cyclopropanecarboxylate pyrethrin 2: (Z)-(S)-2-methyl-4-oxo-3-(penta-2,4-dienyl)cyclopent-2-enyl (E)-(1R,3R)-3-(2methoxycarbonylprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate cinerin 1: (Z)-(S)-3-(but-2-enyl)-2-methyl-4-oxocyclopent-2-enyl (1R,3R)-2,2-dimethyl-3(2-methylprop-1-enyl) cyclopropanecarboxylate cinerin 2: (Z)-(S)-3-(but-2-enyl)-2-methyl-4-oxocyclopent-2-enyl (E)-(1R,3R)-3-(2methoxycarbonylprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate jasmolin 1: (Z)-(S)-2-methyl-4-oxo-3-(pent-2-enyl)cyclopent-2-enyl (1R,3R)-2,2-dimethyl-3(2-methylprop-1-enyl)cyclopropanecarboxylate jasmolin 2: (Z)-(S)-2-methyl-4-oxo-3-(pent-2-enyl)cyclopent-2-enyl (E)-(1R,3R)-3-(2methoxycarbonylprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate	USEPA 2006[2]
Nomenclature of Pyrethrins (CAS Names)	pyrethrin 1: (1S)-2-methyl-4-oxo-3-(2Z)-2,4-pentadienylcyclopenten-1-yl (1R,3R)-2,2dimethyl-3-(2-methyl-1-propenyl) cyclopropanecarboxylate pyrethrin 2: (1S)-2-methyl-4-oxo-3-(2Z)-2,4-pentadienyl-2-cyclopenten-1-yl (1R,3R)-3-[(1E)3-methoxy-2-methyl-3-oxo-1-propenyl]-2,2-dimethylcyclopropanecarboxylate cinerin 1: (1S)-3-(2Z)-2-butenyl-2-methyl-4-oxo-2-cyclopenten-1-yl (1R,3R)-2,2-dimethyl3-(2-methyl-1-propenyl) cyclopropanecarboxylate cinerin 2: (1S)-3-(2Z)-2-butenyl-2-methyl-4-oxo-2-cyclopenten-1-yl (1R,3R)-3-[(1E)-3methoxy-2-methyl-3-oxo-1-propenyl]-2,2-dimethylcyclopropanecarboxylate jasmolin 1: (1S)-2-methyl-4-oxo-3-(2Z)-2-pentenyl-2-cyclopenten-1-yl (1R,3R)-2,2-dimethyl3-(2-methyl-1-propenyl)cyclopropanecarboxylate jasmolin 2: (1S)-2-methyl-4-oxo-3-(2Z)-2-pentenyl-2-cyclopenten-1-yl (1R,3R)-3-[(1E)-3methoxy-2-methyl-3-oxo-1-propenyl]-2,2-dimethylcyclopropanecarboxylate	USEPA 2006[2]
PC Code	069001	USEPA 2006[2]
Case Number	2580	USEPA 2006[2]
CAS Reg. Nos.	8003-34-7 Pyrethrum, 121-21-1 pyrethrin 1, 121-29-9 pyrethrin 2, 25402-06-6 cinerin 1, 121-20-0 cinerin 2, 4466-14-2 jasmolin 1, 1172-63-0 jasmolin 2	USEPA 2006[2]
Molecular Formulas	Various as follows: $C_{21}H_{25}O_3$, $C_{21}H_{25}O_5$, $C_{20}H_{25}O_3$,	USEPA 2006[2]

PARAMETER	VALUE(s)	SOURCES
	$C_{22}H_{30}O_5$, $C_{21}H_{28}O_3$, $C_{22}H_{28}O_5$	
Molecular Weights	328.4 g/mol pyrethrin 1 372.4 g/mol pyrethrin 2 316.4 g/mol cinerin 1 360.4 g/mol cinerin 2 330.5 g/mol jasmolin 1 357.7 g/mol jasmolin 2	USEPA 2006[2]

1 The structures of pyrethrins are available at the chemical's data sheet at the following URL (accessed 08/28/2015): http://www.alanwood.net/pesticides/pyrethrins.html.

2 USEPA. 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006.

The laboratory environmental fate studies conducted for the pyrethrins were based on the data obtained for pyrethrin 1, which was chosen as a surrogate for all the six pyrethrins. This selection appears to be appropriate since pyrethrin 1 is the pyrethrin with the highest abundance in the pyrethrum extract (*e.g.*, Essig and Zhao 2001[18]). The following conclusions were derived for these compounds: Pyrethrins are considered to be persistent in certain environments and short lived in other environments. Hydrolysis under alkaline conditions is an important route of dissipation for pyrethrins in water (half-life at pH 9 range 14-17 days); however, this reaction appears to be relatively slow under neutral or acidic conditions (pH 5 and 7). Pyrethrins quickly photodegrade in shallow clear water. Pyrethrins adsorb strongly to soil surfaces and are generally considered to have a relatively low mobility in soils (mean K_F = 301.5 L/kg); therefore, the potential to leach into groundwater is considered low. They could reach surface water via spray drift or runoff events accompanied by erosion where they quickly adsorb to suspended solids in the water column, and partition into the sediment. Sediments are likely to be an environmental sink for any non-degraded pyrethrins since they appear to persist under anaerobic conditions. Biodegradation under aerobic conditions occurs fairly rapidly with half-lives of a few days. Volatilization is not expected to be an important transport process since pyrethrins tend to have relatively low vapor pressure and Henry's Law constant.

Pyrethrins 1 and 2 have a range of water solubilities of 0.2-9.0 mg/L, and the hydrophobic nature leads to strong soil sorption and a tendency to partition to sediment in aquatic systems. The reported values of log octanol/water partition coefficients of 4.3-5.9 suggest that pyrethrins have a potential to bioaccumulate in aquatic organisms; however, the measured bioconcentration factor in fish (471x whole fish) and rapid depuration (by day 1, 77% of the accumulated [^{14}C]-residues were eliminated, **Table 17**), suggest that pyrethrins metabolism by fish is substantial. Pyrethrins have a moderately high molecular weight of ≥324 g/mol. With a vapor pressure of ~2.0 x 10^{-5} to 4.0 x 10^{-7} torr, and due to its solubility limit range, its calculated Henry's Law Constant is relatively low (*e.g.*, 7.73 x 10^{-7} atm-m^3/mol for pyrethrins 1). Pyrethrin 1's air/water partition coefficient (K_{AW}) is ~3.14 x 10^{-5} (unitless), which classifies it as 'slightly volatile from a water surface' (USEPA 2008), and the $C_{water+soil}/C_{air}$ = ~9.58 x 10^6, which classifies the chemical as 'non-volatile from moist soil' (USEPA 2008). Based on these properties, pyrethrin 1 would have a slight potential to volatilize from wet surfaces, but not from moist soil. The slight potential to volatilize of pyrethrin 1 is attenuated by its tendency to bind to organic matter (*e.g.*, soils, sediments, or organic matter and particulate in natural water). **Table 16** lists various important physicochemical

[18] Essig, K. and Z.J. Zhao. 2001. Preparation and Characterization of a Pyrethrum Extract Standard. LCGC 19 (7) July 2001, pp. 722-730, available at www.chromatographyonline.com.

characteristics of the chemical.

Table 16. Physicochemical Properties of Pyrethrins

Property	Pyrethrin	
	Value	**MRID or Source**
Density/ Specific Gravity	0.982 g/mL pyrethrin 1 1.5242 g/mL pyrethrin 2 1.5355 g/mL	USEPA 2006[1]
Boiling Point (^{0}C)	146–148 °C at 2x10^{-3} torr for pyrethrin 1 196–198 °C at 7x10^{-3} torr for pyrethrin 2 136–138 °C at 8x10^{-3} torr for cinerin 1 182–184 °C at 0.001 torr for cinerin 2	USEPA 2006[1]
Vapor Pressure (25^{0}C)	pyrethrin 1: 2x10^{-5} torr pyrethrin 2: 4x10^{-7} torr cinerin 1: 1.1x10^{-6} torr[(a)] cinerin 2: 4.6x10^{-7} torr[(a)] jasmolin 1: 4.8x10^{-7} torr[(a)] jasmolin 2: 1.9x10^{-7} torr[(a)]	USEPA 2006[1] [(a)] Estimated value from EPISuite
Water Solubility (ppm)	pyrethrin 1: 0.2 ppm pyrethrin 2: 9.0 ppm	USEPA 2006[1]
Henry's Law Constant (atm-m^3/mole)	pyrethrin 1: ~7.7x10^{-7} Atm-m^3/mol pyrethrin 2: ~2.2x10^{-8} Atm-m^3/mol 'Non-volatile under field conditions' cinerin 1: 9.6x10^{-7} Atm-m^3/mol cinerin 2: 9.2x10^{-10} Atm-m^3/mol jasmolin 1: 1.3x10^{-6} Atm-m^3/mol jasmolin 2: 1.2x10^{-9} Atm-m^3/mol	Calculated for pyrethrin 1 and pyrethrin 2 Estimated for all the other chemicals using EPISuite
Octanol – water partition coefficient (log K_{OW}) (25°C)	pyrethrin 1: 5.9 pyrethrin 2: 4.3	USEPA 2006[1]
Air-water partition coefficient (K_{AW})	$K_{AW} = C_{air}/C_{water}$ = HLC/RT = 3.14 x 10^{-5} (unitless) for pyrethrin 1 'Slightly volatile from a water surface'	Temperature assumed to be 25^{0}C, calculated value; USEPA, 2010[2]
Octanol-air partition coefficient (K_{OA})	$K_{OA} = K_{OW}/K_{AW}$ = 2.53 x 10^{10} for pyrethrin 1	Calculated Value
C_{water}/C_{air}	$\frac{C_{water}}{C_{air}} = \left(\frac{S \times T \times R \times 760}{P \times GMW \times 10^6}\right)$ = RT/HLC = 1/K_{AW} = 31,757 (unitless) for pyrethrin 1 'Slightly volatile from a water surface'	Calculated USEPA, 2010[2]
Volatilisation Flux	≤0.002 µg/cm^2·hour	MRID 43096604
$C_{water+soil}/C_{air}$	$C_{water+soil}/C_{air}$ = (1/K_{AW}) (1/r + K_d) = 9.58 x 10^6 'Non-volatile from moist soil'	Calculated Value, using the mean K_F (assumed to be the same than K_d) USEPA, 2010[2]

[1]USEPA 2010 is available at the following URL (accessed 05/12/2015): http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm.

[2]USEPA. 2006. Reregistration Eligibility Decision (RED) Document for Pyrethrins, List B, Case No. 2580, Office of Chemical Safety and Pollution Prevention, Document ID EPA 738-R-06-004, June 2006.

Bioconcentration

For pyrethrin 1, log K_{OA}> 5, log K_{OW}> 2 and therefore is preliminarily identified as having a

potential to biomagnify in terrestrial food chains.[19] However, its rate of biotransformation is moderate in the environment, and it appears to be moderately rapid in fish. Specifically, the bioconcentration factor is 471x for whole fish, which is much lower than would be expected if biotransformation was minimal. Furthermore, it is depurated rapidly in fish (depuration half life <1 day). Therefore, the potential of pyrethrins to biomagnify in terrestrial food chains appears to be low because it should be similarly biotransformed by terrestrial organisms.

Pyrethrins is a naturally occurring substance that contains six esters that are biologically active. As it has been said earlier, all the pyrethrins have the same backbone structure, with the exception of variations in the substitutions in the external or outermost groups. Due to the fact that all the pyrethrins have very similar structures, the environmental fate studies were conducted and well characterized with only one of the pyrethrins: pyrethrin 1. Diastereoisomers could have somewhat different basic properties. In this case the differences are in the substituents at two sites. The substituents at -R are expected to have low reactivity, with the ethene being slightly more reactive. In any case, the driving fate reaction is the breaking of the ester bond which is away from -R. On the other hand, in the case of -R', we have two different moieties. The methyl moiety will be relatively unreactive, while the acetyl group (ester bond) will be susceptible to hydrolysis, resulting in an acid and an alcohol. It is noted from the **Table 16** that the water solubility of the various pyrethrins varies due to some structure variations among them, however, since the environmental fate of only pyrethrin 1 was characterized, its solubility will be used in the models. This may add some uncertainty to the final ecological risk assessment. Nevertheless, EFED does not expect major differences in the overall biotic and abiotic degradation of the pyrethrins.

Transformation Products

Even though various degradates were observed in the laboratory studies (*e.g.* chrysanthemic acid, pyrethric acid and chrysanthemum dicarboxilic acid), it was found that all of them were the result of the rupture of the ester bond of the parent molecule. It is believed that the resulting molecules are not as toxic as the parent because they presumably have lost the neurotoxic mode of action. **Figure 1** shows the chemical structures of pyrethrins' major potential degradation products. All of them are expected to be more soluble and mobile than their respective parent compounds, especially the acids. Based on the information from pyrethrin 1, chrysanthemic acid appeared to be short lived and pyrethric acid and chrysanthemum dicarboxylic acid would be expected to behave similarly. The E-isomer of pyrethrin 1 (not shown in the figure) was observed in the photolysis on soil study to be short lived as well, therefore, it is of low concern.

Table 17 lists available environmental fate characteristics of pyrethrin 1, along with information on the major and minor degradates detected in the submitted environmental fate and transport studies.

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[19] This preliminary conclusion is based on the following presumption: If log K_{OA} > 5, log K_{OW} > 2 and the rate of chemical transformation is low, the chemical may biomagnify in terrestrial food chain. Gobas *et al.* 2003 and Armitage & Gobas, 2007 support this presumption, which is utilized here only as a broad reference to determine the potential for biomagnification. (References: Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025; and, Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.)

Table 17. Summary of Environmental Fate Properties for Pyrethrin 1

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Abiotic Hydrolysis 25±1°C	Half-life[1] = pH 5 no evidence of degradation pH 7 no evidence of degradation pH 9 14 days	Major degradate: chrysanthemic acid (53.9–64.5% at 21–30 days at pH 9)	43188201	Acceptable
	Half-life[1] = pH 5 no evidence of degradation pH 7 no evidence of degradation pH 9 17 days	Major degradate: chrysanthemic acid (54–64% at 21 days, and was 60–62% at 30 days). Also a dimer derived from the hydrolysis product pyrethrolone (MW=320), identified as the single main alcohol-derived degradate, in a parallel test at pH 9.	43567502	
Direct Aqueous Photolysis (pH 7, irradiated with sunlight in Irvine, CA)	Half-life[1] = ~1 hr for the isomerization 11.8 hours, for the combination of pyrethrin and the (E)-Isomer of pyrethrin 1	Major degradate: (E)-isomer of pyrethrin 1(50.7–55.7% AR at 2 hr) More than 24 minor products (<10%)	43096601, 43567601	Supplemental
Soil Photolysis (natural sunlight from California at 24±2°C)	Half-life = <1 day in a sandy loam	Numerous minor degradation products (<10% AR)	43096602	Supplemental
Atmospheric Degradation	Half-life[1] = 0.036 days for hydroxyl radical 0.012 days for ozone reaction	N/A	EPISuite v.4.0	N/A
Aerobic Soil Metabolism (at 75% of 0.33 bar moisture at 25±1°C)	Half-life[1] = 9.5 days sandy loam from ND	Major unidentified: Reg-3 (29.7% at 3 days) Minor degradate: chrysanthemic acid (4.0% at 3 days)	43499803	Supplemental
Aerobic Aquatic Metabolism	Half-life[1] (25±1°C) = Flooded sandy loam soil: 10.5 days for the total system (study lasted only 30 days) In the water, the parent at 7.6% initially and was last detected at 14 days with 0.4% AR	Major degradate: Water: chrysanthemic acid (11.5–14.0% at 14–30 days) Sediment: chrysanthemic acid (8.1% at 14 days)	43499802	Supplemental
	Half-life (20°C) = 6.44 days (IORE) in a Germany Pond Water:sandy silt sediment 5.37 days (DFOP) in a Germany Creek Water:sand sediment	Major degradates: Chrysanthemic acid (67.8% at 14 days) Unextracted residues (46.1% at 30 days) CO_2 (53.0% at 120 days)	**49123501**	Supplemental; High levels of UERs were observed.

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Anaerobic Aquatic Metabolism (25±1°C)	Half-life[1] = Flooded sandy loam soil: 86 days The parent compound was not detected in the water phase.	Major degradate: Water phase: Chrysanthemic acid (10.3% AR at 90 days) Chysanthemum dicarboxylic acid (14.2% AR, 364 days) In the sediment phase, Jasmolin-1 (10.0% AR at 364 days) Chrysanthemic acid (7.0% AR, single replicate, at 3 days) and other minor unidentified degradates (each ≤6.6% AR) $^{14}CO_2$ (13.49% AR at 364 days)	43499801	Supplemental
Freundlich solid-water distribution coefficient (K_F)	All soils were domestic. K_F, 1/n, soil texture 198 L/kg, 1.10, sand 268 L/kg, 0.91, sandy loam 430 L/kg, 1.05, silty loam 310 L/kg, 0.92, silty clay loam Mean K_F = 301.5 L/kg Note: Inspection of the data shows that the K_F model represents the mobility of pyrethrin 1 better than K_{FOC}.	N/A	43096603	Acceptable
Freundlich organic-carbon normalized distribution coefficient (K_{FOC})	K_{FOC}, 1/n, soil texture 37847 L/kg, 1.10, sand 12472 L/kg, 0.91, sandy loam 74175 L/kg, 1.05, silty loam 16190 L/kg, 0.92, silty clay loam	N/A	43096603	Acceptable
Volatility from Soil (Laboratory) 50–75% of field moisture capacity	Limited volatility, ≤0.002 µg/cm^2·hour from Mutchler sandy loam soil. Maximum mean air concentrations were 5.839–7.316 µg/m^3.	After 30 days, volatilized residues totaled a maximum of ~16% of which ~9% was CO_2, ~0.3% was pyrethrin, ~10% chrysanthemic acid, and ~≤2.4 of two minor degradates.	43096604	Acceptable
Terrestrial Field Dissipation	Dissipation Half-life[1,2] = Bare plots of sandy loam soils in Porterville, CA, Pinehurst, GA, and Mason, MI: ~1-2 days	NA	42745501	Supplemental

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Bioconcentration Factor (BCF) – Bluegill Sunfish (*Lepomis macrochirus*) Water temp. 17^{0}C	Mean or Steady State BCF= 873X viscera; 127X edible tissues; 471x whole fish. Depuration was rapid; by day 1, 77% of the accumulated [^{14}C]residues were eliminated from the edible tissues, 66% from the nonedible tissues, and 68% from the whole fish. In the edible tissue, of the extracted radioactivity pyrethrin 1 was 56.4% and 19.6% in the nonedible tissue.	Major degradates: In the edible tissue, chrysanthemic acid was 29.5%, and three Unknowns totaled 23.2%. In the nonedible tissue, chrysanthemic acid was 32.9%, and five Unknowns totaled 21.8%.	43302301, 43884102	Acceptable

Abbreviations: wt=weight; NA=Not Available; N/A=Not Applicable. [1]Half-lives were calculated using the single-first order equation and nonlinear regression, unless otherwise specified. [2]The value may reflect both dissipation and degradation processes.

In general, the environmental fate and transport data base of pyrethrin 1 is adequate to characterize the environmental fate, drinking water, and ecological exposure of the pyrethrins. There are no mobility and little persistence data for the degradates of pyrethrin 1. In addition, studies using radiolabeling on the cyclopentene side of the ester linkage were not conducted and cold analysis was not performed in the cyclopentene labeled studies (with the exception of one of the hydrolysis studies). Consequently, there was no analysis of potential degradates containing the cyclopentene ring originating from the cleavage of the carboxylate ester linkage.

Metabolism and Abiotic Degradation

Pyrethrin 1 was relatively stable in sterile aqueous pH 5 and pH 7 buffer solutions that were incubated in the dark at 25°C for 30 days. In pH 9 solutions, pyrethrin 1 hydrolyzed with a calculated half-life of 14 days and 17 days in two separate studies. The major degradation product identified was chrysanthemic acid at up to 64% of the applied at 21 days.

In an aqueous photolysis experiment, pyrethrin 1 isomerized to the (E)-isomer of pyrethrin 1 (which reached a maximum 50.7–55.7% of the applied amount at 2 hours post-treatment) with an observed half-life of approximately 1 hour in sterile solutions (pH 7) that were irradiated with sunlight in Irvine, California. The overall calculated half-life of dissipation of pyrethrin 1 and its (E)-isomer was 11.8 hours. In a soil photolysis study [^{14}C]-pyrethrin photodegraded with an observed half-life of <1 day. The registrant reported half-life was 12.9 hours. The test was conducted in sandy loam soil from ND that was treated at 9.0–9.6 ppm, and irradiated with natural sunlight in California at 24°C. In the irradiated soil, [^{14}C]-pyrethrin was 66.0-49.3% of the applied amount at 0 hours posttreatment, ranged from 42.8 to 59.0% at 1 through 4 hours, and was only 11.7-21.1 % at 24 hours. In contrast, the dark control samples degraded with a reported half-life of 82.9 hours (~3.5 days). In the dark control, [^{14}C]-pyrethrin comprised 66.7-73.9% of the applied through 4 hours posttreatment, and was 57.6% at 24 hours.

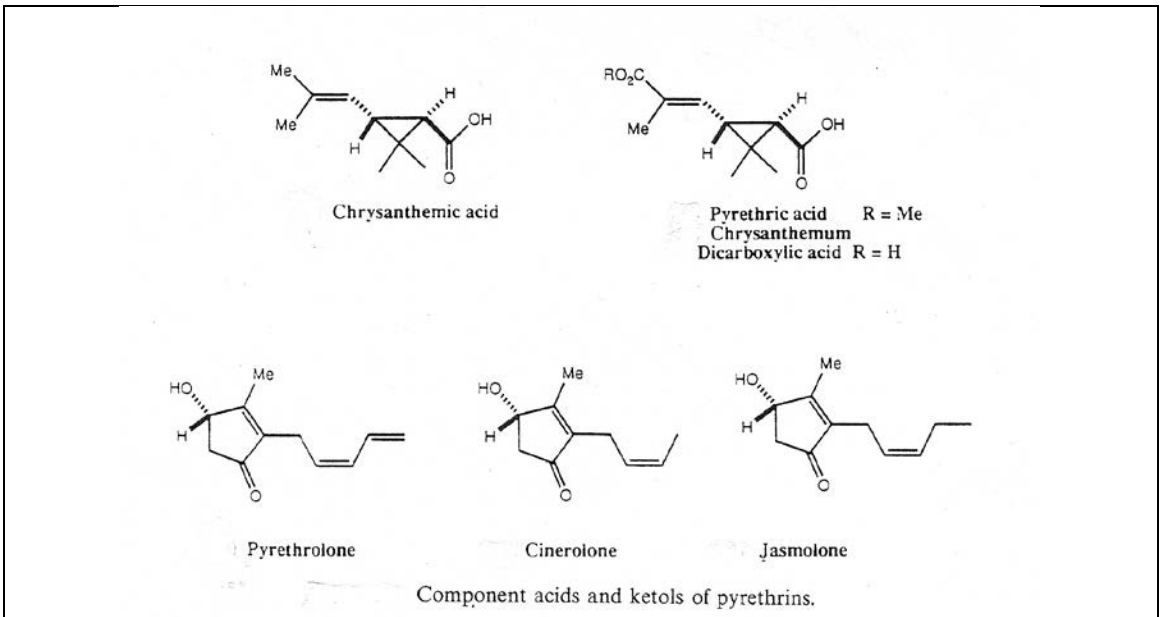
The reported half-life of [^{14}C]-pyrethrin 1 applied at 1 ppm, in an aerobic sandy loam soil

adjusted to 75% of field capacity and incubated in the dark at 25°C was 9.5 days. The degradation was reported as biphasic [half-lives were 3.2 days (0–14 day data) and 23.5 days (14–59 day data)]. Chrysanthemic acid was a minor identified metabolite. Another band (which appears to consist of multiple peaks) could not be identified.

[^{14}C]-Pyrethrin 1 degraded with a half-life of 10.5 days in flooded sandy loam soil incubated at 25°C in an aerobic aquatic dissipation study. In a new aerobic aquatic study, half-lives of 6.44 and 5.37 days were reported in two Germany sediments. High levels of unextracted radioactivity were reported. In addition, in an anaerobic aquatic dissipation study the half-life of pyrethrin 1 was 86 days. The behavior of the system was reported to be bi-phasic (86 days being the half-life for the total system and 27.8 days for 0–31 day data). In both instances, chrysanthemic acid was reported as a major metabolite. Also, chysanthemum dicarboxylic acid was reported at a maximum of 14.2% AR at 364 days, and in the sediment phase, jasmolin-1 was 10.0% AR at 364 days.

Uncertainties

It is noted that in all the studies, the material was radiolabeled in the cyclopropane ring. As a result, the degradate that is most likely to be observed is chrysanthemic acid. Material radiolabeled in the cyclopentenolone ring would result in different degradation products; however, the first step in the degradation of pyrethrin 1 is the rupture of the ester bridge, resulting in a carboxylic acid, and an alcohol. The resulting molecules are expected to lose their pyrethroid toxicological activity; therefore, in the preliminary ecological risk assessment (PRA), they will not be considered stressors. Furthermore, the available data shows that chrysanthemic acid does not reach high levels except upon hydrolysis at pH 9. In the many of the studies multiple degradates at very low concentrations were observed, but not characterized. The only significant isomer observed in the aqueous photolysis study was the (E)-isomer of pyrethrin 1; however, the half-life of pyrethrin 1 was reported for the photolysis of pyrethrin 1 plus the isomer (as if it was parent) in the calculation (the resulting half-life was less than one day).



Chrysanthemic acid	2-(1-isobutenyl-3,3-dimethylcyclopropanecarboxylic acid or 3-isobutenyl-2,2-dimethylcyclopopanecarboxylic acid
CDA or Chrysanthemum Dicarboxylic Acid	2,2-dimethyl-1,3-cyclopropanedicarboxylic acid

Figure 2. Structures of Potential Degradation Products of the Pyrethrins

Transport, Mobility, Sorption

Based on batch equilibrium experiments, [^{14}C]pyrethrin 1 was noted to have a relatively low mobility in sand, sandy loam, silt loam and silty clay loam soil:calcium chloride solution slurries (1:100, w:v). The mean K_F value was 301.5 L/kg.

Potential transport mechanisms for a pesticide include surface water runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. Surface water runoff and spray drift are expected to be the major routes of exposure for pyrethrins to non-target organisms. The magnitude of transport via secondary drift depends on the pyrethrins' ability to be mobilized into air and its eventual removal through wet and dry deposition of gases/ particles and photochemical reactions in the atmosphere. Therefore, physicochemical properties of pyrethrins that describe its potential to enter the air from water or soil (*e.g.*, Henry's Law constant and vapor pressure), pesticide use data, modeled estimated concentrations in water and air, and available air monitoring data are considered in evaluating the potential for atmospheric transport of pyrethrins. Pyrethrins have a moderately low vapor pressure (2.03×10^{-5} torr) and a low Henry's Law constant (7.7×10^{-7} atm-m^3/mol); thus, volatilization from water and soil surfaces is expected to be very low. Pyrethrins' potential for volatilization is also reduced significantly because it adsorbs strongly to soils. Pyrethrins' estimated atmospheric half-life is short (~0.04 days for the hydroxyl radical reaction), indicating a low potential for transport via volatilized active substance (as opposed to present in suspended solids).

Terrestrial Field Dissipation

A study, providing marginally supplemental data (bare ground soils in CA, GA, and MI) appears to indicate that dissipation in the field is very rapid (~1-2 days). The test substance was pyrethrum extract (mixture of pyrethrins I and pyrethrins II). The results appear to confirm what would be expected from the laboratory studies.

Cypermethrin and *Zeta*-Cypermethrin

An environmental fate assessment was provided in the Problem Formulation (DP Barcode D395264, dated March 1, 2012). Cypermethrin and *zeta*-cypermethrin (PC Codes 109702 and 129064) are broad-spectrum insecticides used in four major sectors: agriculture settings, commercial, industrial, institutional, food & non-food, mosquito abatement, domestic home and garden, and pet care. Agricultural products are restricted use, while residential, commercial, and industrial products are general use. For the structures of cypermethrin and *zeta*-cypermethrin and further identification information, refer to **Figures 3** and **4** and **Table 18**, respectively.

Physical and Chemical Properties

Cypermethrin (CAS number 52315-07-8) is a pyrethroid pesticide prepared from the esterification of 3-phenoxybenzaldehyde and 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid. It consists of a mixture of four diastereoisomers, each of which is present as a pair of enantiomers, resulting in eight geometrical and optical isomers. Since the analytical methods do not distinguish cypermethrin from *zeta*-cypermethrin, the toxicological endpoints are the same, and the environmental fate data has been bridged, this document will refer to both chemicals as "cypermethrins", where appropriate.

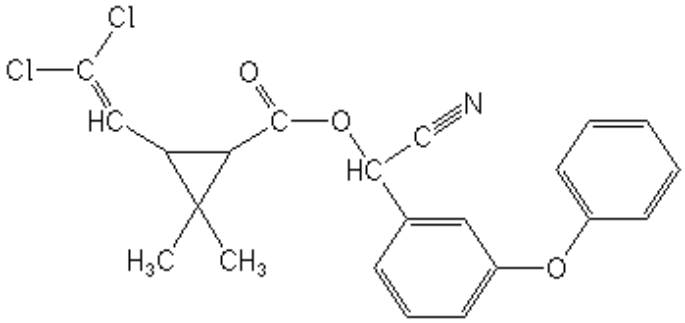


Figure 3. The general structure of cypermethrin[20]

Cypermethrin is a combination of 8 stereoisomers with percentage compositions ranging from 11-14%, and very low volatility and water solubility. *Zeta*-cypermethrin is an enriched enantiomer of cypermethrin consisting of the 4 stereoisomers with an "S" configuration at the cyano-bearing carbon at 24% each, and 4 insecticidally less active stereoisomers at a concentration of 1% each. Since the analytical method does not distinguish cypermethrin from *zeta*-cypermethrin, and the toxicological endpoints are the same, the Agency's environmental fate assessment considers both cypermethrins.

[20] The structure of cypermethrin was found in the chemical's data sheet accessed 08/28/2015 and available at http://www.alanwood.net/pesticides/cypermethrin.html.

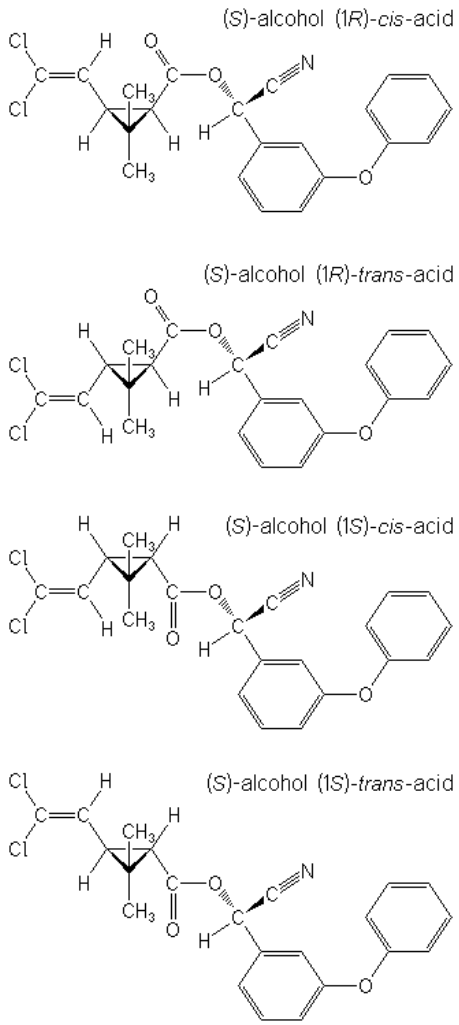


Figure 4. Specific structures of each of the isomers of *zeta*-cypermethrin[21]

Table 18. Identification information for cypermethrin and *zeta*-cypermethrin

PARAMETER	VALUE(s)	SOURCES
SMILES notation	ClC(Cl)=CC1C(C)(C)C1C(=O)OC(C#N)c2cccc(Oc3ccccc3)c2	
Nomenclature of Cypermethrin (IUPAC Names)	Cypermethrin: (*RS*)-α-cyano-3-phenoxybenzyl (1*RS*,3*RS*,1*RS*,3*SR*)-3-(d,d-dichlorovinyl)-2,2-dimethylcyclopropanecorboxylate *Zeta*-cypermethrin: mixture of the stereoisomers (*S*)-α-cyano-3-phenoxybenzyl (1*RS*,3*RS*;1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate where the ratio of the (*S*);(1*RS*,3*RS*) isomeric pair to the (*S*);(1*RS*,3*SR*) isomeric pair lies in the ratio range 45-55 to 55-45 respectively	USEPA 2006[1]
Nomenclature of Cypermethrin (CAS Names)	Cypermethrin: cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate *Zeta*-cypermethrin: (*S*)-cyano(3-phenoxyphenyl)methyl 3-(2,2-	USEPA 2006[1]

[21] The structures of *zeta*-cypermethrin was found in the chemical's data sheet accessed 08/28/2015 and available at http://www.alanwood.net/pesticides/zeta-cypermethrin.html.

PARAMETER	VALUE(s)	SOURCES
	dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate	
PC Code	Cypermethrin: 109702 *Zeta*-cypermethrin: 129064	USEPA 2006[1]
CAS Reg. Nos.	52315-07-8	USEPA 2006[1]
Molecular Formula	$C_{22}H_{19}Cl_2NO_3$	USEPA 2006[1]
Molecular Weight	416.3	USEPA 2006[1]

1 USEPA 2006. Reregistration Eligibility Decision (RED) Document for Cypermethrin, List B, Case No. 2130, Office of Chemical Safety and Pollution Prevention, Document ID EPA OPP-2005-0293, June 2006, revised January 2008.

Cypermethrin's water solubility of 4.0×10^{-3} mg/L and its hydrophobic nature leads to strong soil adsorption and a tendency to partition to sediment in aquatic systems. The reported log octanol/water partition coefficient value (6.4) suggests that the cypermethrins have the potential to bioaccumulate in aquatic organisms, assuming that chemical metabolism is negligible. The cypermethrins have a high molecular weight of 416.3 g/mmol. With a vapor pressure of 2.5×10^{-9} mm Hg and a limited solubility, the calculated Henry's Law Constant for the cypermethrins is relatively low (3.4×10^{-7} atm-m^3/mol). **Table 19** lists various important physicochemical characteristics of the chemicals. **Table 21** lists available environmental fate characteristics of the cypermethrins, along with information on the major and minor degradates detected in the submitted environmental fate studies.

Table 19. Physical and Chemical Properties of the Cypermethrins

Property	Value	Reference
Water solubility	4.0×10^{-3} mg/L	Laskowski (2002)[1]
Melting point	78-81 ^{o}C	Tomlin 1994[2]
Boiling point	200 ^{o}C at 9.3 Pa	Tomlin 1994[2]
Vapor pressure	2.5×10^{-9} mm Hg	Laskowski (2002)[1]
log K_{ow}	6.4	Laskowski (2002)[1]
Henry's Law constant	3.4×10^{-7} atm-m^3/mol	Laskowski (2002)[1]

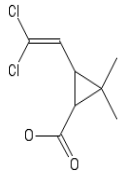
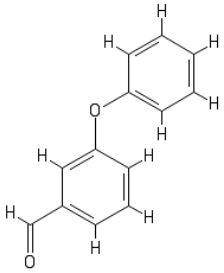
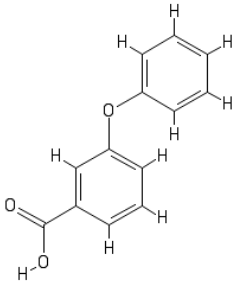
1 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
2 Tomlin CDS; The Pesticide Manual. 11th Ed. Crop Protection Publ: British Crop Protection Council 49 Downing St, Farnham United Kingdom (1997).

Transformation Products

Cleavage at the ester moiety of the cypermethrins results in two primary degradation products, 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane carboxylic acid (DCVA) and 3-phenoxybenzaldehyde, which degrades further to 3-phenoxybenzoic acid (3-PBA). Based on the assumption that cleavage of the ester bond in the parent compound results in biologically inactive degradates, these compounds are not expected to pose greater toxicity to non-target organisms; therefore only the parent compounds were considered for toxicological concern for both aquatic and terrestrial ecosystems. In fact, this assumption is supported by the results of acute toxicity studies in freshwater fish and invertebrates which indicate that the *zeta*-cypermethrin degradate 3-

phenoxy benzoic acid is much less toxic than the parent compound. **Table 20** shows the chemical structures of the cypermethrins' major potential degradation products.

Table 20. Nomenclature and Structures of Potential Degradation Products of the Cypermethrins

Common Name	Chemical Name	Structure
DCVA	3-(2,2-dichloroethenyl)-2,2-dimethylcyclo-propane carboxylic acid	
3-PBald	3-phenoxy-benzaldehyde	
3-PBA	3-phenoxybenzoic acid	

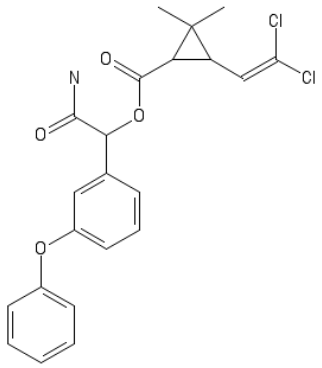
Common Name	Chemical Name	Structure
Not available	cyperamide	

Table 21 summarizes the environmental fate/transport properties of the cypermethrins. Structures of the observed degradates are provided in **Table 20**.

Table 21. Summary of the environmental fate properties of the cypermethrins

Property	**Value / Degradates observed**	**Reference**
Hydrolysis half-life: pH 5 pH 7 pH 9	stable stable 1.8 (acid labeled) and 2.5 days (alcohol label) *cis*/*trans*-DCVA (max. 79% at 120 hr) and 3-phenoxybenzaldehyde (max. 65% at 120 hr)	MRID 42620501
Aqueous photolysis half-life	36.2 days 3-PBA (max. 35% at 35 days)	MRID 42395701
Soil photolysis half-life	sandy loam 55 days cyperamide (steadily increased to a max. of 13.3%)	MRID 42129001
Aerobic soil metabolism half-life	60.7 days (sandy loam, acid label) 59.8 days (sandy loam, alcohol label) *cis*/*trans*-DCVA (max. 24% at 62 days, study duration 150 days)	MRID 42156601
Anaerobic soil metabolism half-life	53.3 days (sandy loam, acid label) 63 days (sandy loam, alcohol label) *cis*/*trans*-DCVA (max. 33% 30 days after flooding), 3-PBA (max. 26% at 60 days after flooding or end of study)	MRID 42156602
Aerobic aquatic half-life	8.9 days 10.1 days *trans*-DCVA (max. 49% at 30 days), *cis*-DCVA (max. 19% at 30 days), 3-PBA (max. 42% at 30 days); study duration, 90 or 183 days.	MRID 45920801
	Zeta-cypermethrin 11.3 days (IORE), sand	MRID **48762908** Supplemental.

Property	Value / Degradates observed	Reference
	54.9 days (DFOP), clay 13.8 days (IORE), sandy clay loam Cypermethrin 7.01 days (IORE), sand 37.9 days (IORE), clay 5.88 days (IORE), sandy clay loam	Water and sediment were extracted together. Non-radiolabeled material was used in this study.
Anaerobic aquatic half-life	13.8 days (clay loam, benzyl label) 16.5 days (clay loam, cyclopropyl label) DCVA (max. 34% at 71 days)	MRID 44876105
	Zeta-cypermethrin 70.4 days (DFOP), sand 50.1 days (IORE), clay 39.6 days (DFOP), sandy clay loam Cypermethrin 28.1 days (SFO), sand 37.1 days (IORE), clay 27.8 days (IORE), sandy clay loam	MRID **48762908** Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used in this study.
Adsorption coefficient K_{oc} (L/Kg)	328,500 (Sand) 134,900 (Sandy loam) 82,600 (Silty loam) 20,800 (Clay loam)	MRID 42129003
Aged Column Leaching Study	Degradate *cis*/*trans*-DCVA found at up to 13.2% in the leachate	MRID 42129002
Terrestrial Field Dissipation Study	13 days (CA soil) 5 days (LA soil)	MRID 42459601
Bioconcentration factor (BCF)	161X edible portion 448X whole fish 883X non-edible Moderately slow depuration, with 10-15% of residues remaining after 21 days of depuration	MRID 42868203
POTW Treatability Study	Removal percent for cypermethrin: Primary Settling LR Aerobic Chamber 76.39% Anaerobic Digestion 78.1% Ultrafiltration 95.4%	MRID **48762906** Supplemental; POTW treatability study of eight pyrethroids.

The environmental fate data for the cypermethrins was developed mostly with studies on cypermethrin; however, some studies were conducted on *zeta*-cypermethrin. *Zeta*-cypermethrin is expected to have a similar fate profile in the environment as cypermethrin.

Metabolism and Abiotic Degradation

Laboratory studies have indicated that the cypermethrins degrade through a combination of biotic and abiotic reactions and is moderately persistent in the environment. Under acidic and neutral conditions this compound is relatively stable, but is readily hydrolyzed under alkaline conditions with a half-life of approximately 2 days at pH 9. The cypermethrins are relatively stable to photolysis in laboratory studies using distilled water at pH 7, with a half-life of approximately

36 days. The cypermethrins have been shown to biodegrade in aerobic and anaerobic soils with half-lives on the order of about 2 months and in aerobic and anaerobic aquatic systems with half-lives on the order of one to two weeks. The cypermethrins are considered immobile in soils (Kocs >20,000 L/Kg) and its potential to leach into groundwater is low. If released to water, the cypermethrins will rapidly partition to the sediment compartment which acts as an environmental sink for this compound. The cypermethrins bioaccumulate moderately in fish (448X in whole fish), with moderate depuration. In terrestrial field dissipation studies the cypermethrins do not appear to be very persistent in soils or leach substantially (half-lives 1-2 weeks). In supplemental aquatic field dissipation studies (*zeta*-cypermethrin), the chemical appears to persist in the sediment, with reported half-lives of 126 and 181 days in LA and CA, respectively.

Cypermethrin labeled with ^{14}C at the cyclopropyl and benzyl moieties was relatively stable at pH 5 and 7 buffered solutions, but degraded rapidly with half-lives of approximately 2 days in pH 9 solutions. The major degradation products of the base catalyzed hydrolysis of cypermethrin were *cis*- and *trans*-DCVA (maximum 79% at 120 hours or study duration) and 3-phenoxybenzaldehyde (maximum 65% at 120 hours). Photolysis of cypermethrin in distilled water occurs slowly, but the rate of degradation appears to be enhanced in natural waters, which contain humic and fulvic acids. A photolysis half-life of 36 days was observed for cypermethrin in pH 7 aqueous buffered solution exposed to sunlight in California from March to April. Shorter half-lives on the order of less than 1 to 4 days were observed for cypermethrin dissolved in river water, seawater and distilled water with 1% humic acid exposed to sunlight (Takahashi et al. 1985). The half-life for thin films of cypermethrin in a sandy loam soil matrix was approximately 55 days; however, degradation was also observed in control samples and the dark control corrected half-life is over 100 days. The only transformation product observed was cyperamide, at 13.3% at the end of the study (35 days). Cypermethrin degraded with a half-life of approximately 60 days in a fine sandy loam soil maintained at 25 ^{o}C and held under aerobic conditions. Carbon dioxide and a mixture of *cis*- and *trans*-DCVA (maximum 24% at 62 days in a 150 day study) were the major degradation products.

Under aquatic conditions, cypermethrin degraded more rapidly (8.9-10.1 days in a supplemental aerobic aquatic study and 13.8-16.5 days in an anaerobic aquatic study). Degradation products (see **Table 20** for structures) under aerobic aquatic conditions included *trans*-DCVA (max. 49% at 30 days), *cis*-DCVA (max. 19% at 30 days) and 3-PBA (max. 42% at 30 days, study duration 183 days). Under anaerobic conditions, the only degradation product was DCVA at 34% at 71 days (study duration 90 days for benzyl label and 183 days for cyclopropyl label).

In a supplemental study, a combined aerobic and anaerobic aquatic metabolism study yielded aerobic aquatic metabolism half-lives of 7.01, 37.9, and 5.88 days for cypermethrin in a sand, clay and sandy clay loam sediments from California. Additionally, for *zeta*-cypermethrin the aerobic half-lives were 11.3, 54.9, and 13.8 days, respectively for the same sediments. Under anaerobic aquatic conditions, the half-lives were 28.1, 37.1 and 27.8 days for cypermethrin in a sand, clay and sandy clay loam sediments. For *zeta*-cypermethrin the anaerobic half-lives were 70.4, 50.1 and 39.6 days, respectively for the same sediments. The study was found to be supplemental since it was conducted using non-labeled material and the water and sediments were extracted together.

Transport, Mobility, Sorption

Cypermethrin is considered immobile in soil. Soil organic carbon adsorption coefficients (K_{oc}) for cypermethrin ranged from approximately 21,000 to 385,000 L/Kg in four soils (sand, sandy loam, silty loam and clay). If released into water, cypermethrin rapidly partitions to the sediment column. The tendency to adsorb to soil and sediment along with the relatively low vapor pressure (2.5×10^{-9} mm Hg) and Henry's law constant (3.4×10^{-7} atm-m^3/mol), indicates that volatilization from water and soil will not be an important transport process. It can be concluded that the cypermethrin degradates 3-PBA and *trans*-DCVA have a high potential for mobility as they were weakly sorbed to four soils tested. 3-PBA was slightly more sorbed (K_{oc} values ranging from 118 to 215) to the tested soils than was *trans*-DCVA (K_{oc} values ranging from 18 to 48).

Terrestrial Field Dissipation Studies

Terrestrial field dissipation studies conducted in Madera, CA and Cheneyville, LA indicated that the field dissipation half-life of formulated cypermethrin is approximately 1 to 2 weeks.

Cypermethrin in the form of Ammo 2.5 EC was applied three times at 0.2 lb ai/acre/application to a bare silt loam soil (78-82% sand, 14-20% silt, 2-4% clay, 0.2-0.6% OM, pH 6.5-7.2) located in Madera, California and soil samples were analyzed for cypermethrin and potential degradates *cis*-DCVA, *trans*-DCVA, and 3-phenoxybenzoic acid. Cypermethrin was detected in 3-6" cores collected immediately after each application (18, 8, and 33 µg/kg), and on day 2 (20 µg/kg) and day 4 (29 µg/kg) following the third application. Cypermethrin was detected at 10 µg/kg in one 6-12" core collected 2 days after the final application, but it was not detected in any soil cores collected below this depth (detection limit of 7 µg/kg). The degradate 3-phenoxybenzoic acid was detected in 0-3" cores collected immediately after the second application (8 µg/kg), immediately after the third application (17 µg/kg), and the following days after the third application: day 2 (25 µg/kg), day 4 (32 µg/kg), day 7 (25 µg/kg), day 14 (24 µg/kg), day 21 (8 µg/kg), and day 28 (7 µg/kg). It was not detected above a detection limit of 7 µg/kg in any soil cores collected below 3 inches. Potential degradates *cis*- and *trans*-DCVA were not detected above the detection limit of 7 µg/kg in any of the soil cores. An analysis of the cypermethrin concentration as a function of time yielded a field dissipation half-life of 13 days.

In a second study, cypermethrin in the form of Ammo 2.5 EC was applied three times at 0.2 lb a.i./acre/application to a bare loamy sand soil (30% sand, 64% silt, 6% clay, 0.7% OM, pH 7.0) located in Cheneyville, LA. The soil cores were analyzed for cypermethrin and potential degradates *cis*-DCVA, *trans*-DCVA, and 3-phenoxybenzoic acid. Based upon dissipation in the top 0-3" soil cores, the dissipation half-life for cypermethrin was 5 days. Cypermethrin was not detected above a detection limit of 7 µg/kg in any cores collected below 3 inches. The degradate *trans*-DCVA was detected in 0-3" cores collected on the following days after the third application: day 2 (16 µg/kg) and day 7 (8 µg/kg). The degradate 3-phenoxybenzoic acid was detected in 0-3" cores collected immediately after the second application (10 µg/kg), immediately after the third application (20 µg/kg), and 2 days after the 3rd application (44 µg/kg). The degradate *cis*-DCVA was not detected above a detection limit of 7 µg/kg in any of the soil cores. None of the analytes were detected above a detection limit of 7 µg/kg in any of the soil cores collected below 3 inches.

Cypermethrin is not labeled for use in aquatic sites; however, there are two supplemental aquatic field dissipation studies conducted with *zeta*-cypermethrin in California and Louisiana. The half-lives were 181 days and 126 days, respectively. These half-lives are not similar to those observed in the laboratory studies. Nevertheless, the reported half-lives included the sediments only.

Other Studies – POTW Treatability

In a POTW treatability study, cypermethrin showed limited removal upon primary settling, and around 76% removal in the aerobic chamber. In the anaerobic digester only 78% of the parent compound was removed. Under ultrafiltration, nearly 95.4% of the cypermethrin was removed.

Alpha-Cypermethrin

An environmental fate assessment was provided in the New Chemical risk assessment (DP Barcode D376120, dated September 19, 2012).

Physical and Chemical Properties

Alpha-cypermethrin is a broad-spectrum Type II pyrethroid insecticide. Synonyms include (BAS 310 40 I; (R)-cyano(3-phenoxyphenyl)methyl (1S,3S)-rel-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate; CAS#: 67375-30-8; PC code: 209600). Racemic cypermethrin consists of eight stereoisomers with two optically active centers (designated "R" and "S"). *Alpha*-cypermethrin is an enriched enantiomeric mixture of racemic cypermethrin consisting of 2 stereoisomers at 50% each.

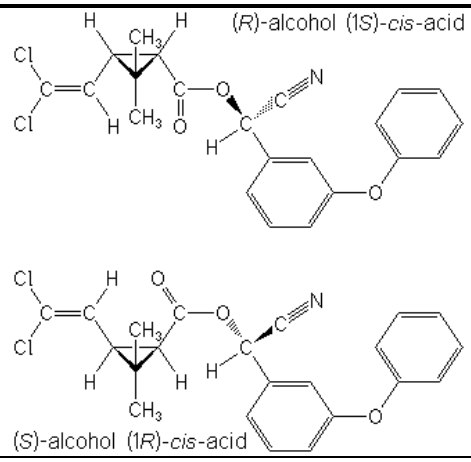
The environmental fate database for *alpha*-cypermethrin was bridged from the database for the racemic and *zeta* cypermethrin. Therefore the majority of the fate and transport data presented herein were conducted using the racemic cypermethrin as the test substance. Throughout the remainder of the document when discussing the environmental fate and transport of the *alpha* isomer, it is referred to *alpha*-cypermethrin even though the data were generated using cypermethrin as the test substance.

Alpha-cypermethrin is expected to persist in both terrestrial and aquatic environments under aerobic and anaerobic conditions, and is considered immobile, lipophilic, and nonvolatile. *Alpha*-cypermethrin is persistent in soil, with half-lives ranging from 60 to 61 days in aerobic soil and 53 to 63 days in anaerobic soil. There is no evidence of degradation via hydrolysis, which was studied across environmental pHs. Laboratory data show that *alpha*-cypermethrin degraded by aerobic aquatic metabolism with half-lives ranging from 9 to 10 days. A potentially major route of degradation in shallow, clear waters (*e.g.*, applications to flooded rice paddies) may be aqueous photolysis (environmental half-life of 55 days). *Alpha*-cypermethrin has the potential to bioconcentrate in aquatic organisms; however, this potential is tempered by the sensitivity of aquatic animals to the chemical.

The general physical/chemical properties of *alpha*-cypermethrin are summarized in **Table 22**. These data represent cypermethrins (i.e., data were generated for the racemic mixture, but are bridged across the enriched isomers). Environmental fate and transport properties of *alpha*-cypermethrin are characterized in further detail in the following sections, and data specific to *alpha*-cypermethrin is noted. The Agency's understanding of these properties is limited by the available dataset. Many of the chemical properties and environmental fate parameters of *alpha*-cypermethrin listed in **Table 23** are based on studies classified as supplemental.

Table 22. General Physical and Chemical Properties of *Alpha*-Cypermethrin

Parameter	Value	Reference
PC code	209600	--
CAS No.	67375-30-8	--

Parameter	Value	Reference
Structure		--
Chemical name (IUPAC)	racemate comprising (*R*)-α-cyano-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate **or** racemate comprising (*R*)-α-cyano-3-phenoxybenzyl (1*S*)-*cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*)-*cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate	--
Chemical name (CAS)	(*R*)-cyano(3-phenoxyphenyl)methyl (1*S*,3*S*)-*rel*-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate	--
Common name	*Alpha*-Cypermethrin (BAS 310 40 I)	--
Chemical formula	$C_{22}H_{19}Cl_2NO_3$	--
Molecular weight	416.3 g/mol	USEPA 2006[1]
Water solubility (20ºC, pH 7)	4.0×10^{-3} mg/L	Laskowski (2002)[2]
Vapor pressure (25ºC)	2.5×10^{-9} torr	Laskowski (2002)[2]
Henry's law constant	3.4×10^{-7} atm-m^3/mol	Laskowski (2002)[2]
Octanol-water partitioning coefficient Log K_{OW} (20ºC, pH 7)	6.4	Laskowski (2002)[2]

1 USEPA 2006. Reregistration Eligibility Decision (RED) Document for Cypermethrin, List B, Case No. 2130, Office of Chemical Safety and Pollution Prevention, Document ID EPA OPP-2005-0293, June 2006, revised January 2008.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

Alpha-cypermethrin's water solubility of 4.0×10^{-3} mg/L and its hydrophobic nature leads to strong soil sorption and a tendency to partition to sediment in aquatic systems. The reported log octanol/water partition coefficient value (6.4) suggests that the cypermethrins have the potential to bioaccumulate in aquatic organisms, assuming that chemical metabolism is negligible. The cypermethrins have a high molecular weight of 416.3 g/mmol. With a vapor pressure of 2.5×10^{-9} mm Hg and a limited solubility, the calculated Henry's Law Constant for the cypermethrins is relatively low (3.4×10^{-7} atm-m^3/mol). A summary of the submitted environmental fate and transport data is summarized in **Table 23**.

Laboratory studies have indicated that the cypermethrins degrade through a combination of biotic and abiotic reactions and is moderately persistent in the environment. Under acidic and neutral conditions this compound is relatively stable, but is readily hydrolyzed under alkaline conditions with a half-life of approximately 2 days at pH 9. *Alpha*-cypermethrin may be susceptible to photodegradation in clear shallow waters with an aqueous photolysis half-life of 5 to 36 days. Cypermethrins are shown to biodegrade in aerobic and anaerobic soils with half-lives on the order of about 2 months and in aerobic and anaerobic aquatic systems with half-lives on the order of one to two weeks. *Alpha*-cypermethrin is considered immobile in soils (K_{oc}'s > 20,000 L/Kg) and its potential to leach into groundwater is low. If released to water, *alpha*-cypermethrin will rapidly partition to the sediment compartment which acts as an environmental sink for this compound. *Alpha*-cypermethrin may bioconcentrate moderately in fish (BCF = 448X in whole fish), with moderate depuration. In terrestrial field dissipation studies *alpha*-cypermethrin does not appear to be very persistent in soils or leach substantially (half-lives 1-2 weeks). In supplemental aquatic field dissipation studies (*zeta*-cypermethrin), the chemical appears to persist in the sediment, with reported half-lives of 126 and 181 days in LA and CA, respectively.

Table 23. Environmental Fate Data Summary for *Alpha*-Cypermethrin

Property	Value / Degradates observed	Reference
Hydrolysis half-life: pH 5 pH 7 pH 9	stable stable 1.8 (acid labeled) and 2.5 days (alcohol label) *cis*/*trans*-DCVA (max. 79% at 120 hr) and 3-phenoxybenzaldehyde (max. 65% at 120 hr) *Alpha*-cypermethrin: 67 days (pH 7, 25ºC)	MRID 42620501 MRID 48425002
Aqueous photolysis half-life	36.2 days 3-PBA (max. 35% at 35 days) *Alpha*-cypermethrin: 5 days	MRID 42395701 MRID 48425003
Soil photolysis half-life	Sandy loam 55 days Cyperamide (steadily increased to a maximum of 13.3%)	MRID 42129001
Aerobic soil metabolism half-life	60.7 days (sandy loam, acid label) 59.8 days (sandy loam, alcohol label) *cis*/*trans*-DCVA (max. 24% at 62 days, study duration 150 days) *Alpha*-cypermethrin:	MRID 42156601 MRID 48450006

Property	Value / Degradates observed	Reference
	28 days (UK sandy loam soil)	
Anaerobic soil metabolism half-life	53.3 days (sandy loam, acid label) 63 days (sandy loam, alcohol label) *cis*/*trans*-DCVA (max. 33% 30 days after flooding), 3-PBA (max. 26% at 60 days after flooding or end of study)	MRID 42156602
Aerobic aquatic metabolism half-life	8.9 days 10.1 days *trans*-DCVA (max. 49% at 30 days), *cis*-DCVA (max. 19% at 30 days), 3-PBA (max. 42% at 30 days); study duration, 90 or 183 days. *Alpha*-cypermethrin: 2.8 – 11 days	MRID 45920801 MRID 48425011, 48425012
Anaerobic aquatic metabolism half-life	13.8 days (clay loam, benzyl label) 16.5 days (clay loam, cyclopropyl label) DCVA (max. 34% at 71 days)	MRID 44876105
Adsorption coefficient K_{oc} (L/Kg)	328,500 (Sand) 134,900 (Sandy loam) 82,600 (Silty loam) 20,800 (Clay loam) *Alpha*-cypermethrin: 26,492 – 144,662	MRID 42129003 MRID 48425008
Aged Column Leaching Study	Degradate *cis*/*trans*-DCVA found at up to 13.2% in the leachate	MRID 42129002
Terrestrial Field Dissipation Study	13 days (CA soil) 5 days (LA soil)	MRID 42459601
Bioconcentration factor (BCF)	161X edible portion 448X whole fish 883X non-edible moderately slow depuration, with 10-15% of residues remaining after 21 days of depuration	MRID 42868203

Transport, Mobility, Sorption

Alpha-cypermethrin is considered immobile in soil. Soil organic carbon adsorption

coefficients (K_{oc}) for cypermethrin ranged from approximately 21,000 to 385,000 L/Kg in four soils (sand, sandy loam, silty loam and clay). If released into water, cypermethrin rapidly partitions to the sediment column. The tendency to adsorb to soil and sediment along with the relatively low vapor pressure (2.5×10^{-9} mm Hg) and Henry's law constant (3.4×10^{-7} atm-m^3/mol), indicates that volatilization from water and soil will not be an important transport process. It can be concluded that the cypermethrin degradates 3-PBA and *trans*-DCVA have a high potential for mobility as they were weakly sorbed to four soils tested. 3-PBA was slightly more sorbed (K_{oc} values ranging from 118 to 215) to the tested soils than was *trans*-DCVA (K_{oc} values ranging from 18 to 48).

Metabolism and Abiotic Degradation

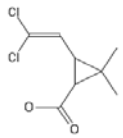
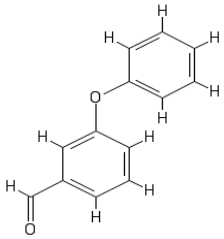
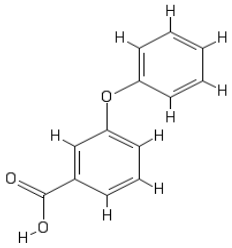
Cypermethrin labeled with ^{14}C at the cyclopropyl and benzyl moieties was relatively stable at pH 5 and 7 buffered solutions, but degraded rapidly with half-lives of approximately 2 days in pH 9 solutions. The major degradation products of the base catalyzed hydrolysis of cypermethrin were *cis*- and *trans*-DCVA (maximum 79% at 120 hours or study duration) and 3-phenoxybenzaldehyde (maximum 65% at 120 hours). Photolysis of cypermethrin in distilled water occurs slowly, but the rate of degradation appears to be enhanced in natural waters, which contain humic and fulvic acids. A photolysis half-life of 36 days was observed for cypermethrin in pH 7 aqueous buffered solution exposed to sunlight in California from March to April. Shorter half-lives on the order of less than 1 to 4 days were observed for cypermethrin dissolved in river water, seawater and distilled water with 1% humic acid exposed to sunlight (Takahashi et al. 1985). The half-life for thin films of cypermethrin in a sandy loam soil matrix was approximately 55 days; however, degradation was also observed in control samples and the dark control corrected half-life is over 100 days. The only transformation product observed was cyperamide, at 13.3% at the end of the study (35 days). Cypermethrin degraded with a half-life of approximately 60 days in a fine sandy loam soil maintained at 25 ^{o}C and held under aerobic conditions. Carbon dioxide and a mixture of *cis*- and *trans*-DCVA (maximum 24% at 62 days in a 150 day study) were the major degradation products.

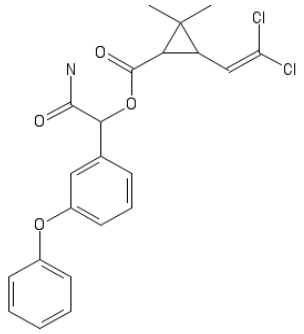
Under aquatic conditions, cypermethrin degraded more rapidly (8.9-10.1 days in a supplemental aerobic aquatic study and 13.8-16.5 days in an anaerobic aquatic study). Degradation products (see **Table 24** for structures) under aerobic aquatic conditions included *trans*-DCVA (max. 49% at 30 days), *cis*-DCVA (max. 19% at 30 days) and 3-PBA (max. 42% at 30 days, study duration 183 days). Under anaerobic conditions, the only degradation product was DCVA at 34% at 71 days (study duration 90 days for benzyl label and 183 days for cyclopropyl label).

Transformation Products

Major transformation products resulting from the environmental degradation of cypermethrin are 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane carboxylic acid (DCVA) and 3-phenoxybenzaldehyde, which degrades further to 3-phenoxybenzoic acid (3-PBA).

Table 24. Nomeclature and Structures of Potential Degradation Products of *Alpha*-Cypermethrin

Common Name	Chemical Name	Structure
DCVA	3-(2,2-dichloroethenyl)-2,2-dimethylcyclo-propane carboxylic acid	
	3-phenoxy-benzaldehyde	
3-PBA	3-phenoxybenzoic acid	

Common Name	Chemical Name	Structure
Not available	cyperamide	

Terrestrial Field Dissipation

Terrestrial field dissipation studies conducted in Madera, CA and Cheneyville, LA indicated that the field dissipation half-life of formulated cypermethrin is approximately 1 to 2 weeks.

Cypermethrin in the form of Ammo 2.5 EC was applied three times at 0.2 lb ai/acre/application to a bare silt loam soil (78-82% sand, 14-20% silt, 2-4% clay, 0.2-0.6% OM, pH 6.5-7.2) located in Madera, California and soil samples were analyzed for cypermethrin and potential degradates *cis*-DCVA, *trans*-DCVA, and 3-phenoxybenzoic acid. Cypermethrin was detected in 3-6" cores collected immediately after each application (18, 8, and 33 µg/kg), and on day 2 (20 µg/kg) and day 4 (29 µg/kg) following the third application. Cypermethrin was detected at 10 µg/kg in one 6-12" core collected 2 days after the final application, but it was not detected in any soil cores collected below this depth (detection limit of 7 µg/kg). The degradate 3-phenoxybenzoic acid was detected in 0-3" cores collected immediately after the second application (8 µg/kg), immediately after the third application (17 µg/kg), and the following days after the third application: day 2 (25 µg/kg), day 4 (32 µg/kg), day 7 (25 µg/kg), day 14 (24 µg/kg), day 21 (8 µg/kg), and day 28 (7 µg/kg). It was not detected above a detection limit of 7 µg/kg in any soil cores collected below 3 inches. Potential degradates *cis*- and *trans*-DCVA were not detected above the detection limit of 7 µg/kg in any of the soil cores. An analysis of the cypermethrin concentration as a function of time yielded a field dissipation half-life of 13 days. In a second study, cypermethrin in the form of Ammo 2.5 EC was applied three times at 0.2 lb a.i./acre/application to a bare loamy sand soil (30% sand, 64% silt, 6% clay, 0.7% OM, pH 7.0) located in Cheneyville, LA. The soil cores were analyzed for cypermethrin and potential degradates *cis*-DCVA, *trans*-DCVA, and 3-phenoxybenzoic acid. Based upon dissipation in the top 0-3" soil cores, the dissipation half-life for cypermethrin was 5 days. Cypermethrin was not detected above a detection limit of 7 µg/kg in any cores collected below 3 inches. The degradate *trans*-DCVA was detected in 0-3" cores collected on the following days after the third application: day 2 (16 µg/kg) and day 7 (8 µg/kg). The degradate 3-phenoxybenzoic acid was detected in 0-3" cores collected immediately after the second application (10 µg/kg), immediately after the third application (20 µg/kg), and 2 days after the 3rd application (44 µg/kg). The degradate *cis*-DCVA was not detected above a detection limit

of 7 µg/kg in any of the soil cores. None of the analytes were detected above a detection limit of 7 µg/kg in any of the soil cores collected below 3 inches.

Cypermethrin is not labeled for use in aquatic sites; however, there are two supplemental aquatic field dissipation studies conducted with *zeta*-cypermethrin in California and Louisiana. The half-lives were 181 days and 126 days, respectively. These half-lives are not similar to those observed in the laboratory studies. Nevertheless, the reported half-lives included the sediments only.

Bioconcentration

The reported value of log octanol/ water partition coefficient of 6.4 suggests that the cypermethrins have the potential to bioaccumulate in aquatic organisms assuming that chemical metabolism is negligible. Maximum BCFs for the cypermethrins are 161x for edible tissue, 883x for viscera, and 448x for whole fish (MRID 42868203). Depuration appeared to be moderately slow, with ~10-15% of the initial residues remaining after 21 days. Thus, it appears that there is potential for bioaccumulation/bioconcentration in aquatic organisms and biomagnification in terrestrial organisms.

Esfenvalerate

An environmental fate assessment was provided in the Problem Formulation (DP Barcode 379293, dated June 21, 2010). Previously, in 2003 a Section 3 environmental risk assessment for the use of esfenvalerate on almonds, cabbage, cocoa bean, peanuts, walnuts, Brussels sprouts, canola, pistachios, bok choy, cardoon, and sweet potatoes was conducted for esfenvalerate (Felthousen, R. W., & Abdel-Saheb, I. 2003[22]). The environmental fate assessment is being updated here with two newly submitted studies.

Esfenvalerate is a broad spectrum nonselective insecticide that is used to control a variety of insects in agriculture, commercial, residential, and industrial settings both indoors and outdoors. Esfenvalerate is a Type II synthetic pyrethroid (*i.e.*, contains an *alpha*-cyano group); however, it demonstrates toxicity properties of both Type I and Type II pyrethroids (USEPA, 2009[23]). The primary mechanism of action of pyrethroids is interference with the closing of voltage-dependent sodium channels, resulting in repetitive firing of neurons or blocking of an action potential (ATSDR, 1993[24]). After exposure the organism may exhibit hyper-excitation, tremors, convulsions, and/or salivation, followed by lethargy, paralysis, and death (Kelley, 2003[25]). Type II pyrethroids, those that contain a cyano group in the alcohol and halogen in the acid, are also reported to have effects at the presynaptic membrane of voltage dependent calcium channels and to interfere with ATPase enzymes involved with maintaining ionic concentration gradients across membranes (Solomon *et al.*, 2001[26]).

Physical and Chemical Properties

Esfenvalerate, cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate, has two chiral centers – one at the 2C position of the acid and one at the alpha C position of the alcohol (see **Table 25**), resulting in four possible isomers: RS, SR, SS, and RR. While fenvalerate is made up of approximately equal amounts of each isomer, esfenvalerate is enriched with the SS-isomer (75

[22] Felthousen, R. W., & Abdel-Saheb, I. 2003. *EFED Risk Assessment for Section 3 Registration for use of Esfenvalerate on Almonds,Cabbage, Cocoa Bean, Peanuts, Walnuts, Brussel sprouts, Canola, Pistachios, Bok Choy,Cardoon and Sweet Potatoes*. D. D257890, D259704, D257273. June 16, 2003. Environmental Fate and Effects Division. Office of Pesticide Programs.

[23] USEPA. (2009). *Draft Science Polciy Paper: Proposed Common Mechanisms Grouping for The Pyrethrins and Synthetic Pyrethroids, United States Environmental Proteciton Agency*. Washington, D.C.

[24] ATSDR. (1993). *Toxicological Profile for Pyrethrins and Pyrethroids, Agency for Toxic Substances and Disease Registry (ATSDR)*. Washington, D.C.: Government Printing Office. Available at http://www.atsdr.cdc.gov/toxprofiles/tp155.html#bookmark08 (Accessed June 19, 2009).

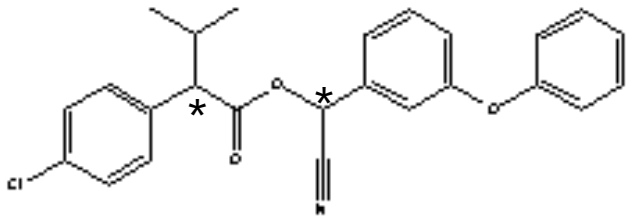
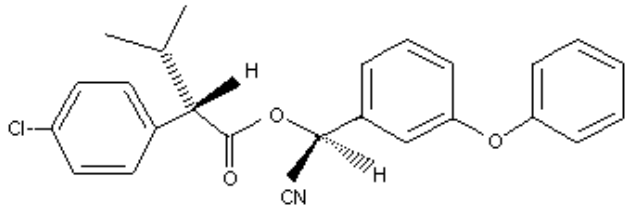
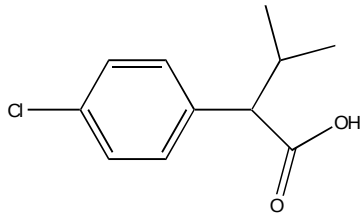
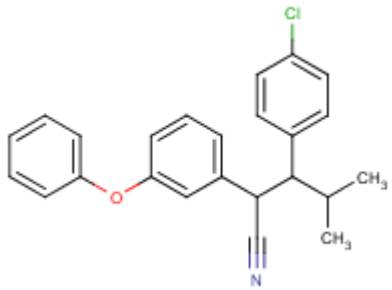
[25] Kelley, K. 2003. *Environmental Fate of Esfenvalerate*. Environmental Monitoring Branch. Department of Pesticide Regulation. California Environmental Protection Agency. Available at (accessed June 19, 2009): http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/esfen.pdf.

[26] Solomon, K. R., Giddings, J. M., & Maund, S. J. 2001. Probabilistic risk assessment of cotton pyrethroids:I. Distributional analyses of laboratory aquatic toxicity data. *Environmental Toxicology and Chemistry, 20*(3), 652-659.

– 90%) (Adelsbach and Tjeerdema, 2003[27]; ATSDR, 1993[28]; Solomon *et al.*, 2001[29]), which is a more effective insecticide than the other isomers (Katagi, 1993[30]; Solomon *et al.*, 2001[31]). Unless otherwise specified, all fate studies discussed were conducted using the SS-isomer. **Table 25** shows the chemical structure of esfenvalerate and related compounds; **Table 26** lists the physico-chemical properties.

[27] Adelsbach, T. L., & Tjeerdema, R. S. 2003. Chemistry of fenvalerate and esfenvalerate. *Reviews of Environmental Contamination and Toxicology, 176*, 137-154.
[28] ATSDR. (1993). *Toxicological Profile for Pyrethrins and Pyrethroids*, *Agency for Toxic Substances and Disease Registry (ATSDR)*. Washington, D.C.: Government Printing Office. Available at http://www.atsdr.cdc.gov/toxprofiles/tp155.html#bookmark08 (Accessed June 19, 2009).
[29] Solomon, K. R., Giddings, J. M., & Maund, S. J. 2001. Probabilistic risk assessment of cotton pyrethroids:I. Distributional analyses of laboratory aquatic toxicity data. *Environmental Toxicology and Chemistry, 20*(3), 652-659.
[30] Katagi, T. 1993. Photodegradation of esfenvalerate in clay suspensions. *Journal of Agricultural and Food Chemistry, 41*, 2178-2183.
[31] See above.

Table 25. Chemical Structures of Esfenvalerate and Related Compounds

Chemical Name	Structure
Cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate with chiral centers denoted with (*) at the 2C position of the acid and at the alpha C position of the alcohol (Eisler 1992).[1, 4]	
(S)-alpha-cyano-3-phenoxybenzyl (S)-2-(4-chlorophenyl)-3-methylbutyrate (esfenvalerate)[2]	
4-chloro-alpha-(1-methylethyl)-benzeneacetic acid (CPIA)	
4-chloro-beta-(1-methylethyl)-alpha -(3-phenoxyphenyl)-benzenepropane-nitrile (decarboxyfenvalerate)[3]	

[1] Structure obtained from Chemfinder available at http://chemfinder.cambridgesoft.com/ (accessed 1/11/2008)
[2] Structure obtained from IPCSINTOX Databank from the UK National Poisons Information Service Monograph for esfenvalerate available at http://www.intox.org/databank/documents/chemical/esfenval/ukpid63.htm (accessed 1/11/2008).
[3] Structure obtained from TOXNET available at http://toxnet.nlm.nih.gov/index.html (accessed 1/14/2008).
[4] Eisler, R. 1992. *Fenvalerate Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report No 85(2).* United States Fish and Wildlife Service (USFWS). Available at (accessed June 19, 2009): http://www.pwrc.usgs.gov/infobase/eisler/CHR_24_Fenvalerate.pdf.

Table 26. Summary of Physico-Chemical Properties of Esfenvalerate.

Property	Value (Method)	MRID #, Author[1]	Study Status, Date of Memorandum
Empirical Formula	$C_{25}H_{22}ClNO_3$	---	---
Molecular Weight	419.9 g/mol	---	---

Property	Value (Method)	MRID #, Author[1]	Study Status, Date of Memorandum
Melting Point	59.5 – 61.5°C (OECD 102)	467253-05, Comb 2002	Acceptable, 6/1/06
Boiling Point	Not determinable (OECD 103)	467253-03, Comb 2002	Acceptable, 6/1/06
Relative Density	1.13 g/cm^3 at 23°C(OECD 109)[2]	467253-03, Comb 2002	Acceptable, 6/1/06
Vapor Pressure	6.3 x 10^{-5} Pa at 25°C (OECD 109) 6.7 x 10^{-5} Pa	467253-04, Comb 2002 Open Lit., (Jones, 2002[3]), (European Commission, 2005[4])	Acceptable, 6/1/06 Screened
Henry's Law Constant	>1.87 Pa-m^3/mol at 25°C (est.) 1.4 x 10^{-7} Pa-m^3/mol	467253-04, Comb 2002 Open Lit., (Laskowski, 2002[5])	Not Reviewed Screened
Water Solubility	< 0.01 mg/L at 20°C (OECD 105) 0.006 mg/L 0.002 mg/L	467253-03, Comb 2002 Open Lit., (Laskowski, 2002[5]), (European Commission, 2005[4]) Open Lit., (Kelley, 2003[6])	Acceptable, 6/1/06 Screened Screened
Log K_{OW}	>6 (OECD 117) 5.62 - >6 6.24 at 25°C	467253-04, Comb 2002 Open Lit., (Laskowski, 2002[5]) Open Lit., (European Commission, 2005[4])	Acceptable, 6/1/06 Screened Screened

[1] Open literature (lit.) indicates the study was obtained from the open literature and the study was not submitted to the EPA for review.

[2] Memorandum reviewing the product chemistry sent by Indira Gairola to George Larocca on June 1, 2006 indicated that the relative density was slightly lower (1.13) than that reported by (MRID 46725304, 2002).

[3] Jones, R. D. 2002. *Chemical properties of the pyrethroid insecticides to support surface water modeling*. Memorandum From to Environmental Fate and Effects Division. Office of Pesticide Programs. United States Environmental Protection Agency.

[4] European Commission. (2005). *Review Report for the Active Substance Esfenvalerate, European Commission. Directorate-General Heath & Consumer Protection.* Available at (accessed Jun 19, 2009): http://ec.europa.eu/food/plant/protection/evaluation/existactive/list1-15_en.pdf.

[5] Laskowski, D. A. 2002. Physical and chemical properties of pyrethroids. *Reviews of Environmental Contamination and Toxicology*, *174*, 49-170.

[6] Kelley, K. 2003. *Environmental Fate of Esfenvalerate*. Environmental Monitoring Branch. Department of Pesticide Regulation. California Environmental Protection Agency. Available at (accessed June 19, 2009): http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/esfen.pdf.

Metabolism and Abiotic Degradation

Soil: The environmental fate database for esfenvalerate is largely complete, except for an assessment of microbial degradation in water and sediment. The major route of dissipation for esfenvalerate on soil appears to be sorption onto soil and organic matter, with slower microbial degradation (rates generally on the order of months). In some instances, photolysis may occur in shallow water where light is available or on soil before the chemical sorbs to soil.

Water: Esfenvalerate is not expected to remain in the water column because of its high sorption coefficients. Most of it will sorb to organic materials or sediment. Samsoe-Petersen *et al.* (2001)[32] observed 50 percent mineralization of esfenvalerate in pond sediment between 73 and 350 days,

[32] Samsoe-Peterson, L., K., G., Madsen, T., Mogensen, B. B., Lassen, K., Skjernov, K., et al. 2001. Fate and effects of esfenvalerate in agricultural ponds. *Environmental Toxicology and Chemistry*, *20*(7), 1570-1578.

suggesting that esfenvalerate sorbed onto sediment is likely to persist (Samsoe-Peterson *et al.*, 2001[33]).

In a supplemental study, a combined aerobic and anaerobic aquatic metabolism study yielded aerobic aquatic metabolism half-lives of 50.3, 81.2, and 31.7 days for esfenvalerate in a sand, clay and sandy clay loam sediments from California. Under anaerobic aquatic conditions, the half-lives were 94.7, 72.3 and 66.6 days for esfenvalerate in a sand, clay and sandy clay loam sediments, respectively. The study was found to be supplemental since it was conducted using non-radiolabeled material and the water and sediments were extracted together.

Transformation Products

Degradates: The only major aerobic or anaerobic metabolism degradate was carbon dioxide (MRID 146578, 1992; MRID 42396801, 1992). When sunlight is available, photolysis may occur and photolysis degradates include up to 27 % CPIA and 12 % decarboxyfenvalerate (Dynamac Corporation, 1988). Based on the data available, decarboxyfenvalerate is less toxic (rat oral LD_{50} was 67-87 mg/kg for esfenvalerate and >500 mg/kg for decarboxyfenvalerate) and concentrations of decarboxyfenvalerate will be much lower, approximately 87% lower, than the parent compound (Holmstead *et al.*, 1978[34]; Kelley, 2003[35]). No toxicity data were available for CPIA; however, breaking the ester bond is expected to significantly decrease the toxicity of the substance as compared to the parent compound. Additionally, aquatic toxicity data estimated using ECOSAR indicate that CPIA is expected to be much less toxic than esfenvalerate. As the expected toxicity and exposure of the degradates do not exceed that of esfenvalerate, they were not considered to contribute substantially to the toxicity exposure. The SS-isomer may stereoisomerize into the RS and SR-isomers in water. However, application rates are based on the SS-isomer and half-lives used in the exposure estimates are based on breakdown of the combined isomers. Thus, in the aquatic environment, the estimated concentration of the SS-isomer represents the sum of all isomers present or the maximum concentration of the SS-isomer. As the SS-isomer is the most toxic isomer for insects and only limited toxicity data is available for other individual isomers, this may be assumed to be the most protective assumption (Adelsbach and Tjeerdema, 2003[36]; ATSDR, 1993[37]); (Eisler, 1992[38]).

Table 27 summarizes the environmental fate properties of esfenvalerate, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

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[33] See previous reference (above).

[34] Holmstead, R. L., Fullmer, D. G., & Ruzo, L. O. 1978. Pyrethroid photodecomposition: Pyrdrin. *Journal of Agricultural and Food Chemistry*, *26*(4), 954-959.

[35] Kelley, K. 2003. *Environmental Fate of Esfenvalerate*. Environmental Monitoring Branch. Department of Pesticide Regulation. California Environmental Protection Agency. Available at http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/esfen.pdf (Accessed June 19, 2009).

[36] Adelsbach, T. L., & Tjeerdema, R. S. 2003. Chemistry of fenvalerate and esfenvalerate. *Reviews of Environmental Contamination and Toxicology*, *176*, 137-154.

[37] ATSDR. (1993). *Toxicological Profile for Pyrethrins and Pyrethroids, Agency for Toxic Substances and Disease Registry (ATSDR)*. Washington, D.C.: Government Printing Office. Available at http://www.atsdr.cdc.gov/toxprofiles/tp155.html#bookmark08 (Accessed June 19, 2009).

[38] Eisler, R. 1992. *Fenvalerate Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report No 85(2)*. United States Fish and Wildlife Service (USFWS). Available at http://www.pwrc.usgs.gov/infobase/eisler/CHR_24_Fenvalerate.pdf (Accessed June 19, 2009).

Table 27. Summary of Esfenvalerate Environmental Fate Properties.

Study	Value, SS-isomer/All Isomers[1] (units)	Major Degradates Minor Degradates	MRID #, Author[2]	Study Status (Date of Memorandum Referenced)
Hydrolysis	Minimal degradation in 30 days at pH 5, 7, 9, All isomers	Not Applicable	40999303, Lee 1989	Acceptable (3/14/1991)
Direct Aqueous Photolysis	$T_{1/2}$ = 6 days at pH 5, SS-isomer $T_{1/2}$ = 9 days, All isomers	CO_2, CPIA, decarboxyfenvalerate	40443801, Stevenson 1987 40443801, Stevenson 1987	Acceptable (1/5/1988, 7/27/1992) Calculated
Soil Photolysis	Minimal in 30 days, SS-isomer[3] Range from < 1 day in kaolinite to 100 days in a Noichi upland soil, SS-isomer	CO_2, CPIA, decarboxy fenvalerate 3-phenoxybenzyl alcohol, 3-phenoxybenzoic acid, and decarboxy fenvalerate+	41728501 Castle *et al.* 1990 Open Lit., (Katagi, 1991[4]), (Katagi, 1993[5])	Acceptable (3/6/1991) Screened
Aerobic Soil Metabolism	$T_{1/2}$= 75 days in silt loam soil, SS-isomer[3] Reported range of 15 – 546 days in literature with an average of 107 days	CO_2, 4''-chloro-(2'''-isopropyl)phenylaceto-2-(3'-hydroxyphenoxy)phenylacetonitrile, alpha-carbamoyl-3-phenoxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate 3-phenoxybenzoic acid, and 4-(hydroxyphenoxy)benzoic acid	00146578, Lee *et al.* 1985 Open Lit., (Laskowski, 2002[6])	Acceptable (11/29/1994) Screened
Anaerobic Soil Metabolism	$T_{1/2}$ = 77 days in sandy loam, SS-isomer[3] Reported range of 104 - 203 days with an average of 154 days	CO2, 4''-Chloro-(2'''-isopropyl)phenylaceto-2-(3'-hydroxyphenoxy)phenyl acetonitrile, 4''-chloro-(2'''-isopropyl)phenylaceto-2-(3'-phenoxy)phenylacetamide, 3-phenoxybenzoic acid, and 4-(hydroxyphenoxy)benzoic acid	42396801 Gaddamidi *et al.* 1992 Open Lit., (Kelley, 2003[7])	Acceptable (3/30/1993) Screened
Aerobic Aquatic Metabolism	$T_{1/2}$= 17.2 days in water:sand sediment $T_{1/2}$= 48.2 days in water:sandy loam sediment	IN-F4864, 3-PBA, CO_2	**49140401** Allan J. 2013	[4]In Review
	$T_{1/2}$= 50.3 days (IORE), sand 81.2 days (DFOP), clay 31.7 days (DFOP), sandy clay loam	N/A	**48762908**	Supplemental (9/4/2013). Water and sediment were extracted

Study	Value, SS-isomer/All Isomers[1] (units)	Major Degradates Minor Degradates	MRID #, Author[2]	Study Status (Date of Memorandum Referenced)
				together. Non-radiolabeled material was used.
Anaerobic Aquatic Metabolism	$T_{1/2}$= 11.5 days in water:sand sediment $T_{1/2}$= 73.7 days in water:sandy loam sediment	IN-F4864, 3-PBA, CO_2	**49140402** Allan J. 2013	[4]In Review
	$T_{1/2}$= 94.7 days (SFO), sand 72.3 days (SFO), clay 66.6 days (SFO), sandy clay loam	N/A	**48762908**	Supplemental (9/4/2013). Water and sediment were extracted together. Non-radiolabeled material was used.
$K_{d\text{-}ads}$ (mL/g) $K_{OC\text{-}ads}$ / (mL/g) K_{OM} (mL/g)	600, 700, 750, 1,700, 5,200, 15,500 (sandy loam, sandy clay loam, silt loam, loam, loamy sand, silt clay loam) 85,700, 140,000, 141,700, 171,700, 375,000, 596,200 (sandy loam, sandy clay loam, loam, loamy sand, silt loam, silt clay loam) 50,000, 77,800, 85,000, 101,000, 187,500, 352,300 (sandy loam, sandy clay loam, loam, loamy sand, silt loam, silt clay loam)	Not applicable Not applicable Not applicable	45555102 Ohm 2001	
Terrestrial Field Dissipation	$T_{1/2}$ = 14 days in sandy loam/sandy clay loam, Isomer information was not specified	Not reported	41728502 Castle *et al.* 1990 and supplement	Acceptable (7/27/1992)
Aquatic Field Dissipation	Not available	Not available	---	---
Bioconcen-tration Factor	334-3650 Carp, All isomers	Metabolites included glucuronide of 4'-OH-fenvalerate, CPIA, 4'-OH-fenvalerate, and sulfate of 4'-OH-PB acid	42922401 Oshima *et al.* 1993 42170501 Oshima *et al.*	Acceptable (11/29/1994)

Study	Value, SS-isomer/All Isomers[1] (units)	Major Degradates Minor Degradates	MRID #, Author[2]	Study Status (Date of Memorandum Referenced)
			1991	
POTW Treatability Study	Removal percent for esfenvalerate: Primary Settling LR Aerobic Chamber 56.1% Anaerobic Digestion 79.2% Ultrafiltration 93.6%	Not Available	**48762906**	Supplemental; POTW treatability study of eight pyrethroids.

[1] Cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate has four different isomers. All fate studies were conducted using the SS-isomer but the rate data may apply to the SS-isomer or total isomers as the SS-isomer may undergo isomerization. If the SS-isomer is listed the data was specific to the SS-isomer. If all isomers is listed, then the rate data is specific to total isomers.

[2] Open literature (lit.) indicates the study was obtained from the open literature and the study was not submitted to the EPA for review.

[3] Limited information was available on the various isomers in the study. However, the value was reported as specific to esfenvalerate or the SS-isomer.

[4] Katagi, T. 1991. Photodegradation of the pyrethroid insecticide esfenvalerate on soil, clay minerals, and humic acid surfaces. *Journal of Agricultural and Food Chemistry 39*, 1351-1356.

[5] Katagi, T. 1993. Photodegradation of esfenvalerate in clay suspensions. *Journal of Agricultural and Food Chemistry, 41*, 2178-2183.

[6] Laskowski, D. A. 2002. Physical and chemical properties of pyrethroids. *Reviews of Environmental Contamination and Toxicology, 174*, 49-170.

[7] Kelley, K. 2003. *Environmental Fate of Esfenvalerate*. Environmental Monitoring Branch. Department of Pesticide Regulation. California Environmental Protection Agency. Available at (accessed June 19, 2009): http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/esfen.pdf.

Transport, Mobility, Sorption

Potential transport mechanisms include pesticide surface water runoff, spray drift, and secondary drift of soil-bound residues leading to deposition onto nearby or more distant ecosystems. Surface water runoff and spray drift are expected to be the major routes of exposure for esfenvalerate. Because of its high tendency to sorb to soil (as evidenced by high K_d/K_{OC} values reported in **Table 27**), esfenvalerate is expected to reach water bodies primarily sorbed to sediment. With its persistence, esfenvalerate may accumulate in sediment, where it may be a reservoir for exposure for benthic organisms Esfenvalerate is not persistent in the atmosphere and is not expected to move via long range transport processes.

Based on its vapor pressure (approximately 0.063 mPa and estimated Henry's Law constant (greater than 1.87 Pa-m^3/mol), esfenvalerate is not likely to volatize at environmental temperatures (Comb 2002, MRID 467253-04). Esfenvalerate is not expected to persist in air due to its susceptibility to photo-oxidation in air (European Commission, 2005[39]; Comb, 2002, MRID 467253-04). Based on the short half-life, it is not expected to undergo long range transport.

[39] European Commission. (2005). *Review Report for the Active Substance Esfenvalerate, European Commission. Directorate-General Heath & Consumer Protection.* Available at http://ec.europa.eu/food/plant/protection/evaluation/existactive/list1-15_en.pdf (Accessed Jun 19, 2009).

Esfenvalerate is not very soluble (0.002 – <0.01 mg/L) and is hydrophobic (reported log K_{OW}s range from 5.62 to greater than 6.24) (Laskowski 2002[40]; European Commission 2005[41]; Comb 2002, MRID 467253-03). It is likely to sorb onto organic matter or suspended particles in the water column and in sediments (log K_{OC}s range from 4.93 to 5.8 mL/g) (Ohm 2001, MRID 45555102). Based on a leaching study and high K_{OW}s, K_ds, and K_{OM}s, esfenvalerate is unlikely to leach into ground water [Houston, 1978 (Acc. No. 243109); MRID 42350201, 1992; MRID 45555102, 2001].

Terrestrial and Aquatic Field Dissipation Studies

A field soil dissipation study measured a half-life of 7 to 14 days after a single surface application (0.5 lb/acre) to sandy loam to sandy clay loam soil from Madera, CA (Castle *et al.* 1990, MRID 41728502), but may not have accounted for the fraction sorbed to soil. The European Commission (2005) estimated field dissipation half-lives of 62-126 days for a summer application and 68 – 87 days from an autumn application of esfenvalerate to bare sandy silt loam soil. Field dissipation studies measure degradation in the field and allow for many types of dissipation pathways while anaerobic and aerobic degradation are specific to one type of degradation pattern. Many variables could contribute to the different rates measured; however, it is speculated that sunlight and irrigation contributed to the high rate of degradation in the Castle *et al.* (1990, MRID 41728502) study. It is also possible that esfenvalerate sorbed onto soil and organic particles and remained resistant to analytical extraction methods used.

Another field study examined the distribution of esfenvalerate after application directly to a pond. Samsoe-Petersen et al. (2001)[42] sprayed esfenvalerate directly onto a pond (0.022 lb a.i./acre, near the highest recommended field dose in Denmark) and measured concentrations in the surface microlayer, water column, and sediment fractions. Two weeks after application, the highest concentrations were found in sediment (9 µg/kg), with lower concentrations found on the surface microlayer (0.4 µg/L) and in the water column (0.05 µg/L) (Samsoe-Peterson *et al.*, 2001)[43]. Percentages of the total amount applied in each compartment were not provided.

Water Monitoring Data

The Agency found no monitoring data for esfenvalerate in either surface water or ground water in its previous assessments. Esfenvalerate has been removed from the United States Geological Survey (USGS) National Water-Quality Assessment Program (NAWQA) analytical methods because of poor recovery during analysis.

Esfenvalerate was included in surface water and sediment monitoring data obtained from the California Department of Pesticide Regulation (CDPR). Esfenvalerate was detected in 3 of 365 surface water samples (0.8% detections) where the limits of quantification ranged from 0.02 to

[40] Laskowski, D. A. 2002. Physical and chemical properties of pyrethroids. *Reviews of Environmental Contamination and Toxicology, 174*, 49-170.
[41] See reference above.
[42] Samsoe-Peterson, L., K., G., Madsen, T., Mogensen, B. B., Lassen, K., Skjernov, K., et al. 2001. Fate and effects of esfenvalerate in agricultural ponds. *Environmental Toxicology and Chemistry, 20*(7), 1570-1578.
[43] See previous reference.

0.05 µg/L. The detections – 0.06, 0.14, and 0.17 µg/L – all occurred in Stanislaus County in 2003. The two highest detections occurred in tributaries of the San Joaquin River while the lowest detection was found in an irrigation distribution drain. Esfenvalerate was also detected in 21 out of 259 sediment samples (8% detections), with limits of quantification from 0.001 to 0.01 µg/g (ppm). The detections, ranging from 0.002 to 0.07 µg/g, or 20 to 70 ng/g (ppb), were reported in Imperial (2 detects), Monterey (5 detects), Placer (5 detects), and Stanislaus (9 detects) counties between 2003 and 2005.

Weston *et al.* (2004)[44] evaluated sediment samples from the Central Valley of California, with a focus on the pyrethroid insecticides. Esfenvalerate was detected in 32% of 70 sediment samples collected from 10 counties in the Central Valley, with the highest detections ranging from 11 to 30 ng/g (0.01 to 0.03 ppb) in three sampled creeks and sloughs and from 10 to 28 ng/g (0.01 to 0.028 ppb) in three irrigation canals (Weston *et al.*, 2004)[45].

Bioconcentration

Daily bioconcentration factors (BCF) for total isomer residues ranged from 334-3650 in carp (*Cyprinus carpio*) exposed to 0.046 – 0.061 parts per billion esfenvalerate (Oshima *et al.* 1991, MRID 42922401; Oshima *et al.* 1993, MRID 42922401). Approximately 70% of accumulated residues were eliminated during the 14-day depuration period, resulting in an estimated half-life of 7-8 days. The metabolic pathways were oxidation of the 4' position of the alcohol moiety and the 3 position of the acid moiety, cleavage of the ester linkage, and conjugation of the resultant phenol and acid with glucuronic acid or sulfuric acid. The major metabolites were the glucuronide of 4'-OH-fenvalerate, 4'-OH-fenvalerate, sulfate of 4'-OH-PB acid, and CPIA (Oshima *et al.* 1991, MRID 42170501).

When metabolism, growth dilution, and other confounding factors are ignored, bioconcentration factors are expected to increase with increasing log K_{OW}s (for log K_{OW} up to ~ 6) (Bintein *et al.*, 1993[46]; Gobas and Morrison, 2000[47]). Using the relationship published by Mackay between K_{OW} and BCF, results in a predicted BCF of 48000 or log BCF of 4.68 for esfenvalerate (Gobas and Morrison, 2000)[48]. This indicates that esfenvalerate has a high potential to bioconcentrate in organisms. However, measured BCFs for carp are much lower than predicted and significant bioconcentration is not expected to occur in organisms that readily metabolize pyrethroids, such as mammals and birds. Mammals and birds tend to metabolize pyrethroids while insects are more susceptible to toxicity and bioconcentration because of less developed metabolic systems (Eisler, 1992[49]). The ability of fish to metabolize pyrethroids varies. For example, carp

[44] Weston, D. P., You, J., & Lydy, M. J. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. *Environmental Science and Technology, 38*, 2752-2759.
[45] See previous reference.
[46] Bintein, S., Devillers, J., & Karcher, W. 1993. Nonlinear dependence of fish bioconcentration on n-Octanol/water partition coefficients. *SAR and QSAR in Env. Res, 1*, 29-39.
[47] Gobas, F. A. P. C., & Morrison, H. A. 2000. Bioconcentration and Biomagnification in the Aquatic Environment. In S. R. Boethling & D. Mackay (Eds.), *Handbook of Property Estimation Methods for Chemicals* (pp. 189-227). Boca Raton: Lewis Publishers.
[48] See reference above.
[49] Eisler, R. 1992. *Fenvalerate Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report No 85(2).* United States Fish and Wildlife Service (USFWS). Available at

are known to have a well-developed esterase metabolism that will metabolize esfenvalerate, thus reducing its bioconcentration and toxicity (Adelsbach and Tjeerdema, 2003[50]). On the other hand, rainbow trout are known to have decreased rates of metabolism and low rates of esterase activity for pyrethroids; they are more susceptible to toxicity and bioconcentration of esfenvalerate (Adelsbach and Tjeerdema, 2003[51]). Amphibians in later developmental stages may have a more developed metabolic system than their younger counterparts and amphibians in developmental stages can be more susceptible to xenobiotic toxicity (Greulich and Pflugmacher, 2003[52]).

In a POTW treatability study, esfenvalerate showed limited removal upon primary settling, and around 56% removal in the aerobic chamber. In the anaerobic digester 79% of the parent compound was removed. Under ultrafiltration, nearly 93.6% of the esfenvalerate was removed.

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http://www.pwrc.usgs.gov/infobase/eisler/CHR_24_Fenvalerate.pdf (Accessed June 19, 2009).

[50] Adelsbach, T. L., & Tjeerdema, R. S. 2003. Chemistry of fenvalerate and esfenvalerate. *Reviews of Environmental Contamination and Toxicology, 176*, 137-154.

[51] See previous reference.

[52] Greulich, K., & Pflugmacher, S. 2003. Differences in susceptibility of various life stages of amphibians to pesticide exposure. *Aquatic Toxicology, 65*, 329-336.

Lambda- and *Gamma*-cyhalothrin

An environmental fate assessment was provided in the Problem Formulation (DP Barcode D379543, dated November 22, 2010). Additionally, in late 2012, an endangered species assessment for a number of California species was issued[53]. The environmental fate assessment is being updated here with newly submitted studies.

Physical and Chemical Properties

Lambda-cyhalothrin (**Table 28**) is a synthetic pyrethroid insecticide. Its structure has three rings, two phenyl rings attached to each other by an oxygen atom (phenyl and phenoxy), and a cyclopropyl ring. It is a Type II synthetic pyrethroid (it is cyano-substituted in the *alpha* position). The chemistry of cyhalothrin may be dictated by its ester moiety. It would be expected to hydrolyze as the pH increases; this is confirmed from the hydrolysis studies, where *lambda*-cyhalothrin and *gamma*-cyhalothrin were stable at pH 5, nearly stable at pH 7 and hydrolyzed at pH 9. The structure of the molecule has three chiral centers and a double bond which raise the number of possible isomers to $2^4 = 16$. However, *lambda*-cyhalothrin consists only of two of these isomers.

Lambda-cyhalothrin has a 2-chloro-3,3,3-trifluoropropenyl group and it is 2,2-dimethyl substituted in the cyclopropane ring. Chemically, it is the (S)-alcohol (*Z*)-(1R)-*cis* acid and the (R)-alcohol (*Z*)-(1S)-*cis* acid out of 16 isomeric esters. *Gamma*-cyhalothrin is a single isomer out of 16 possibilities of its structure, and one of the two isomers in *lambda*-cyhalothrin. Chemically, it is the (S)-alcohol (*Z*)-(1R)-*cis* acid out of 16 isomeric esters (**Table 28**).

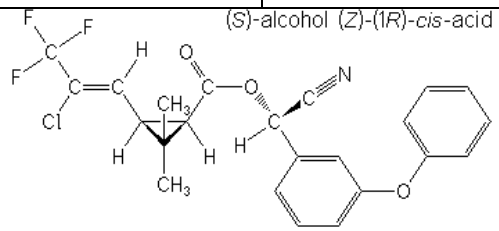
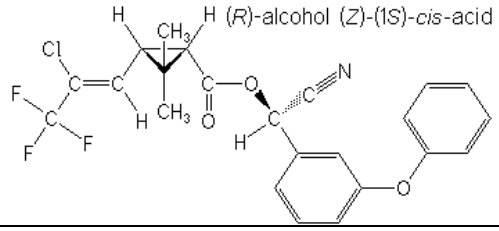
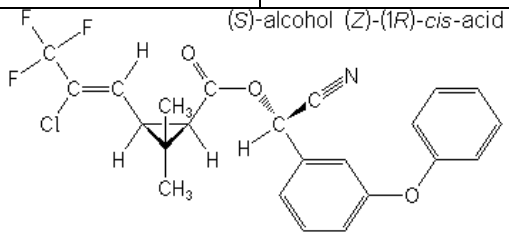
In addition, cyhalothrin (not *lambda*- nor *gamma*-cyhalothrin) consists of four of the 16 possible isomers in its structure, of which two of them are present in *lambda*-cyhalothrin and one is present in *gamma*-cyhalothrin (**Table 29**). Cyhalothrin is not a registered pesticide in the U.S.

In general, the physicochemical and environmental fate properties of cyhalothrin, *lambda*-cyhalothrin and *gamma*-cyhalothrin may be expected to be similar to each other. Information about the identification of *lambda*-cyhalothrin and *gamma*-cyhalothrin is provided in **Table 28**. A summary of physicochemical properties of *lambda*-cyhalothrin and *gamma*-cyhalothrin is included in **Table 29**.

Table 28. Identification information for *lambda*-cyhalothrin and *gamma*-cyhalothrin

CHEMICAL	*LAMBDA*-CYHALOTHRIN		*GAMMA*-CYHALOTHRIN	
PARAMETER	**VALUE(S) (units)**	**SOURCE**	**VALUE(S) (units)**	**SOURCE**
CAS Chemical Name	(*R*)-cyano(3-phenoxyphenyl)methyl (1*S*,3*S*)-*rel*-3-[(1*Z*)-2-chloro-3,3,3-trifluoro-1-propenyl]-2,2-dimethylcyclopropanecarboxylate	*Lambda*-cyhalothrin data sheet	(*S*)-cyano(3-phenoxyphenyl)methyl (1*R*,3*R*)-3-[(1*Z*)-2-chloro-3,3,3-trifluoro-1-propenyl]-2,2-dimethylcyclopropanecarboxylate	*Gamma*-cyhalothrin data sheet
PC Code	128897	OPP Databases	128807	OPP Databases

[53] Available at http://www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html (accessed 06/16/2015).

CHEMICAL	*LAMBDA*-CYHALOTHRIN		*GAMMA*-CYHALOTHRIN	
PARAMETER	**VALUE(S) (units)**	**SOURCE**	**VALUE(S) (units)**	**SOURCE**
Case Number	7408	OPP Databases	7437	OPP Databases
IUPAC Chemical Name	reaction product comprising equal quantities of: (*R*)-α-cyano-3-phenoxybenzyl (1*S*,3*S*)-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate **or of** (*R*)-α-cyano-3-phenoxybenzyl (1*S*)-*cis*-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-3-phenoxybenzyl (1*R*)-*cis*-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate	*Lambda*-cyhalothrin data sheet	(*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate **or** (*S*)-α-cyano-3-phenoxybenzyl (1*R*)-*cis*-3-[(*Z*)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate	*Gamma*-cyhalothrin data sheet
CAS Reg. No.	91465-08-6	*Lambda*-cyhalothrin data sheet	76703-62-3	*Gamma*-cyhalothrin data sheet
Chemical Structure (from chemical's data sheet)	 			

Lambda-cyhalothrin data sheet accessed 08/28/15: http://www.alanwood.net/pesticides/*lambda*-cyhalothrin.html .
Gamma-cyhalothrin data sheet accessed 08/28/15: http://www.alanwood.net/pesticides/*gamma*-cyhalothrin.html

Table 29. Summary of physicochemical properties of *lambda*-cyhalothrin and *gamma*-cyhalothrin

PARAMETER	VALUE(s) units (chemical name)	SOURCES
CAS Reg. No.	68085-85-8 (cyhalothrin) 91465-08-6 (*lambda*-cyhalothrin) 76703-62-3 (*gamma*-cyhalothrin)	TOXNET/ HSDB[1] *Lambda*- and *gamma*-cyhalothrin data sheets
Composition	**Cyhalothrin** / ***Lambda*-cyhal** / ***Gamma*-cyhal** 60:40 A:B / 1:1 enantiomers of pair B / Only S-alcohol (*Z*)-(1R)-*cis* acid where, (1R,3R,alphaR) and (1S,3S,alphaS) is known as pair A (1R,3R,alphaS) and (1S,3S,alphaR) is known as pair B	Laskowski, 2002[2] & *lambda*- and *gamma*-cyhalothrin data sheets

PARAMETER	VALUE(s) units (chemical name)	SOURCES
	Alternative nomenclature for Pair B is also (S)-alcohol (*Z*)-(1R)-*cis* acid and (R)-alcohol (*Z*)-(1S)-*cis* acid	
Molecular Formula	$C_{23}H_{19}ClF_3NO_3$ (cyhalothrin, *lambda*-cyhalothrin and *gamma*-cyhalothrin)	*Lambda*-cyhalothrin and *gamma*-cyhalothrin's data sheets
Molecular Weight	449.86 (cyhalothrin, *lambda*-cyhalothrin and *gamma*-cyhalothrin)	TOXNET/ HSDB
Melting Point	Below 10ºC (cyhalothrin) 49.2ºC (*lambda*-cyhalothrin)	TOXNET/ HSDB & EXTOXNET[3] NPIC[4]
Boiling Point	187-190°C @ 0.2 mmHg; decomposes at 275°C (cyhalothrin)	TOXNET/ HSDB
Solubility in Organic Solvents	In acetone, dichloromethane, methanol, diethyl ether, ethyl acetate, hexane, toluene, all >500 g/l at 20°C (cyhalothrin)	TOXNET/ HSDB
Solubility in Water	5.0×10^{-3} mg/L or 5.0 ppb, temp not spec. (cyhalothrin) 5×10^{-3} mg/L @ pH 6.5 and 20°C (*lambda*-cyhalothrin) 5.00×10^{-3} mg/L or 5.00 ppb @ 20°C (*lambda*-cyhalothrin) 0.0021 ppm or 2.1 ppb at 20ºC (*gamma*-cyhalothrin) 'Not Soluble'	TOXNET/ HSDB EXTOXNET & 00151580 Laskowski 2002, MRID 45794902 FAO, 2000[5]
Vapor Pressure	7.5×10^{-9} mm Hg at 25°C (cyhalothrin) 1.56×10^{-9} mmHg at 20°C (*lambda*-cyhalothrin) 2.60×10^{-9} mmHg at 25ºC (*gamma*-cyhalothrin) 7.73×10^{-10} mmHg at 20ºC (*gamma*-cyhalothrin) 'Non-volatile under field conditions' ($\leq 9.98 \times 10^{-7}$ mmHg)	TOXNET/ HSDB Laskowski 2002 MRID 45794902 USEPA, 2008
Henry's Law Constant	1.5×10^{-6} atm-m^3/mol (cyhalothrin) 1.9×10^{-7} atm-m^3/mol at 20ºC (*lambda*-cyhalothrin) 2.18×10^{-7} atm-m^3/mol at 20ºC (*gamma*-cyhalothrin)	TOXNET/ HSDB Laskowski, 2002 MRID 45794901
Octanol-Water Partition Coefficient K_{OW} (log K_{OW})	6.3×10^6 (6.8) (temp. not specified) (cyhalothrin) 1.00×10^7 (7.00) (temp. not spec.) (*lambda*-cyhalothrin) 90698 (4.96) at 19ºC (*gamma*-cyhalothrin)	TOXNET/ HSDB Laskowski, 2002 MRID 45794902
Octanol-Air Partition Coefficient K_{OA} (log K_{OA})	$K_{OA} = \frac{K_{OW}}{K_{AW}} = \frac{K_{OW}RT}{\text{Henry's Law Constant}}$ 1.3×10^{12} (12.1) (*lambda*-cyhalothrin) 1.0×10^{10} (10.0) (*gamma*-cyhalothrin) $1.282 \times 10^{10} - 1.043 \times 10^{11}$ (10.108-11.018) (*lambda*-cyhalothrin); EPIWEB estimate	Calculated Values EPIWEB v.4.0 Estimate
K_{AW} (log K_{AW})	$K_{AW} = C_{air}/C_{water} = HLC/RT$ 7.9×10^{-6} (-5.1) (*lambda*-cyhalothrin) 9.0×10^{-6} (-5.0) (*gamma*-cyhalothrin) 6.05×10^{-5} (-4.22) (*lambda*-cyhalothrin); EPIWEB v. 4.0 estimate 'Non-volatile'	Calculated Values EPIWEB v.4.0 USEPA, 2008
C_{water}/C_{air}	$\frac{C_{water}}{C_{air}} = \left(\frac{S \times T \times R \times 760}{P \times GMW \times 10^6}\right) = RT/HLC$ 130,000 (unitless) (*lambda*-cyhalothrin) 110,000 (unitless) (*gamma*-cyhalothrin) 'Non-volatile'	Calculated USEPA, 2008
OH Radical Reaction Half-life	0.340 days (*lambda*-cyhalothrin) (Assumptions: 12-hr days; 1.5×10^6 OH/cm^3)	EPIWEB v.4.0 Estimate
Biomagnification Potential	Presumption: If log K_{OA} > 5, log K_{OW} > 2 and the rate of chemical transformation is low, the chemical may biomagnify in terrestrial food chains** For *lambda*-cyhalothrin and *gamma*-cyhalothrin, log K_{OA}> 5, log K_{OW}> 2 and rate of transformation is moderate in the environment, and it appears to moderate in fish, with very high bioconcentration factors (4,600x) and moderate to slow depuration (~9 days, based on a bioaccumulation in	**Gobas *et al.* 2003[6] and Armitage & Gobas, 2007[7] support this presumption utilized here only as a broad reference to determine the potential for biomagnification.

PARAMETER	VALUE(s) units (chemical name)	SOURCES
	fish study conducted with cyhalothrin); it appears that *lambda*-cyhalothrin and *gamma*-cyhalothrin *may have some potential to biomagnify* in terrestrial food chains under certain circumstances.	

1 http://toxnet.nlm.nih.gov/ (data for cyhalothrin, accessed 05/24/10).
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
3 EXTension TOXicology NETwork at http://extoxnet.orst.edu/pips/lambdacy.htm (accessed 05/24/10).
4 National Pesticide Information Center at http://npic.orst.edu/npicfact.htm (accessed 05/24/10).
5 Food and Agriculture Organization of the United Nations. FAO PESTICIDE DISPOSAL SERIES 8. Assessing Soil Contamination: A Reference Manual. Appendix 2. Parameters of pesticides that influence processes in the soil. Editorial Group, FAO Information Division: Rome, 2000. http://www.fao.org/DOCREP/003/X2570E/X2570E00.htm.
6 Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.
7 Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

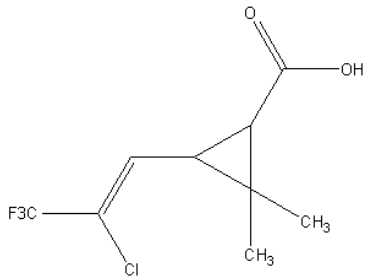
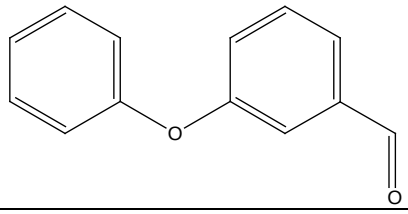
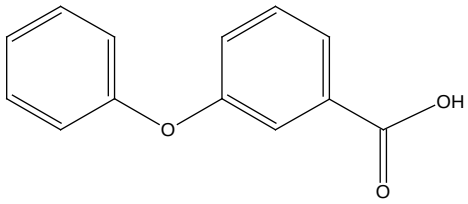
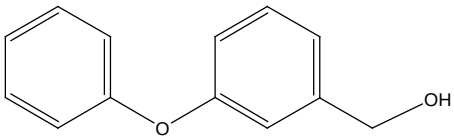
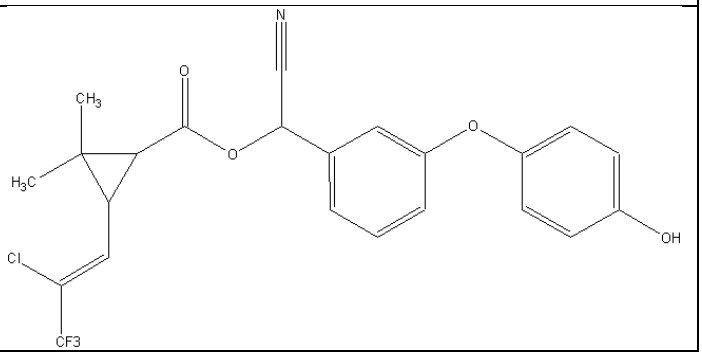
Cyhalothrin, *lambda*-cyhalothrin and *gamma*-cyhalothrin have a high molecular weight of 449.9 g/mol. They also have a small solubility (only 2-5 ppb) and a high octanol/ water partition coefficient (log K_{OW} = 5.0 to 7.0). Based on their octanol/ water partition coefficient, it appears that *lambda*- and *gamma*-cyhalothrin have the potential to bioaccumulate/ bioconcentrate ($K_{OW} \geq$ 1000) in fish and other aquatic organisms. With a vapor pressure of ~10^{-9} mmHg, they are considered "non-volatile under field conditions." Their calculated Henry's Law Constant is low (~10^{-7} atm-m^3/mol). In addition, their C_{water}/C_{air} is ≥110,000, which classify them as "non-volatile" (USEPA 2008). Thus, *lambda*-cyhalothrin and *gamma*-cyhalothrin do not have a potential to volatilize from dry or wet surfaces. The potential to volatilize may be further attenuated in the environment by their tendency to bind to organic matter (*e.g.*, soils, sediments, or organic matter and particulate in natural water).

Lambda-cyhalothrin was found to be highly bioaccumulative (4,600x in the whole body), and its depuration rate is considered moderately slow (half-depuration time of around 9 days). It is noted that its predicted depuration rate based on K_{OW} alone would be much longer (*i.e.*, 30 to > 300 days), thus suggesting that biotransformation processes may be contributing to its faster depuration. Biotransformation in biota is typical for synthetic pyrethroids. For *lambda*-cyhalothrin and *gamma*-cyhalothrin, the log K_{OA} is in the range of 10-12 (calculated and EPIWEB v.4.0 estimates), the log K_{OW} is ~5-7 and the rate of transformation is moderate in the environment and in fish, with high bioconcentration factors and a moderately slow rate of depuration, it appears that *lambda*-cyhalothrin and *gamma*-cyhalothrin may have *some potential to biomagnify* in terrestrial food chains under certain circumstances (*i.e.*, if biotransformation rates are sufficiently slow), based on the presumption made by Gobas *et al.* and Armitage & Gobas, in 2003 and 2007 articles, respectively, as they relate to poorly metabolized chemicals. Even though EFED has not adopted an official reference or guideline to distinguish chemicals that biomagnify, Gobas *et al.* and Armitage & Gobas' presumption was utilized here as a general or broad reference to detect the potential for biomagnification in terrestrial food chains for these chemicals.

Transformation Products

Even though various degradates were observed in the laboratory studies (*e.g.* Compound Ia and Compound V), it was found that the majority were the result of the rupture of the ester bond of the parent molecule. It has been believed that the resulting molecules are not as toxic as the parent because they presumably have lost the neurotoxic mode of action. **Table 30** shows the chemical structures of cyhalothrin's major degradation products. At this time, it appears that only Compound XV may be considered a stressor of concern in the forthcoming environmental fate and ecological risk assessment.

Table 30. Major Transformation Products of *Lambda*-cyhalothrin & *Gamma*-cyhalothrin

Common Name	Chemical Name	Structure
Compounds Ia and Ib	**Ia**: (1*RS*)-*cis*-3-(*ZE*)-2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclopropanecarboxylic acid, and **Ib**: (1*RS*)-*trans*-3-(*ZE*)-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylic acid	
Compound IV	3-Phenoxybenzaldehyde	
Compound V	3-Phenoxybenzoic acid	
Compound VI	3-Phenoxybenzenemethanol	
Compound XV	1α(S*),3α(*Z*)-(±)-cyano-[3-(4'-hydroxyphenoxy)phenylmethyl]-3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclo-propanecarboxylate	

Cyhalothrin (PP563) is a racemic mixture that consists of four isomers (1R,*cis*,*Z*-S'; 1S,*cis*,*Z*-R'; 1R,*cis*,*Z*-R'; and 1S,*cis*,*Z*-S'); while *lambda*-cyhalothrin (PP321) is a racemic mixture that consist of two of the isomers present in cyhalothrin (1R,*cis*,*Z*-S' and 1S,*cis*,*Z*-R'). Greater than 98% of *gamma*-cyhalothrin (XDE-225 or XR-225) is the biologically active enantiomer (1R,*cis*,*Z*-S'). **Table 31** summarizes the environmental fate/transport properties of *lambda*-cyhalothrin and *gamma*-cyhalothrin. For information about the physicochemical properties of these compounds, refer to **Table 29**.

Table 31. Summary of environmental fate parameters for *lambda*- and *gamma*-cyhalothrin

	***Lambda*-cyhalothrin**		***Gamma*-cyhalothrin**	
Parameters	**Value**	**Source**	**Value**	**Source**
Hydrolysis $T_{1/2}$	pH 5 stable pH 7 stable pH 9 13 days	00151604 (S) Rate exceeded the limit of solubility.	pH 5 stable **pH 7 relatively stable** pH 9 2.5 days* Natural river water 26.8 days*	45447409 (pH 5, 7, A) (pH 9, U, upgradable) *River water and pH 9 $T_{1/2}$ values are of high uncertainty.
Aqueous Photolysis (pH 5) $T_{1/2}$	Reviewer calculated linear half-lives: 29.5 days* (phenyl label) 36.9 days* (cyclopropyl)	44861501 (U) *Half-lives are uncertain. Test substance did not remain in solution throughout the study.	8.2 days (cyclopropyl) 8.3 days (phenoxy label) 8.6 days (combined lab) **13 days** (environmental phototransformation $T_{1/2}$)	46394702 (A)
Soil Photolysis $T_{1/2}$	**Fairly stable** loam, only 13-16% degraded after *ca.* 35 days. Compound II was a minor product.	40052405 (A)	Not Available	Not Available
Aerobic Soil Metabolism $T_{1/2}$	**$T_{1/2}$ 46.2 days** sandy loam Reported DT_{50} 31, 55, 26 days sandy loam 102 days loamy sand *12.2 days loam 14.5 days silt loam (CS formulation Warrior T; purity 11.8% a.i.) **[****For cypermethrin: 24 days clay loam, 73 d. loamy coarse sand, 42 days fen peat]	00151607 & 44861504 (A) **[**For cyhalothrin: DT_{50} 26, 48 days SL 83 days loamy sand**]** *45447410 (S) **[****00089995 (A) Cypermethrin tested to provide info on alcohol moiety]	**28.2 days** sandy loam **36.9 days** silt loam *32.5 days loam 51.5 days silt loam (CS formulation GF-231; purity 14.8% a.i.)	45447411 (S) **[+**For cyhalothrin: **46.8 days** sandy loam **60.5 days** - silt loam**]** *45447410 (S)
Anaerobic Soil Metabolism $T_{1/2}$	Aerobic 30 days, then flooded, **$T_{1/2}$ = 30 days** sandy loam cyhalothrin; flooded DT_{50} **110 days** for cyhalothrin; **107 days** for *lambda*-cyhalothrin; **59 days** for *lambda*-cyhalothrin in silty clay loam; **148 days** for *lambda*-cyhalothrin in clay loam soil.	00151607 & 44861504 (A) 49540102 (S)	Not Available	Not Available

Parameters	*Lambda*-cyhalothrin		*Gamma*-cyhalothrin	
	Value	**Source**	**Value**	**Source**
Aerobic aquatic metabolism $T_{1/2}$	**21.1 days** sand **34.1 days** sandy loam **52.9 days** loam (123.8 days silty clay – $T_{1/2}$ is of limited value) 82.2 days sand 60.4 days clay 25.9 days sandy clay loam	44861506 (A) 44367402 (S) **48762908** (S) Water and sediment were extracted together.	Silty clay sediment: **40.1 days** - total system 41.0 days - in sediment <3 days - water column (Extrapolated values) 38.6 days sand 55.9 days clay 29.9 days sandy clay loam	45447412 (S) **48762908** (S) Water and sediment were extracted together.
Anaerobic aquatic metabolism $T_{1/2}$	**142 days** silty clay; **6320 days** loamy sand and **57.7 days** silt loam. 146 days sand 92.8 days clay 62.4 days sandy clay loam	44367401 (S) 49540101 (S) **48762908** (S) Water and sediment were extracted together.	123 days sand 101 days clay 72.8 days sandy clay loam	**48762908** (S) Water and sediment were extracted together.
Soil Partition Coefficient (K_d in mL/g) Mean K_d (*lambda*-cyhalothrin) = 4,350 mL/g Mean K_d (*gamma*-cyhalothrin) = 622 mL/g	Sandy Loam 3810 Loamy Sand 1970 Silty Clay Loam 5880 Loamy Sand 2100 Silty Clay Loam 4490 Sandy Loam 6890 Sandy Loam 7610 Loamy Sand 3470 Sand 2400 Sandy Loam 4870	44861503 (A)	Loamy Sand 672, Sandy Loam 751, Silty Loam 826, Sandy Loam 239 ---------- Loamy Sand 555, Sandy Loam 601, Silty Loam 630, Sandy Loam 355	45447413 (S) ---------- These values are for cyhalothrin, which was tested concurrently with *gamma*-cyhalothrin.
Soil Partition Coefficient (K_{OC} in mL/g_{OC}) Mean K_{OC} (*lambda*-cyhalothrin) = 333,200 mL/g_{OC} Mean K_{OC} (*gamma*-cyhalothrin) = 59,700 mL/g_{OC}	Sandy Loam 346,000 Loamy Sand 200,000 Silty Clay Loam 298,000 Loamy Sand 724,000 Silty Clay Loam 209,000 Sandy Loam 270,000 Sandy Loam 305,000 Loamy Sand 352,000 Sand 518,000 Sandy Loam 110,000	44861503 (A)	Loamy Sand 34133, Sandy Loam 92692, Silty Loam 69952, Sandy Loam 41932 ---------- Loamy Sand 28176, Sandy Loam 74212, Silty Loam 53345, Sandy Loam 62242	45447413 (S) ---------- These values are for cyhalothrin, which was tested concurrently with *gamma*-cyhalothrin. Mean = 54,500
Aged Adsorption/ Desorption	In aged batch equilibrium study (up to 8 weeks of incubation in darkness at 4 and 20°C, sandy loam), ≥97.6% of the applied radioactivity remained adsorbed after 24 hr of equilibration. However, it was >80% for soil incubated under ambient light and subject to wet/ dry cycles.	44861509 (S)	Not Available	Not Available
Column Leaching	The aged (30 days) residues of cyhalothrin and *lambda*-cyhalothrin were immobile in two soil columns (loamy sand and sandy loam). All residues were wthin the upper 0-5 cm soil depth.	00151608 (A, partial)	Not Available	Not Available

Parameters	*Lambda*-cyhalothrin		*Gamma*-cyhalothrin	
	Value	**Source**	**Value**	**Source**
Terrestrial Field Dissipation $T_{1/2}$	IL Clay Loam 33 days (~18-21% AR remained at 279 days) MS Silty Loam 12 days In IL & MS most of the AR in the 0-5 & 5-10 cm depth (1 lb/gal EC ^{14}C-PP321, 2 labels).	40052407 (A)	MS Silty Loam 15.6 days CA Loam 29.5 days All residues in the 0-15 cm soil depth. GF-231 CS; 14.8% a.i.	45794902 (A)
Aquatic Field Dissipation $T_{1/2}$	MS (rice) 0.4-1.8 days CA (rice) 1.0-1.8 days ($T_{1/2}$ from water, no data on soil/ sediment)	44367403 (S) 44367404 (S) Artificial pond	Not Available	Not Available
Dissipation in Aquatic Microcosm $T_{1/2}$	17 hours water layer, 34 hours total system	44861508 (S) (water pH 9.83)	Not Available	Not Available
Bioaccumulation in Fish	Cyhalothrin: **4600x** whole fish (carp); DT_{50} **~9 days** depuration. 77-79% of the radioactivity eliminated after 28 days. ~50-70% of the residues were cyhalothrin and ~10-19% was Compound Ia. Cypermethrin: Benzyl label: 111x edible; 468x whole fish; 579X non-edible; 83-87% depurate after 21 days. DT_{50} ~1.2 days for depuration. mPBacid was ~7% in edible tissue.	00152744, 00152745 (A) 42868203 (A) [Cypermethrin: provided information about the alcohol moiety]	Not Available	Not Available
POTW Treatability Study	Removal percent for *lambda*-cyhalothrin: Primary Settling LR Aerobic Chamber 48.6% Anaerobic Digestion 57.0% Ultrafiltration 93.1%	**48762906** Supplemental; POTW treatability study of eight pyrethroids.	Not available	Not available

Lambda-cyhalothrin and *gamma*-cyhalothrin are Type II synthetic pyrethroids (they are cyano substituted in the *alpha*-position). They have a 2-chloro-3,3,3-trifluoropropenyl group and they are 2,2-dimethyl substituted in the cyclopropane ring. The environmental fate database for *lambda*-cyhalothrin is substantially complete, but it contains various supplemental studies. The database for *gamma*-cyhalothrin is smaller and it consists mostly of supplemental studies, but it was largely supplemented with data from *lambda*-cyhalothrin. All studies on *gamma*-cyhalothrin were considered supplemental, except for the terrestrial field dissipation study. Both *lambda*-cyhalothrin and *gamma*-cyhalothrin show very low solubilities (≤5.0 ppb). They are hydrophobic compounds and their octanol/ water partition coefficients are high (log $K_{OW} \geq 4.96$). Based on their octanol/water partition coefficient, they would be predicted to be hightly bioaccumulative (which appears to be confirmed by the bioaccumulation in fish study, see further details below). Volatilization from moist or dry surfaces is not expected to be an important transport process, since both chemicals have relatively low vapor pressures and Henry's Law constants. Furthermore, *lambda*-cyhalothrin and *gamma*-cyhalothrin readily bind to soils or partition with suspended matter and sediment. Thus, potential volatilization would be greatly reduced.

Based on a combination of data for *lambda*-cyhalothrin and *gamma*-cyhalothrin, it is

concluded that they are moderately persistent in the environment and degrade slowly through a combination of biotic and abiotic mechanisms. *Lambda*-cyhalohrin and *gamma*-cyhalothrin are stable to relatively stable in acidic and neutral water, but hydrolyze in a matter of several days to weeks under alkaline conditions (half-life 13 days for *lambda*-cyhalothrin at pH 9). *Lambda*-cyhalothrin and *gamma*-cyhalothrin are more stable to light than the first or second generation pyrethroids like, for example, allethrin and resmethrin, but still undergo some photolysis in water, with half-lives of several weeks in water (half-life 13 environmental days for *gamma*-cyhalothrin). It appears that the *alpha*-cyano group stabilizes somewhat the molecules and they do not undergo photolysis readily. On soil, *lambda*-cyhalothrin is fairly stable (with very little degradation on the order of only ~13% in 35 days). Under both aerobic and anaerobic soil metabolism conditions, cyhalothrin, *lambda*-cyhalothrin and *gamma*-cyhalothrin biodegrade at moderate rates, with comparable half-lives of several weeks. Various aerobic soil studies available with all three test substances, which included even additional capsule suspension formulated studies, corroborate that the rates of aerobic transformation is similar for these chemicals (range of aerobic soil half-lives is 28.2-60.5 days out of five studies). In aquatic metabolism conditions, *lambda*-cyhalothrin and *gamma*-cyhalothrin may biodegrade at moderate rates under aerobic condition, with half-lives on the order of about 21-53 days (aerobic, both chemicals), but more slowly under anaerobic condition, with half-life of 57.7 to 6320 days (*lambda*-cyhalothrin only). Terrestrial field dissipation studies confirm the results observed in the laboratory, indicating that a combination of biotic and abiotic mechanisms of dissipation take place. Half-lives of 12-33 days were observed in the field for both *lambda*-cyhalothrin and *gamma*-cyhalothrin, with the majority of the residues remaining in the uppermost soil layer. Due to their low mobility observed in laboratory studies and in the field, both chemicals are expected to have little mobility on soil surfaces and, therefore, leaching into groundwater is not expected to be an important environmental fate process. However, despite the protective imposed buffer zone and vegetated buffer strip, they could reach adjacent surface waters via spray drift or runoff events accompanied by erosion. In aquatic environments, these chemicals will partition with the sediment and will linger for long periods of time (several months). The sediments could serve as repositories of *lambda*-cyhalothrin and *gamma*-cyhalothrin in dynamic equilibrium with the pore water and with the surface water, occurring after numerous applications. *Lambda*-cyhalothrin and *gamma*-cyhalothrin are highly bioaccumulative (~4,600x), based on a study performed with cyhalothrin, and they depurate at moderately slow rates (~9 days). There is the potential for bioaccumulation and biomagnification to take place. Willis and McDowell (1987) indicate that for synthetic pyrethroids with similar structure to that of *lambda*-cyhalothrin and *gamma*-cyhalothrin, dissipation from plant foliage occurs with half-lives on the order of 5-6 days, but it may be higher for the total residues. A low rate of volatilization was observed from leaves (88% of applied remaining on the leaves after 24 hours).[54] The chemical does not translocate in the plant tissue.

Abiotic Degradation

Both, *lambda*-cyhalothrin and *gamma*-cyhalothrin have an ester moiety that is expected to be susceptible to hydrolysis (particularly at high pHs). This behavior is confirmed in the hydrolysis studies, where both *lambda*-cyhalothrin and *gamma*-cyhalothrin are fairly stable in pH 5 and pH 7 buffered solutions. In pH 9 solution, *lambda*-cyhalothrin degraded with a half-life of 13 days

[54] European Commission Review Report for the Active Substance Lambda-Cyhalothrin, 7572/VI/97-final; Jan 25, 2001

(however, the pH 9 part of the study conducted with *gamma*-cyhalothrin was considered highly uncertain, and the study conducted with *lambda*-cyhalothrin was conducted at a rate that exceeded the solubility limit). (1*RS*)-*cis*-3(*ZE*)-2-chloro-3,3,3-trifluro-1-propenyl)-2,2-dimethylcylo-propanecarboxylate (Compound Ia, maximum 68% AR at 30 days) was the major metabolite observed in the *lambda*-cyhalothrin study. Even though there is a reported half-life for *gamma*-cyhalothrin at pH 9, it was not considered in this assessment; however, in the study, two major metabolites were observed. For *gamma*-cyhalothrin, at pH 9, the major early degradate observed was 3-phenoxybenzaldehyde (Compound IV, maximum 55.6% AR at 2 days), followed by subsequent oxidation into 3-phenoxybenzoid acid (Compound V or 3-PBA, maximum 54.6% AR at 30 days).

Upon aqueous photolysis (pH 5), *gamma*-cyhalothrin showed a half-life of 13 environmental days. This half-life was considered representative for both chemicals. The half-life of 30-37 days observed in the study conducted with *lambda*-cyhalothrin was not considered accurate because there was evidence of precipitation in the study. Aquatic photolysis appears to be a moderate route of dissipation for these chemicals when compared to other soil, sediment, and water half-lives. In the new chemical review of *gamma*-cyhalothrin, and considering the registrant's bridging plan, the aqueous photolysis study was not requested, since aqueous photolysis is not expected to be enantioselective (although it was submitted and found acceptable). For the assessment it was assumed that the *gamma*-cyhalothrin photodegradation rate is comparable to that of *lambda*-cyhalothrin. It is worth noting that for aqueous photolysis, the relative contribution of this route of degradation in surface water modeling and the environment is not expected to be significant. *Lambda*-cyhalothrin and *gamma*-cyhalothrin's high soil binding affinity and the limited light penetration into most water bodies greatly reduce the potential for aqueous photodegradation. Nonetheless, both studies coincided with respect to the identity of the metabolites. Compounds Ia and Ib were a maximum of 13.7 and 7.1% AR, respectively in the study with *lambda*-cyhalothrin. Unspecified compounds Ia and Ib were a maximum of 45.0% AR in the study with *gamma*-cyhalothrin. The other metabolite identified was Compound V, which was a maximum of 25.0-42.0% AR (both chemicals).

Upon soil photodegradation, *lambda*-cyhalothrin appeared to be persistent through the testing period. Only 13-16% of the applied *lambda*-cyhalothrin degraded after *ca.* 35 days. Compound V was a minor product in the study. *Gamma*-cyhalothrin is expected to show a similar photolytic behavior on soils.

Metabolism

Several aerobic soil metabolism studies were identified for cyhalothrin, *lambda*-cyhalothrin and *gamma*-cyhalothrin. Among the studies, half-lives were in the relatively narrow range of 28.2-60.5 days (5 half-lives, observed in three soils and three test substances). Further, the registrant conducted aerobic soil metabolism studies with *lambda*-cyhalothrin and *gamma*-cyhalothrin in capsule suspension (CS) formulation in order to evaluate whether encapsulating would increase the persistence of the test substances relative to the technical material. For *lambda*-cyhalothrin, the half-lives were 12.2 and 14.5 days and for *gamma*-cyhalothrin, the half-lives were 32.5 and 51.5 days, for a loam and a silt loam, respectively. The CS half-lives will not be considered in assessment because they represent other additional processes which are not related to metabolism,

but they generally also indicate that the aerobic soil half-lives are of the same order of magnitude for both chemicals and relatively comparable. Degradation of *gamma*-cyhalothrin in aerobic soil appears to occur in a similar manner to that of cyhalothrin and *lambda*-cyhalothrin. The studies submitted for bridging purposes do not provide an indication of those soil properties that may increase or decrease the rate of degradation. However, the degradates observed in the aerobic soil metabolism studies for *lambda*-cyhalothrin and *gamma*-cyhalothrin (*e.g.*, hydroxylated products) suggest that the type and activity of soil microbes could affect the rate of *lambda*-cyhalothrin and *gamma*-cyhalothrin degradation. Hydroxylation at the *para*-carbon of the phenoxy ring of *lambda*-cyhalothrin and *gamma*-cyhalothrin appears to yield 3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethyl-cyclopropanecarboxylic acid cyano[3-(4-hydroxyphenoxy) phenyl]methyl ester (Compound XV, 12.5% at 63 days for *lambda*-cyhalothrin). Compound XV and the parent compound can yield 3-(4-hydroxyphenoxy)-benzaldehyde and Compound V, respectively, following ester cleavage, and loss of the cyano group. Further oxidation and hydrolysis reactions presumably result in the ultimate formation of carbon dioxide (CO_2). In aerobic soil metabolism study of technical product *gamma*-cyhalothrin the major degradation product was 3-(4-hydroxyphenoxy)-benzaldehyde (maximum 12.2% AR at 17 days). Other metabolites were only minor (<10% AR).

Two anaerobic soil metabolism studies conducted on cyhalothrin were identified in this assessment. The half dissipation times were 30 to 110 days, after which the degradation appeared to proceed much slower. Due to the limited number of data points in the study with the 30 day half-life, the DT_{50} was considered highly uncertain. Three *lambda*-cyhalothrin anaerobic soil metabolism studies yielded half-lives of 59 to 110 days. After reaching natural water bodies, *lambda*-cyhalothrin and *gamma*-cyhalothrin will partition to dissolved organic material, suspended solids, and sediment. Four aerobic aquatic metabolism studies were identified in this assessment (three for *lambda*-cyhalothrin and one for *gamma*-cyhalothrin). The half-lives were in the range of 21.1 to 52.9 days for *lambda*-cyhalothrin and it was 40.1 days for *gamma*-cyhalothrin, indicating that both test substances degrade with similar rates under the test conditions. In the aerobic aquatic metabolism study, *gamma*-cyhalothrin dissipated from the water layer very rapidly and was detected at ≤4.5% AR at any sampling interval from time zero through 30 days posttreatment. The first measurement of *gamma*-cyhalothrin in the dissolved phase on day 0 of the study was 3.7% of applied material. On day 14 the dissolved level had decreased to 1.8% of the applied material. In the sediment *gamma*-cyhalothrin degraded with an extrapolated half-life of 41 days. The end products of the aerobic aquatic process are consistent with those observed in the aerobic soil metabolism study. One of the products appears to be Compound V (16.0% AR at 30 days for *lambda*-cyhalothrin and 26.9% AR at 30 days for one replicate in the *gamma*-cyhalothrin study) and Compound Ia (22.0% AR at 30 days for *gamma*-cyhalothrin). Compound XV was a minor product. Under anaerobic aquatic conditions, *lambda*-cyhalothrin appears to be more stable than under aerobic condition. For three studies, the anaerobic aquatic metabolism half-life varied between 57.7 and 6320 days. Consistent with the other metabolism studies, the major metabolites were Compound 1a and Compound V.

In a supplemental study, a combined aerobic and anaerobic aquatic metabolism study yielded aerobic aquatic metabolism half-lives of 82.2, 60.4, and 25.9 days for *lambda*-cyhalothrin in a sand, clay and sandy clay loam sediments from California, respectively. Additionally, for *gamma*-cyhalothrin the respective half-lives were 38.6, 55.9, and 29.9 days. Under anaerobic aquatic

conditions, the half-lives were 146, 92.8, and 62.4 days for *gamma*-cyhalothrin in a sand, clay and sandy clay loam sediments, respectively. For *gamma*-cyhalothrin the respective half-lives were 123, 101, and 72.8 days. The study was found to be supplemental since it was conducted using non-labeled material and the water and sediments were extracted together.

Mobility

In an acceptable study, for *lambda*-cyhalothrin, the K_d values ranged from 1970 to 6890 mL/g and the K_{OC} values ranged from 110,000 to 518,000 mL/g_{OC} (10 soils were tested, immobile according to FAO mobility classification, FAO 2000). It is noted that this study was conducted with sterile soils. *Gamma*-cyhalothrin simple K_d values ranged from 239 to 826 mL/g, while for cyhalothrin (tested concurrently) K_d values ranged from 355-601 mL/g. For *gamma*-cyhalothrin the corresponding K_{OC} values ranged from 34,133 to 92,692 mL/g_{OC} (hardly mobile as per FAO 2000) for all tested soils and for cyhalothrin K_{OC} values were 28,176 -74,212 mL/g_{OC} (hardly mobile, FAO 2000). Just as for cyhalothrin and *lambda*-cyhalothrin there was no linear relationship between the soil organic carbon content and the K_d values for different soils for *gamma*-cyhalothrin. Because K_d values were obtained only at one concentration, the Freundlich adsorption/desorption coefficients could not be calculated for *gamma*-cyhalothrin or for cyhalothrin. However, the data suggest that *gamma*-cyhalothrin, similar to cyhalothrin and *lambda*-cyhalothrin, is expected to be largely immobile in soil and water environments with settled sediment. The bulk of *lambda*-cyhalothrin and *gamma*-cyhalothrin transport would most likely occur with movement of soil as erosion in runoff and suspended sediment in lotic (moving) water bodies.

In a soil column study (two soils tested: loamy sand and sandy loam), aged (30 days) *lambda*-cyhalothrin's residues remained mostly in the uppermost soil layer (0-5 cm). Residues were characterized as immobile. In a supplemental study, *lambda*-cyhalothrin was aged for up to 8 weeks in darkness at 4 and 20°C in a sandy loam. The soil was then equilibrated in a batch equilibrium-type study for 24 hours. It was found that ≥97.6% AR remained adsorbed to the soil. In the same study, another sample of sandy loam soil was incubated under ambient light and subject to wet/ dry cycles. In this latter instance ≥80% AR remained in the soil after equilibration.

Terrestrial Field Dissipation

Lambda-cyhalothrin and *gamma*-cyhalothrin appear to be immobile and moderately persistent in laboratory studies and in the field environment. It is highly unlikely that *lambda*-cyhalothrin and *gamma*-cyhalothrin will reach ground water resources due to their high soil adsorption affinity. For *lambda*-cyhalothrin, two terrestrial field dissipation studies indicated half-lives of 33 days (IL) and 12 days (MS). The test substance remained mostly in the uppermost layers of soil (0-5 and 5-10 cm). *Gamma*-cyhalothrin was not detected below the 0-15 cm soil depth, with the exception of a single detection below the LOQ (0.010 µg/g) at 4 days post-treatment in the 15-30 cm soil depth in MS site. *Gamma*-cyhalothrin dissipation half-lives were similar to those of *lambda*-cyhalothrin with 15.6 days (MS) and 29.5 days (CA). Because the capsule suspension formulation might be expected to behave differently in the environment compared to non-encapsulated formulations, a terrestrial field dissipation study using the *gamma*-cyhalothrin capsule suspension (CS) was conducted. In the terrestrial field dissipation study conducted with *lambda*-cyhalothrin,

transformation products monitored at the two sites were reported to be at low levels (<7%). Field soil samples were not analyzed for transformation products in the *gamma*-cyhalothrin study. The study authors stated that *gamma*-cyhalothrin was the only residue of environmental concern because the major degradates are fully and rapidly mineralized in soil and water, do not leach, and are formed via the detoxification process of ester cleavage. In two supplemental aquatic field dissipation studies conducted on rice plots in MS and CA, *lambda*-cyhalothrin appeared to dissipate rapidly from the water (half-lives were 0.4-1.8 days in the water); however the studies did offer suitable information about the dissipation of the chemical from the soil/sediment.

As indicated earlier, *lambda*-cyhalothrin and *gamma*-cyhalothrin will likely reach surface waters via soil erosion and particulate runoff after rainfall, and via spray drift during or shortly after application. A published report measured 73% to 90% of synthetic pyrethroids are bound to eroding sediment in runoff (Liu *et al.*, 2004). The major routes of *lambda*-cyhalothrin and *gamma*-cyhalothrin transport and dissipation are binding to soil particles (K_{OC} values 110,000 to 518,000 in an acceptable study), degradation through abiotic processes in alkaline environments (at pH 9.0 $t_{1/2}$=13 days), and through biotic processes via aerobic soil metabolism ($t_{1/2}$=28.2-60.5 days) and aerobic aquatic metabolism ($t_{1/2}$=21.1-52.9 days in total system). It appears that in acidic or anaerobic environments, *lambda*-cyhalothrin and *gamma*-cyhalothrin would be more persistent.

Bioconcentration

In a study performed with cyhalothrin, the chemical appears to be highly bioaccumulative (4,600x in the whole fish), but it depurates at moderately slow rates (depuration $t_{1/2}$ about 9 days). It appears that situations may occur, where this test substance, as well and *lambda*-cyhalothrin and *gamma*-cyhalothrin, may persist in fish tissue for extended periods of time. Compound Ia was up to 22% in muscle and viscera. In a study performed with cypermethrin, which provided some information on the alcohol moiety of *lambda*-cyhalothrin and *gamma*-cyhalothrin, around 7% was Compound V in the edible tissue.

Transformation Products

Table 32 provides a summary of the data on the occurrence of the transformation products of *lambda*-cyhalothrin and *gamma*-cyhalothrin.

Table 32. Summary of degradate formation for *lambda*-cyhalothrin & *gamma*-cyhalothrin

STUDY TYPE	DEGRADATE and MAXIMUM CONCENTRATION (% of the applied)			
	Compound Ia[55] and/ or Compound Ib[56]	**Compound IV[57]**	**Compound V[58]**	**Metabolite XV[59]**
Hydrolysis (1)	*Lambda*-cyhalothrin: (at pH 9, Ia 68% at 30 days)	*Gamma*-cyhalothrin: (at pH 9, 55.6%, 2 days)	*Gamma*-cyhalothrin: (at pH 9, 54.6%, 30 days)	*Gamma*-cyhalothrin: (river water, 21.6%, 30 days)

[55] (1*RS*)-cis-3(*ZE*)-2-chloro-3,3,3-trifluro-1-propenyl)-2,2-dimethylcylopropanecarboxylate.
[56] (1*RS*)-trans-3-(*ZE*)-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropane-carboxylic acid.
[57] 3-phenoxybenzaldehyde
[58] 3-PBA or 3-phenoxybenzoic acid
[59] (1*R*) *cis* α-(*S*) *cis* α-(*R*) α-cyano-3-(4-hydroxyphenoxy) benzyl 3-(Z-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate.

STUDY TYPE	DEGRADATE and MAXIMUM CONCENTRATION (% of the applied)			
	Compound Ia[55] and/ or Compound Ib[56]	**Compound IV[57]**	**Compound V[58]**	**Metabolite XV[59]**
Aqueous Photolysis (1)	*Lambda*-cyhalothrin: (Ia 13.7% at 31 days) (cyclopropane ring) (Ib 7.1% at 31 days) (cyclopropane ring) *Gamma*-cyhalothrin: (unspecified 45.0% at 21 days)	*Lambda*-cyhalothrin: Minor product	*Lambda*-cyhalothrin: (25.0% at 31 days) *Gamma*-cyhalothrin: (42.0% at 15 days)	
Soil Photolysis			*Lambda*-cyhalothrin: Minor product	
Aerobic Soil Metabolism (2)	*Lambda*-cyhalothrin: Minor product	Cypermethrin: Minor product	Cypermethrin: Minor product *Gamma*-cyhalothrin: Minor product	*Lambda*-cyhalothrin: (12.5% at 63 days) *Gamma*-cyhalothrin: Minor product
Anaerobic Soil Metabolism	*Lambda*-cyhalothrin: Ia 44.9% at 119 days postflooding.			*Lambda*-cyhalothrin: 11.1% at time of flooding (30 days)
Aerobic Aquatic Metabolism	*Lambda*-cyhalothrin: Ia 11.4% in the water and 10.6% in the sediment of the SL sediment system at 30 days (total 22.0%).		*Lambda*-cyhalothrin: Minor product *Gamma*-cyhalothrin: (14.4% in sediment, 16.0% in total system at 30 days, last interval)	*Lambda*-cyhalothrin: Minor product.
Anaerobic Aquatic Metabolism	*Lambda*-cyhalothrin: Ia 52.4% at 99 days water; 12.7% at 100 days soil.		*Lambda*-cyhalothrin: 57.3 at 99 days in water; 20.5% at 100 days in soil.	*Lambda*-cyhalothrin: Minor product.
Degradation in Aquatic Microcosm (3)	*Lambda*-cyhalothrin: Ia 40.6% at 4 days in water; it was minor in the sediment			
Bioaccumulation in Fish (4)	*Lambda*-cyhalothrin: Ia 22% in mucle and viscera	Cypermethrin: Detected	Cypermethrin: ~7% in edible tissue	

(1). Hydrolysis: Isomerization was rapid in the pH 9 solution and moderate in pH 7 solution. It did not occur in the pH 5 solution. Isomerization also occurred in the aqueous photolysis study.
(2). 3-(4-Hydroxyphenoxy)-benzaldehyde was a major product in the sandy loam (12.2% at 17 days, *gamma*-cyhalothrin study).
(3). In the TFD study conducted with *lambda*-cyhalothrin, transformation products monitored at the two sites were reported to be at low levels (<7%). In the study conducted with *gamma*-cyhalothrin no transformation products were monitored.
(4). In the cypermethrin study, 3-phenoxybenzyl alcohol (mPBalc) was also detected.

The Compounds Ia [(1*RS*)-*cis*-3-(*ZE*)-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethyl-cyclopropanecarboxylic acid] (and possibly Ib, the *trans*-isomer), and Compound IV (3-phenoxybenzaldehyde) are the expected result of the hydrolysis of the ester linkage of the pyrethroid structure, followed by loss of the cyano group. However, in general, the major degradates appear to be Compounds Ia and Ib, and Compound V (3-phenoxybenzoic acid, also named 3-PBA, m-PBA, 3-PBAc or 3-PBacid), which were observed mostly in the metabolism studies. It appears that Compound IV oxidizes quickly to Compound V in metabolic environments. The findings in the field corroborate the laboratory predictions. Compound V shows relatively high mobility, with K_{OC} values 118-215 mL/g_{OC} and K_F values ≤3.11 mL/g

(moderately mobile according to FAO mobility classification, three soils tested, while for a sand soil, the K_{FOC} could not be determined because of the low sorption) (**Table 33**).

Ring-hydroxylated *lambda*-cyhalothrin, (1*R*) *cis* α-(*S*) *cis* α-(*R*) α-cyano-3-(4-hydroxyphenoxy) benzyl 3-(Z-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropane-carboxylate (Compound XV), formed in aerobic soil microbial degradation (12% of the applied at 63 days post-treatment) appears to degrade readily to carbon dioxide in a separate aerobic soil metabolism study, and it appears to partition with soils and sediments. Its solubility is only 9 ppb (WSKOW SAR modeling), similar to the parent compound, which is not surprising due to their structural similarity. It also has low mobility based on the estimated K_{OC} value of 770,900 mL/g_{OC}, from structure activity relationship (SAR) modeling. The aerobic soil metabolism linear half-lives ($t_{1/2}$s) for Compound XV ranged from 13.9 to 17.4 days (three soils tested, **Table 33**). The potential for groundwater contamination with the degradate is low. However, it has the potential to reach surface water via runoff (in erodible particles), after rainfall events.

Table 33 summarizes the available environmental fate/transport properties of Compounds V and XV, which are relevant metabolites of *lambda*-cyhalothrin and *gamma*-cyhalothrin. Note that the results for 3-PBA are also reported in **Table 14** above, for permethrin (same study).

Table 33. Summary of Environmental Fate Parameters for Compounds V and XV

Parameters	Value	Source
Soil Partition Coefficient **Compound V (3-PBA)** (K_F in mL/g)	Not Determined Sand 3.11 Silt Loam 0.98 Sandy Loam 1 2.44 Sandy Loam 2	43424901 (S) [Reported Freundlich correlations were good (r^2 close to unity), but n values were around 1.5 (or 1/n of around 0.7).]
Soil Partition Coefficient **Compound V (3-PBA)** (K_{FOC} in mL/g_{oc})	Not Determined Sand 122 Silt Loam 118 Sandy Loam 1 215 Sandy Loam 2	
Solubility of **Compound XV**	0.009 ppm or 9 ppb - - - - - (reported as <0.01 ppm in a study)	Estimated from log K_{OW} (SAR; WSKOW v1.40) 44861505
Aerobic Soil Metabolism for **Compound XV**, $T_{1/2}$	Sandy clay loam 13.9 days Loamy sand 14.7 days Sandy Loam 17.4 days	44861505 (S) Reviewer calculated first order log-linear half-lives. Three UK soils tested.
Soil Partition Coefficient for **Compound XV** (K_{OC} in mL/g_{oc})	770,900	SAR Modeling

Other Studies – POTW Treatability

In a POTW treatability study, *lambda*-cyhalothrin showed limited removal upon primary settling, and around 49% removal in the aerobic chamber. In the anaerobic digester 57% of the parent compound was removed. Under ultrafiltration, nearly 93.1% of the *lambda*-cyhalothrin was removed.

Cyfluthrin and *Beta*-Cyfluthrin

An environmental fate assessment was provided in the Problem Formulation (DP Barcodes D376232, D376441, dated July 29, 2010). Additionally, in early 2013, an endangered species assessment for a number of California species was issued[60].

Physical and Chemical Properties

The environmental fate properties of cyfluthrin and *beta*-cyfluthrin indicate alkaline catalyzed abiotic hydrolysis, photodegradation, microbial mediated degradation, and sorption on sediment/soil are important dissipation pathways. Consideration of the environmental fate properties along with available monitoring data indicates that water and sediment runoff and spray drift are the principle potential transport mechanisms to the aquatic and terrestrial habitats.

Cyfluthrin (**Tables 34**) is a synthetic pyrethroid insecticide and acaricide. Its structure has three rings, two phenyl rings attached to each other by an oxygen atom, and a cyclopropyl ring. The structure of the molecule has three chiral centers that could result in a total of 2^3 or 8 isomers, which form 4 pairs of diastereomers (I,II,III, IV). *Beta*-cyfluthrin, however, is a mixture of four of the isomers of cyfluthrin and comprise 2 pairs of diastereomers (II and IV). Chemically, it is the (R)-alcohol-(1S)-*cis*-acid, (R)-alcohol-(1S)-*trans*-acid, (S)-alcohol-(1R)-*cis*-acid and (S)-alcohol-(1R)-*trans*-acid out of eight isomeric esters. Although the physicochemical and environmental fate properties of diastereomers will be different, the extent of the differences is not large enough to alter the interpretation of the environmental fate properties of cyfluthrin and *beta*-cyfluthrin.

Cyfluthrin has a high molecular weight of 434.29 g/mol (**Table 35**). It also has a low water solubility (only 2.32 ppb) and a high octanol/ water partition coefficient ($K_{OW} = 9.33x10^5$). Based on its octanol/water partition coefficient, it appears that cyfluthrin has the potential to bioaccumulate/ bioconcentrate ($K_{OW} \geq 1000$) in fish and other aquatic organisms. With a vapor pressure of 1.5×10^{-8} mmHg, it is considered "non-volatile under field conditions." Due to its very low solubility (2.32 ppb), its calculated Henry's Law Constant is moderately low (3.7×10^{-6} atm-m^3/mol). In addition, its C_{water}/C_{air} is 6612, which classifies it as "slightly volatile from a water surface" (USEPA 2008). Cyfluthrin could have a potential to volatilize slightly from wet surfaces. The potential to volatilize may be greatly attenuated in the environment by its tendency to bind to organic matter (*e.g.*, soils, sediments, or organic matter and particulate in natural water). For cyfluthrin, the log K_{OA} range is 9.79 – 11.88 (calculated and EPIWEB v.4.0 estimates), the log K_{OW} is 5.97 and the rate of transformation is moderate in the environment and appears to be moderate in fish (the majority of the residues observed in fish were the parent compound), with moderately rapid depuration (observed depuration DT50 of approximately 3 days). Therefore, it appears that cyfluthrin may have *a low potential* to biomagnify substantially in terrestrial food chains, based on the presumption made by Gobas *et al.* and Armitage & Gobas, in 2003 and 2007 articles, respectively.

[60] Available at http://www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html (accessed 07/14/2015).

Table 34. Identification Information for Cyfluthrin and *Beta*-Cyfluthrin.

CHEMICAL	CYFLUTHRIN		*BETA*-CYFLUTHRIN	
PARAMETER	**VALUE(S) (units)**	**SOURCE**	**VALUE(S) (units)**	**SOURCE**
CAS Chemical Name	cyano(4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate	Cyfluthrin data sheet, at: http://www.alanwood.net/pesticides/cyfluthrin.html (accessed 08/28/15)	cyano(4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate	*Beta*-cyfluthrin data sheet, at: http://www.alanwood.net/pesticides/*beta*-cyfluthrin.html (accessed 08/28/15)
PC Code	128831	OPP Databases	118831	OPP Databases
IUPAC Chemical Name	(*RS*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*RS*,3*RS*;1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate **or** (*RS*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*RS*)-*cis*-*trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate	Cyfluthrin data sheet, at: http://www.alanwood.net/pesticides/cyfluthrin.html	reaction mixture comprising the enantiomeric pair (*R*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate in ratio 1:2 with the enantiomeric pair (*R*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*S*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*R*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate **or** reaction mixture comprising the enantiomeric pair (*R*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*S*)-*cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*R*)-*cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate in ratio 1:2 with the enantiomeric pair (*R*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*S*)-*trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*S*)-α-cyano-4-fluoro-3-phenoxybenzyl (1*R*)-*trans*-3-(2,2-dichlorovinyl)-	*Beta*-cyfluthrin data sheet, at: http://www.alanwood.net/pesticides/*beta*-cyfluthrin.html

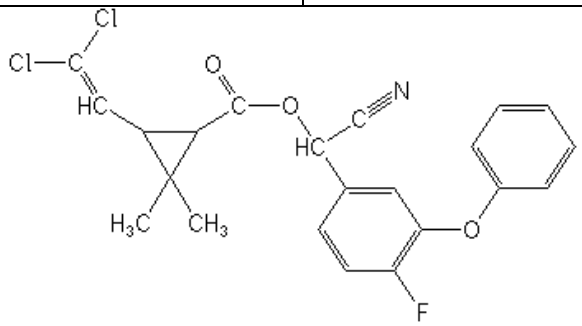
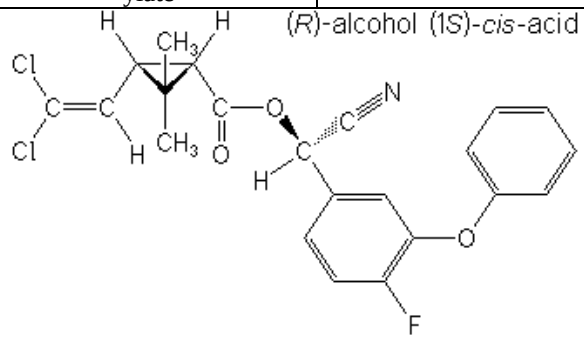
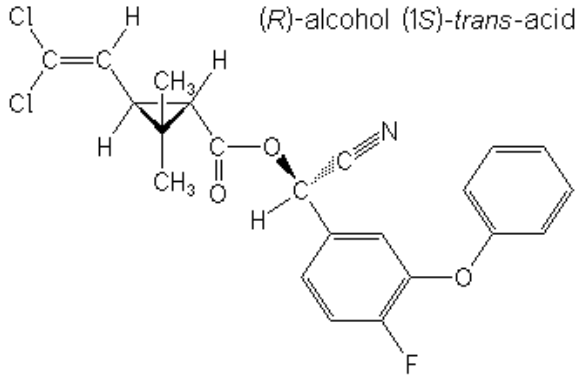
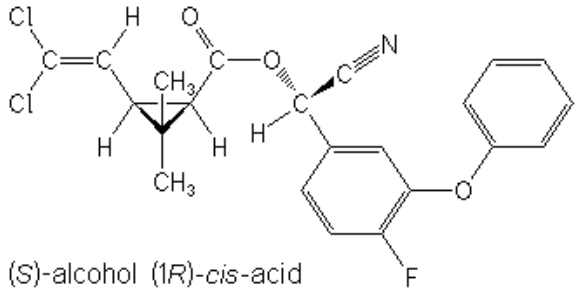
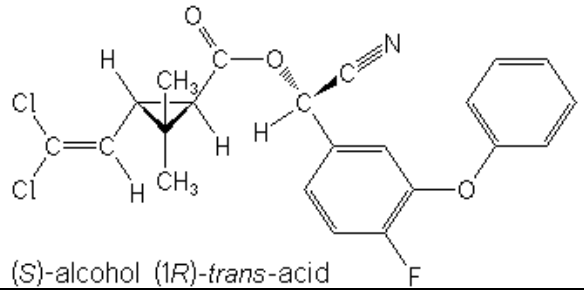
CHEMICAL	CYFLUTHRIN		*BETA*-CYFLUTHRIN	
PARAMETER	**VALUE(S) (units)**	**SOURCE**	**VALUE(S) (units)**	**SOURCE**
			2,2-dimethylcyclopropanecarboxylate	
Chemical Structure (from chemical's data sheet)	 Unstated stereochemistry; It consists of 8 isomers		 (*R*)-alcohol (1*S*)-*cis*-acid  (*R*)-alcohol (1*S*)-*trans*-acid  (*S*)-alcohol (1*R*)-*cis*-acid  (*S*)-alcohol (1*R*)-*trans*-acid	

Table 35. Summary of Physiochemical Properties of Cyfluthrin and *Beta*-Cyfluthrin.

PARAMETER	VALUE(S) (units)	SOURCES
CAS Reg. No.	68359-37-5 (unstated stereochemistry) Cyfluthrin is a mixture of all possible isomers. 86560-92-1 (diastereoisomer I) 86560-93-2 (diastereoisomer II) 86560-94-3 (diastereoisomer III) 86560-95-4 (diastereoisomer IV) *Beta*-cyfluthrin is comprised mainly of diastereoisomers II and IV.	FAO/WHO Specifications[1] and Cyfluthrin (157)/*Beta*-cyfluthrin (228), Draft Review Prepared by *Australian Quarantine and Inspection Service*[2]
Stereochemistry	Diastereoisomer I: (1*R*,3*R*,1*R* + 1*S*,3*S*,1*S* = 1:1; *cis*) Diastereoisomer II: (1*R*,3*R*,1*S* + 1*S*,3*S*,1*R* = 1:1; *cis*) Diastereoisomer III: (1*R*,3*S*,1*R* + 1*S*,3*R*,1*S* = 1:1; *trans*) Diastereoisomer IV: (1*R*,3*S*,1*S* + 1*S*,3*R*,1*R* = 1:1; *trans*)	FAO/WHO Specifications[1]
Composition	**Diastereoisomer** / **Cyfluthrin** / ***Beta*-cyfluthrin** I / 23-27% / ≤2.0% II / 17-21% / 30.0-40.0 III / 32-36% / ≤3.0% IV / 21-25% / 57.0-67.0	FAO/WHO Specifications[1]
Molecular Formula	$C_{22}H_{18}Cl_2FNO_3$	Cyfluthrin's data sheet
Molecular Weight	434.29	TOXNET/ HSDB[3]
Melting Point	60ºC; 64.40 diastereoisomer I; 80.71 diastereoisomer II; 65.04 diastereoisomer III; 106.19 diastereoisomer IV	TOXNET/ HSDB FAO/WHO Specifications[1]
Boiling Point (ºC)	Not measurable; weight loss above 160°C; decomposition >220°C	FAO/WHO Specifications[1]
pKa (20 ºC)	NA; Dissociation characteristics: cyfluthrin does not show basic or acidic characteristics in water	EC Review Report for the Active Substance Cyfluthrin and *Beta*-cyfluthrin[4]
Solubility (20ºC)	2.32 x 10^{-3} mg/L or ppm or **2.32 ppb at 20ºC** pH 3/pH 5: 2.5/2.2 ug/L diast. I; 2.1/1.9 ug/L diast. II; 3.2/2.2 ug/L diast. III; 4.3/2.9 ug/L diast. IV* *The material used was a defined mixture of four diastereoisomeric enantiomer pairs. 'Not Soluble'	Laskowski 2002[5], FAO/WHO Specifications[1] FAO, 2000[6]
Vapor Pressure (20-25ºC)	**1.5 x 10^{-8} mmHg at 25°C** 2.1 x 10^{-9} mmHg at 20°C @20°C 9.6 x 10^{-7} Pa diast. I 1.4 x 10^{-8} Pa diast II 2.1 x 10^{-8} Pa diast. III 8.5 x 10^{-8} Pa diast. IV @25°C 2.1 x 10^{-6} Pa diast. I 3.4 x 10^{-7} Pa diast II 4.7 x 10^{-7} Pa diast. III 2.0 x 10^{-7} Pa diast. IV	Laskowski 2002[5] FAO/WHO Specifications[1] USEPA, 2008[7]

PARAMETER	VALUE(S) (units)	SOURCES
	'Non-volatile under field conditions' ($\leq 9.98 \times 10^{-7}$ mmHg)	
Henry's Law Constant	3.7×10^{-6} atm-m^3/mol (estimated from vapor pressure at 25°C and water solubility at 20°)	Laskowski, 2002[5]
Octanol-Water Partition Coefficient (20 and 22°C) K_{OW} (log K_{OW})	**9.33×10^5** (5.97)* 6.00 diast. I; 5.94 diast. II; 6.04 diast. III; 5.91 diast. IV* 6.18 diast. II; 6.18 diast IV at 22°C *The material used was a defined mixture of four diastereoisomeric enantiomer pairs.	Laskowski, 2002[5] FAO/WHO Specifications[1]
Octanol-Air Partition Coefficient K_{OA} (log K_{OA})	$K_{OA} = \frac{K_{OW}}{K_{AW}} = \frac{K_{OW}RT}{\text{Henry's Law Constant}}$ = **6.17×10^9** (9.79) Calculated using $K_{OW} = 9.33 \times 10^5$ and HLC = 3.7×10^{-6} atm-m^3/mol; the temperature was assumed to be 25°C. EPIWEB estimate: $1.47 \times 10^{10} - 7.52 \times 10^{11}$ (10.164-11.876)	Calculated Value EPIWEB v.4.0 Estimate
K_{AW} (log K_{AW})	$K_{AW} = C_{air}/C_{water}$ = HLC/RT = **1.51×10^{-4}** (-3.82) EPIWEB estimate: $K_{AW} = 1.18 \times 10^{-6}$ (-5.926) 'Slightly volatile from a water surface'	Calculated EPIWEB v.4.0 USEPA, 2008[7]
C_{water}/C_{air}	$\frac{C_{water}}{C_{air}} = \left(\frac{S \times T \times R \times 760}{P \times GMW \times 10^6}\right)$ = 6,612 (unitless) 'Slightly volatile from a water surface'	Calculated USEPA, 2008[7]
OH Radical Reaction Half-life	0.856 days (Assumptions: 12-hr days; 1.5×10^6 OH/cm^3)	EPIWEB v.4.0 Estimate
Biomagnification Potential	Presumption: If log $K_{OA} > 5$, log $K_{OW} > 2$ and the rate of chemical transformation is low, the chemical may biomagnify in terrestrial food chains** For cyfluthrin, log $K_{OA} > 5$, log $K_{OW} > 2$. However, its rate of transformation is moderate in the environment and appears to be moderately rapid in fish, with moderate to rapid depuration indicated. Therefore, it appears that cyfluthrin may have *a low potential to biomagnify* in terrestrial food chains.	**Gobas *et al.* 2003[8] and Armitage & Gobas, 2007[9] support this presumption utilized here only as a broad reference to determine the potential for biomagnification.

Bolded value is considered representative for cyfluthrin.

1 http://www.fao.org/ag/AGP/AGPP/Pesticid/Specs/docs/Pdf/new/cyfluthr.pdf and http://www.fao.org/ag/AGP/AGPP/Pesticid/Specs/docs/Pdf/new/beta_cyf.pdf (accessed 05/05/10).

2 http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/JMPR/Evaluation07/Cyflutrhin.pdf (accessed 05/05/10).

3 http://toxnet.nlm.nih.gov/.

4 http://ec.europa.eu/food/plant/protection/evaluation/existactive/list1-29_en.pdf and http://ec.europa.eu/food/plant/protection/evaluation/existactive/list1-32_en.pdf (accessed 05/05/10).

5 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.

6 Food and Agriculture Organization of the United Nations. FAO PESTICIDE DISPOSAL SERIES 8. Assessing Soil Contamination: A Reference Manual. Appendix 2. Parameters of pesticides that influence processes in the soil. Editorial Group, FAO Information Division: Rome, 2000. http://www.fao.org/DOCREP/003/X2570E/X2570E00.htm.

7 USEPA. 2008. *OPPTS 835.6100 Terrestrial Field Dissipation*. EPA 712-C-08-020. October 2008. Office of Prevention, Pesticides, and Toxic Substances. United States Environmental Protection Agency. Available at http://www.epa.gov/ocspp/pubs/frs/publications/Test_Guidelines/series835.htm (accessed 04/28/2015). [Additionally, USEPA 2010:

http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (accessed 05/12/2015).]

8 Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.

9 Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology*, *41*, 4019-4025.

Because cyfluthrin and *beta*-cyfluthrin are Type II synthetic pyrethroids that have similar structures (cyano substituted in the alpha position and both have a 2,2-dichloroethenyl, and they are 2,2-dimethyl substituted in the cyclopropane ring) and cyfluthrin includes the 4 isomers in *beta*-cyfluthrin, the environmental fate database for cyfluthrin is used as a surrogate fate database for *beta*-cyfluthrin (**Table 35**).

Type II pyrethroids such as cyfluthrin and *beta*-cyfluthrin characteristically show stability to photolysis. Submitted laboratory data, however, indicate that the primary routes of dissipation are aqueous and soil photolysis (4.5 and 5.6 days, respectively) and hydrolysis in alkaline media (2.1 days) (**Table 36**). Cyfluthrin and *beta*-cyfluthrin are moderately persistent in the environment and immobile (aerobic soil metabolism 73.5-94.8 days, aerobic aquatic metabolism 32.9-42 days). The terrestrial field dissipation data confirm the pattern observed in the laboratory studies with half-lives and DT_{50}'s in the range of 18-32 days, which would indicate that the chemical follows mixed routes of dissipation in the field. The K_{OC} values ranged from ~73,000-180,000 mL/g_{OC}, indicating low mobility. Like other pyrethroids, cyfluthrin and *beta*-cyfluthrin bind strongly to soils suggesting a low potential to leach to subsurfaces and to contaminate groundwater. The moderate persistence of the chemical, the high soil affinity and very low solubility indicate that the chemicals have a high potential to reach surface waters in runoff events accompanied by erosion occurring during periods of weeks to months after application. Residues could also reach surface waters via spray drift. Once the chemicals reach surface waters, there is potential impact to water quality, which appears to be mostly due to parent compound. The fate of cyfluthrin in anaerobic environments is uncertain. Cyfluthrin and *beta*-cyfluthrin are likely to partition with sediments in bodies of water. Since cyfluthrin may be applied repeatedly, the material may build up in sediments and affect benthic communities. Cyfluthrin and *beta*-cyfluthrin are moderately bioaccumulative with moderately rapid rates of depuration (estimated half-depuration time ≤3 days). Major metabolites observed in laboratory studies include *cis*- and *trans*-DCVA, FPB-acid and FPB-ald (**Table 37**). These compounds result from the hydrolysis of the ester bond of the parent compounds.

Table 36. Summary of the Environmental Fate and Transport Properties of Cyfluthrin and *Beta*-Cyfluthrin.

PARAMETER	VALUE(S) (units)	SOURCE	COMMENT
Hydrolysis Half-life [pH 5, 7, 9; (25 °C)]	Stable at pH 5, nearly stable at pH 7, $t_{1/2}$ = 2.1 days at pH 9; major degradation product FPB-ald	MRID: 00131493, 00137539, 45022101	Supplemental data shows that the half-life was 9 days in natural waters from the Rhine river. Major product was FPB-acid. Water's pH was 7.7-8.3.
Aqueous Photolysis Half-life (pH 5)	$t_{1/2}$ = 4.5 days linear; $t_{1/2}$ = 0.7 days nonlinear; degradation products: FPB-acid and FPB-ald	MRID: 00149595, 45022102	Value obtained using natural sunlight

PARAMETER	VALUE(S) (units)	SOURCE	COMMENT
Soil Photolysis Half-life	$t_{1/2}$ = 5.6 days; degradation product: FPB-ald	MRID: 00137543, 00157043	Dark control corrected; using natural sunlight
Aerobic Soil Metabolism Half-life	Half-life for cyfluthrin = L $t_{1/2}$ = 73.5 days SL $t_{1/2}$ = 94.8 days major degradate: FPB-acid	MRID: 00131494	–
	Half-life for cyfluthrin = SL $t_{1/2}$ = 174 days (DFOP) major degradate: none, except CO_2	MRID: **48350602**	Supplemental.
	Half-life for cyfluthrin = SL $t_{1/2}$ = 39.7 days (IORE) CL $t_{1/2}$ = 105 days (IORE) major degradate: permethric acid (DCVA)	MRID: **49272603**	Supplemental.
	Half-life for *beta*-cyfluthrin = SL $t_{1/2}$ = 25.7 days (IORE) major degradate: FPB-acid	MRID: **49272605**	Supplemental.
	Half-life for *beta*-cyfluthrin = SCL $t_{1/2}$ = 69.2 days (IORE) SL $t_{1/2}$ = 20.6 days (IORE) SiL $t_{1/2}$ = 20.3 days (IORE) major degradate: permethric acid (DCVA)	MRID: **49272606**	Supplemental.
	Sterile SL from CA: levels of UERs were low (≤1.1% AR in samples taken 43-63 days post-treatment)	MRID: **49272604**	Supplemental study conducted on *beta*-cyfluthrin.
Anaerobic Soil Metabolism Half-life	Half-life for cyfluthrin = $t_{1/2}$ ~ 30 days; degradate FPB-acid declined	MRID: 00131494	Study lasted 60 days.
	Half-life for cyfluthrin = SL $t_{1/2}$ = 130 days (DFOP) major degradate: FPB-acid, permethric acid (DCVA); minor degradate: 4-Hydroxy FPB acid	MRID: **49272607**	Supplemental.
	Half-life for *beta*-cyfluthrin = SL $t_{1/2}$ = 59.8 days (IORE) major degradate: FPB-acid, permethric acid (DCVA); minor degradate: 4-Hydroxy FPB acid	MRID: **49272608**	Supplemental.
Aerobic Aquatic Metabolism Half-life	Half-life for cyfluthrin = German systems: Barmener Gravel Pit $t_{1/2}$ = 10.4 days (IORE) Genkel Creek Catchment $t_{1/2}$ = 55.2 days (DFOP) Degradates DCVA, FPB-acid and FPB-ald	MRID: 46824101	Two Dutch systems, but the quality of these half-lives was considered lower: Lienden Fishpond $t_{1/2}$ = 7.74 days (SFO) IJzendoorn Orchard Drainage $t_{1/2}$ = 7.24 days (SFO)

PARAMETER	VALUE(S) (units)	SOURCE	COMMENT
	Half-life for *beta*-cyfluthrin = Marine S $t_{1/2}$ = 27.8 days (IORE) major degradate: FPB acid; minor degradate: 4-Hydroxy FPB acid Isomer 1 $t_{1/2}$ = 52.3 days (SFO) Isomer 2 $t_{1/2}$ = 43.5 days (DFOP) Isomer 4 $t_{1/2}$ = 7.34 days (IORE) Isomer 2+4 $t_{1/2}$ = 15.1 days (IORE)	MRID: **49272609**	Supplemental.
	Half-life for cyfluthrin = 10.4 days (IORE), sand 47.6 days (DFOP), clay 7.71 days (IORE), sandy clay loam	MRID: **48762908**	Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used.
	Half-life for *beta*-cyfluthrin = 7.68 days (DFOP), sand 34.1 days (IORE), clay 9.76 days (IORE), sandy clay loam		
Anaerobic Aquatic Metabolism Half-life	Half-life for *beta*-cyfluthrin = CL $t_{1/2}$ = 26.2 days (IORE) S $t_{1/2}$ = 10.3 days (IORE) S $t_{1/2}$ = 9.41 days (IORE) major degradates: FPB acid, permethric acid (DCVA); minor degradate: 4-Hydroxy FPB acid	MRID: **49272610**	Supplemental.
	Half-life for cyfluthrin = 48.3 days (IORE), sand 42.4 days (IORE), clay 29.2 days (IORE), sandy clay loam	MRID: **48762908**	Supplemental. Water and sediment were extracted together. Non-radiolabeled material was used.
	Half-life for *beta*-cyfluthrin = 51.8 days (DFOP), sand 22 days (SFO), clay 29.2 days (IORE), sandy clay loam		
Soil Partition Coefficient (K_d) Organic Carbon Partition Coefficient (K_{OC}) And Freundlich Partition Coefficients For Cyfluthrin	**Adsorption:** Soil / K_d / K_{OC} German LS 1116 124000 US LS 1244 180300 US CL 1321 118000 German SiL 1793 73500 **Desorption:** Soil / K_d / K_{OC} German LS 1448 161000 US LS 974 141000 US CL 1307 117000 German SiL 1705 69900 Immobile to hardly mobile. K_{OC} in mL/g_{OC} and K_d in mL/g. There is a linear relationship between the soil OC content and the K_d values (r^2 = 0.92).	MRID: 00131495, 00137544, 45022103	In supplemental studies, TLC data for cyfluthrin on six different soils were submitted. Using the Helling and Turner mobility classification system, cyfluthrin was classified as immobile in the six test soils. To help EFED develop a K_d input for modeling, the registrant later submitted a supplemental study to the Agency which contained a single K_d value for one soil of 810 mL/g.

PARAMETER	VALUE(S) (units)	SOURCE	COMMENT
	Adsorption: Soil K_d K_{OC} WY C 2193 274149 CA SL 1519 253221 ND SCL 7691 226230 IL SiL 2259 230000 CA S 73.8 184458 **Desorption:** Soil K_d K_{OC} WY C 3965 495667 CA SL 2246 374387 ND SCL 11977 352267 IL SiL 3236 323632 CA S 80.6 201516 Immobile. K_{OC} in mL/g_{OC} and K_d in mL/g. There is a strong correlation between the adsorption to soil and %OC (r^2 = 0.997). ---------- **Adsorption:** Soil K_F K_{FOC} 1/n WY C 1549 193698 0.96 CA SL 1.4E7 2.3E9 2.02 ND SCL 1521 44749 0.84 IL SiL 1987 198656 0.99 CA S 28.7 71666 0.86 **Desorption:** Soil K_F K_{FOC} 1/n WY C 1421 177622 0.89 CA SL 5654 942409 1.10 ND SCL 28935 1.08E11 1.08 IL SiL 278 27815 0.74 CA S 30.6 76536 0.88 K_{FOC} (mL/g_{OC})$^{-1/n}$ and K_F (mL/g)$^{-1/n}$.	MRID: **49272602**	Supplemental. Soils were sterilized via gamma irradiation.
Terrestrial Field Dissipation Half-life	NC**:** $t_{1/2}$ (in surface soil) = 18.1 days; was only detected in top 6 in soil layer. CA (Fresno) cotton site**:** $t_{1/2}$ reported to be 4.3 days (using 0-7 day data; or 23.8 days if 0-14 day data are used), cyfluthrin was not detected after day 29 post-treatment; residues remained in top 6 in soil layer, except for two individual samples. FPB-acid and DCVA were detected in this study. AZ, FL, KS, GA, OR, MS, Canada**:** DT_{50} < 32 days	MRID: AN 259211, 44822901, 42794801	Study 42794801 was screened only and a full review will be provided at a later time.
Bioaccumulation in Fish (BCF)	Maximum BCF=854X for whole fish, with moderate depuration. The only major residue was the parent. The depuration time appears to be ≤3 days.	MRID: 00143143	–

PARAMETER	VALUE(S) (units)	SOURCE	COMMENT
POTW Treatability Study	Removal percent for cyfluthrin: Primary Settling LR Aerobic Chamber 73.2% Anaerobic Digestion 81.2% Ultrafiltration 95.7%	MRID: **48762906**	Supplemental; POTW treatability study of eight pyrethroids.

Abbreviations: wt=weight; SL=sandy loam; LS=loamy sand; SiL=silty loam; SCL=sandy clay loam; CL=clay loam; LR=limited removal

[1]Half-lives were calculated using the single-first order equation and nonlinear regression, unless otherwise specified.

[2]The value may reflect both dissipation and degradation processes.

Transport, Mobility, Sorption

The potential impact to water quality from the use of cyfluthrin appears to be mostly due to the parent compound. Laboratory studies show that cyfluthrin is moderately persistent under most environmental conditions making the compound available for runoff. Although the potential for mobility appears low, the likely means of cyfluthrin movement from a crop site to an adjacent body of water would be through erosion of soil, as well as spray drift. Laboratory studies predict that once the chemical reaches surface waters, it may persist for moderate periods of time (relatively stable at pH 7). Even though cyfluthrin undergoes photolysis in water, its lipophilicity and affinity with particulate matter should make it unavailable to photolysis in a short period. In addition, photolysis is expected to be limited only to clear shallow waters or the upper layers of the water column. Conclusions with respect to the mobility of these degradates are limited by the available data.

Abiotic Degradation and Metabolism

The hydrolysis of cyfluthrin is pH dependent, occurring quickly in alkaline media (2.1 days at 9). In a supplemental study conducted on filtered Rhine River water (pH 7.7-8.3), in the dark, cyfluthrin hydrolyzed/ degraded with a half-life of 9 days. An important route of dissipation for this chemical is aqueous photolysis (non-linear half-life of 0.7 days/ linear 4.5 days in an aqueous solution under natural sunlight). The major degradates are FPB-acid (4-fluoro-3-phenoxybenzoic acid) and FPB-ald (4-fluoro-3-phenoxybenzaldehyde). Soil photodegradation is also an important route of dissipation (half-life of 5.6 days (dark control corrected)) for cyfluthrin and *beta*-cyfluthrin. The degradate FPB-ald accounts for up to 8% of the applied. It is assumed that the degradate DCVA [3-(2,2-dichlorovinyl)-2,2-dimethyl-cyclopropanecarboxylic acid] is formed in the hydrolysis and the aqueous photolysis studies. DCVA is stable to hydrolysis at pH's 4, 7 and 9 (European Commission, Appendix 2).

The aerobic soil metabolism appears to play a lesser role in the dissipation of cyfluthrin with half-lives in a loam soil and a sandy loam soil, of 73.5 and 94.8 days, respectively. There was some formation of carbon dioxide and the only fluoro-phenyl degradate detected at appreciable amounts was FPB-acid (7% of the applied). Four additional studies were submitted during Registration Review, conducted using cyfluthrin and *beta*-cyfluthrin. Half-lives in the studies were of similar order of magnitude than the previously described studies, with half-lives ranging from 20.3 to 174 days (for a total of seven new half-lives and a variety of soils). Major degradates included permethric acid (DCVA) or FPB-acid, depending on the radiolabel. In these four studies,

levels of unextracted radioactivity were high; however, a fifth new study, conducted in a sterile sandy loam and a similar extraction method, did not yield high levels of unextracted radioactivity, indicating that the extraction was efficient for the parent compound (not all of the four studies followed exactly the same extraction method).

In an anaerobic soil metabolism study, using aged loam, flooded and purged with nitrogen and based on two points, a half-life of around 30 days was obtained. Two degradates detected at the end of the initial aerobic incubation, FPB-acid and cyfluthrin-amide (minor degradate), declined during the anaerobic phase. The degradate DCVA was identified in a 100-day aerobic soil metabolism study at >10% of the applied, as indicated by the European Commission (Appendix 2). In aerobic soil metabolism studies at 25°C at 40% MWHC, the DT50 range for DCVA was 12-62 days (mean 24 days, median 16 days, 2 soils, 4 isomers). It is indicated that $DT50_{FPBacid} < DT50_{DCVA}$. Two other supplemental studies were conducted in sandy loam soils using cyfluthrin and *beta*-cyfluthrin, with half-lives of 59.8 and 130 days, in two sandy loam soils. Major degradates included FPB-acid and permethric acid (DCVA); the minor degradate observed was 4-Hydroxy FPB acid.

In aerobic aquatic metabolism studies conducted on *beta*-cyfluthrin, based on first order linear regression analysis, the half-lives of cyfluthrin in the total systems were 10.4 and 55.2 days for two German systems, and 7.24 and 7.74 days for two Dutch systems. The quality of the results of the Dutch systems is regarded as lower, and those half-lives should not be used for modeling. Three degradates were identified in the aerobic aquatic systems. In the German systems, DCVA was a maximum of 47.63% at 28 days. In the Dutch systems, FPB acid was a maximum of 44.5% at 11 days, and FPB-ald) was a maximum of 15.7% at 1 day. In an additional new study with *beta*-cyfluthrin, using a marine sand, the half-life was 27.8 days and the major degradate was FPB acid. In a multiple pyrethroid study, for cyfluthrin half-lives were 10.4 days in a sand, 47.6 days in a clay, and 7.71 days in a sandy clay loam sediments. In the study non-radiolabeled test material was used and the sediment and water were extracted together. In the same study (and same sediments), for *beta*-cyfluthrin, the half-lives were 7.68 days in a sand, 34.1 days in a clay, and 9.76 days in a sandy clay loam sediments. The study suggests that under aerobic aquatic metabolism conditions, both cyfluthrin and *beta*-cyfluthrin degrade with similar half-lives.

An anaerobic aquatic metabolism study was conducted using *beta*-cyfluthrin. In a clay loam sediment the half-life was 26.2 days, while in two sand sediments the half-lives were 9.41-10.3 days. The major degradates were FPB acid and permethric acid (DCVA). A minor degradate was 4-Hydroxy FPB acid. In the same multiple pyrethroid study mentioned in the previous paragraph, for cyfluthrin half-lives were 48.3 days in a sand, 42.4 days in a clay, and 29.2 days in a sandy clay loam sediments. For *beta*-cyfluthrin, the half-lives were 51.8 days in a sand, 22 days in a clay, and 29.2 days in a sandy clay loam sediments. The study suggests that under anaerobic conditions cyfluthrin and *beta*-cyfluthrin degrades at slower rates than under aerobic conditions.

Sorption and Mobility

Cyfluthrin is hydrophobic and was hardly mobile to immobile in four soils (K_d range 1116 to 1793 mL/g; K_{OC} range 73,000 to 180,000 mL/g_{OC}; measurements made at single concentrations, FAO

mobility classification, FAO 2000). The chemical will bind strongly to the soil surfaces. There was a linear relationship between the soil organic carbon content and cyfluthrin K_d values (r^2 = 0.92). The soils included German loamy sand and silty loam, and US loamy sand and clay loam. In a new study, cyfluthrin was immobile in five soils (K_d range 73.8 to 2259 mL/g; K_{OC} range 184458 to 274149 mL/g_{OC}, K_F range 28.7 to 1.4×10^7 $(mL/g_{OC})^{-1/n}$; K_{FOC} range 44749 to 2.3×10^9 $(mL/g)^{-1/n}$; 1/n range 0.84 to 2.02). Soils included a clay, sandy loam, sandy clay loam, silt loam soils, and a sand sediment. There is a strong correlation between the adsorption to soil and %OC (r^2 = 0.997).

At least, some of the degradates formed from the cleavage of the carboxylate ester are expected to be more mobile than the parent. Supplemental data available to the Agency, indicates that the degradate DCVA is mobile to moderately mobile in neutral to alkaline soils (K_{OC} range 14 to 356 mL/g_{OC}, FAO mobility classification).

Even though cyfluthrin may be applied aerially, by ground or Ultra Low Volume (ULV), and drift is possible, the chemical appears to be relatively non-volatile (vapor pressure 1.5×10^{-8} mmHg, Henry's Law Constant 3.7×10^{-6} atm-m^3/mol). Furthermore, cyfluthrin readily binds to soils or partitions with suspended matter and sediment. Thus, volatilization would be greatly reduced.

Terrestrial Field Dissipation Studies

Cyfluthrin, applied on Fairmont, NC sandy soil (sand 90.8%, depth 0-6 inches, 0.33% OM), cropped with cotton, at a rate of 0.55 lb a.i./A, dissipated from the field with a half-life of 18 days (r^2 = 0.94, n = 8), or with a DT_{50} of <32 days. Residues were detected only in the top 6" soil layer. No residues were detected below the top 6" of soil depth (sandy loam, 0.33% OM). There were two single detects of Cl_2CA (≤0.012 ug/g), and eight, mostly single detects of FPBA (≤0.016 ug/g). All values were close to the analytical detection limits. Cyfluthrin dissipated from a cotton site in Fresno, California with a registrant-reported half-life of 4.3 days (using 0-7 day data; or 23.8 days if 0-14 day data are used, but the data point for 14 days was higher than for 7 days). Cyfluthrin was not detected after day 29 post-treatment. The DT_{50} was *ca.* 3 days. Residues remained in top 6" in soil layer, except for two individual samples. FPBA and DCVA were detected in this study. In other terrestrial field dissipation studies, in AZ, FL, KS, GA, OR, MS and Canada different soils, with different organic matter content showed that cyfluthrin (in the form of Baythroid 24% EC), sprayed at 1 kg a.i./ha dissipated with DT_{50}'s of <32 days. In these studies, soil sampling intervals, spaced by 30-32 days were inadequate and prevented accurate half-life calculations. Besides the parent, residues of DCVA and FPB-acid were detected in some studies. Cyfluthrin was detected in the 6-12" cores at levels less than 0.13 mg/Kg in five out of the seven studies.

Bioconcentration

Based on the octanol/ water partition coefficient, cyfluthrin shows a high potential to bioaccumulate ($K_{OW} = 9.33 \times 10^5$). The bioconcentration factor in whole rainbow trout was moderate (854x, whole fish). Residues were depurated at moderately rapid rates in untreated water (apparent depuration half-life of approximately ≤3 days). Accumulated residues were found

mostly in non-edible tissues, and the only residue detected at high levels was the parent compound.

Transformation Products

The fate and transport characterization is also summarized for the various degradation products formed by each process for the studies reviewed in **Table 37**.

Table 37. Summary of Degradate Formation from Degradation of Cyfluthrin and *Beta*-cyfluthrin.

STUDY TYPE	SOURCE	DEGRADATE and MAXIMUM CONCENTRATION		
		F-PB-acid (% app)	**F-PB-ald (% app)**	**DCVA (% app)**
Hydrolysis	MRID: 00131493, 00137539, 45022101	–	11% at 35 days at pH 7, 89% at 21 days at pH 9	–
Aqueous Photolysis	MRID: 00149595, 45022101, 45022102	37% at day 14	18% at day 7	–
Soil Photolysis	MRID: 00137543, 00157043	–	18% at days 5-6	–
Aerobic Soil Metabolism	MRID: 00131494, **49272603, 49272605, 49272606**	13.4% at 7 days	–	42.6% at 7 days
Anaerobic Soil Metabolism	MRID: 00131494, **49272607**, **49272608**	64.9% at 91 days	–	76.9% at 120 days
Aerobic Aquatic Metabolism	MRID: 46824101, **49272609**	86.5% at 103 days	15.7% at 1 day	47.63% at 28 days
Aenarobic Aquatic Metabolism	MRID: **49272610**	76.0% at 100 days		92.3% at 100 days
Terrestrial Field Dissipation	MRID: AN 259211, 42794801, 44822901	<0.07 mg/kg in the 0-6” cores	–	0.16 mg/kg at 30 days

Major degradates identified in laboratory studies are FPB-acid, FPB-ald and DCVA, which result from the rupture of the ester linkage of the synthetic pyrethroid. FPB-acid was identified in the aqueous photolysis, and all the metabolism studies (soil and aquatic), at 13-86% of the applied at 7-103 days after treatment. FPB-ald was observed at significant amounts in photolysis/ photodegradation studies at 18% of the applied of the applied (5-7 days posttreatment) and in hydrolysis studies (up to 89% of the applied at pH 9, but only 11% at pH 7). DCVA was identified in the metabolism studies (soil and aquatic) (>10% of the applied). The degradate DCVA was also identified in field studies at up to 0.16 mg/Kg. A minor metabolite observed in some of the metabolism studies was 4-Hydroxy FPB acid.

There are limited data about the persistence of FPB-ald, FPB-acid and DCVA. While it appears that DCVA is much more mobile than the parent compound and has the potential to reach ground waters in vulnerable sites, there are limited data about its mobility (**Table 38**). DCVA has been detected in laboratory studies at 43-92% of the applied.

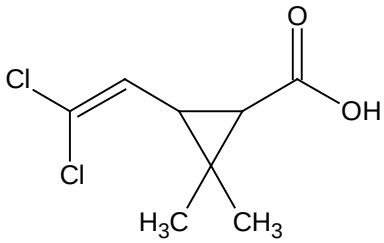
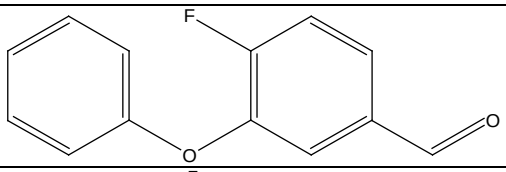
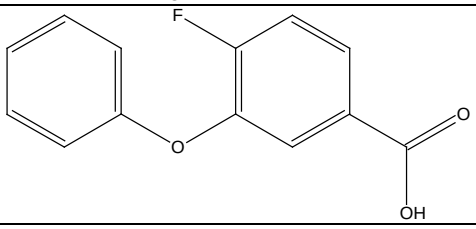
Table 38. Summary of Environmental Fate Parameters for the Degradates *trans*-DCVA and FPB-acid

PARAMETER	VALUE(S) (units)	SOURCE	COMMENT
***trans*-DCVA** Soil Partition Coefficient (K_F) Organic Carbon Partition Coefficient (K_{FOC})	**Adsorption:** Soil / K_F / K_{FOC} Sand / ND / ND Silty Clay / 0.46 / 18 Sandy Loam / 0.16 / 19 Sandy Loam / 0.54 / 48 **Desorption:** Soil / K_F / K_{FOC} Sand / ND / ND Silty Clay / 0.91 / 36 Sandy Loam / 0.36 / 44 Sandy Loam / 0.72 / 64	MRID: 43424901	Provides information to partially fulfill the data requirement.
FPB-acid Soil Partition Coefficient (K_d) Organic Carbon Partition Coefficient (K_{OC}) And Freundlich Partition Coefficient (K_F) Organic Carbon Partition Coefficient (K_{FOC})	**Adsorption:** Soil / K_d / K_{OC} CA SL / 19.63 / 577 ND SCL / 0.68 / 132 IL SiL / 2.48 / 248 **Desorption:** Soil / K_d / K_{OC} ND SCL / 45.78 / 1346 Mobile to highly mobile. K_{OC} in mL/g_{OC} and K_d in mL/g. Strong correlation between the adsorption to soil and %OC (r^2 = 0.995), and CEC (r^2 = 0.992). **Adsorption:** Soil / K_F / K_{FOC} / 1/n CA SL / 14.42 / 424 / 0.66 ND SCL / 0.62 / 119 / 0.80 IL SiL / 1.76 / 176 / 0.56 **Desorption:** Soil / K_F / K_{FOC} / 1/n ND SCL / 22.61 / 665 / 0.62 K_{FOC} (mL/g_{OC})$^{-1/n}$ and K_F (mL/g)$^{-1/n}$.	MRID: **49272601**	Supplemental. Provides information to partially fulfill the data requirement.

ND = Not determined; SL=sandy loam; SCL=sandy clay loam; SiL=silty loam

Even though various degradates were observed in the laboratory studies (*e.g.* FPB-acid and DCVA), it was found that they were the result of the rupture of the ester bond of the parent molecule. It is believed that the toxicity of the resulting molecules is substantially reduced compared to the parent because they presumably have lost the neurotoxic mode of action. **Table 39** shows the chemical structures of cyfluthrin's major degradation products, which were not considered stressors of concern in previous assessments.

Table 39. Major Transformation Products of Cyfluthrin and *Beta*-cyfluthrin

Common Name	Chemical Name	Structure
DCVA (permethric acid)	3-(2,2-dichlorovinyl)-2,2-dimethyl-cyclopropanecarboxylic acid	
FPB-ald	4-fluoro-3-phenoxybenzaldehyde or 3-phenoxy-4-fluorobenzaldehyde	
FPB-acid	4-fluoro-3-phenoxybenzoic acid or 3-phenoxy-4-fluorobenzoic acid	

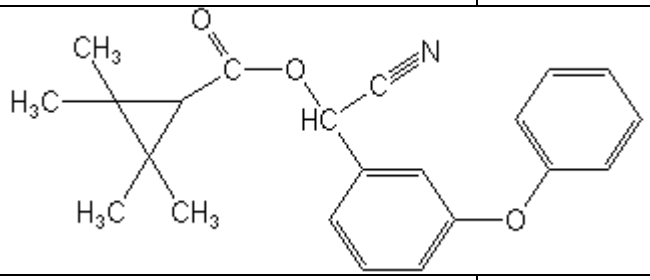
Fenpropathrin

An environmental fate assessment was provided in the Problem Formulation (DP Barcode D371483, dated June 16, 2010). Additionally, in August 2013, a new use assessment was completed (DP Barcode 407810, dated August 27, 2013. The environmental fate assessment is being updated here with several newly submitted studies.

Physical and Chemical Properties

Fenpropathrin (**Table 40**) is a synthetic pyrethroid insecticide and acaricide. Its structure has three rings, two phenyl rings attached to each other by an oxygen atom, and a cyclopropyl ring. It is a Type II synthetic pyrethroid (it is cyano-substituted in the alpha position). The chemistry of fenpropathrin may be dictated by its ester moiety. It would be expected to hydrolyze as the pH increases; this is confirmed by the hydrolysis study results. The structure of the molecule has one chiral center that could result in 2 stereoisomers. Chemically, it is the racemic mixture of both stereoisomers. Fenpropathrin is 2,2,3,3-tetramethyl substituted in the cyclopropyl ring.

Table 40. Summary of physicochemical properties of fenpropathrin.

PARAMETER	VALUE(S) (units)	SOURCE
CAS Chemical Name	cyano(3-phenoxyphenyl)methyl 2,2,3,3-tetramethylcyclopropanecarboxylate	Fenpropathrin data sheet: http://www.alanwood.net/pesticides/index_cn_frame.html accessed 12/29/2015
IUPAC Chemical Name	(RS)-α-cyano-3-phenoxybenzyl 2,2,3,3-tetramethylcyclopropanecarboxylate	
PC Code	127901	OPP Databases
Chemical Structure (from chemical's data sheet)		
Appearance	It is an off-white to pale tan waxy solid with a faint, slightly sweet smell.	
CAS Reg. No.	64257-84-7	Laskowski, 2002[2]
Molecular Weight	349.4	Laskowski, 2002[2]
Melting Point	25-50ºC	
Solubility (25ºC)	0.0103 mg/L or 10.3 µg/L 'Not Soluble' according to FAO solubility classification.	Laskowski, 2002[2] FAO, 2000[3]
Vapor Pressure (25ºC)	1.39×10^{-8} mmHg (by extrapolation) 'Not volatile under field conditions.'	Laskowski, 2002 USEPA, 2008
Henry's Law Constant	6.2×10^{-7} atm-m^3/mol (from vapor pressure and water solubility)	Laskowski, 2002
Octanol-Water Partition Coefficient (20ºC) (log K_{OW} and K_{OW})	6.00 and 1.00×10^6	Laskowski, 2002
Octanol-Air Partition Coefficient, K_{OA} (Log K_{OA})	$K_{OA} = \frac{K_{OW}}{K_{AW}} = \frac{K_{OW} RT}{\text{Henry's Law Constant}} = 3.9 \times 10^{10}$ (10.6) *vs.*	Calculated Value vs. EPISuite v.4.0 Estimate

PARAMETER	VALUE(S) (units)	SOURCE
	3.19×10^9 (9.505)	
C_{water}/C_{air}	$\frac{C_{water}}{C_{air}} = \left(\frac{S \times T \times R \times 760}{P \times GMW \times 10^6}\right)$ = 3.9×10^4 (unitless) Slight volatile from a water surface.	Calculated USEPA, 2008[4]
$C_{water+soil}/C_{air}$[5]	$C_{water+soil}/C_{air} = (C_{water}/C_{air})(1/r + K_d) =$ $(3.9 \times 10^4)(1/6 + 1698) = 6.7 \times 10^7$ Classified as 'non-volatile from a moist soil.'	Calculated USEPA, 2008[4]
OH Radical Reaction Half-life	0.599 days	EPISuite v.4.0 Estimate
Biomagnification Potential	Presumption: If log K_{OA} > 5, log K_{OW} >2 and the rate of chemical transformation is low, the chemical may biomagnify in terrestrial food chains.** For fenpropathrin, log K_{OA}> 5, log K_{OW}>2 and rate of transformation is slow in the environment and appears to be relatively slow in fish, with slow depuration; it appears that bifenthrin has *a potential to biomagnify* in terrestrial food chains.	**Gobas *et al.* 2003[6] and Armitage & Gobas, 2007[7] support this presumption utilized here only as a broad reference to determine the potential for biomagnification.

1 As cited in the EXTOXNET database.
2 Laskowski, D.A., 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 2002; 174:49-170.
3 Food and Agriculture Organization of the United Nations. FAO PESTICIDE DISPOSAL SERIES 8. Assessing Soil Contamination: A Reference Manual. Appendix 2. Parameters of pesticides that influence processes in the soil. Editorial Group, FAO Information Division: Rome, 2000. http://www.fao.org/DOCREP/003/X2570E/X2570E00.htm (accessed 04/28/2015).
4 USEPA. 2008. *OPPTS 835.6100 Terrestrial Field Dissipation.* EPA 712-C-08-020. October 2008. Office of Prevention, Pesticides, and Toxic Substances. United States Environmental Protection Agency. Available at http://www.epa.gov/ocspp/pubs/frs/publications/Test_Guidelines/series835.htm (accessed 04/28/2015). Also, USEPA 2010: http://www.epa.gov/pesticides/science/efed/policy_guidance/team_authors/endangered_species_reregistration_workgroup/esa_reporting_fate.htm (accessed 05/12/2015).
5 Assuming 2% organic carbon, soil to soil water ratio (w/w) = 6, and soil water to soil air (v/v) = 1.
6 Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.
7 Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

Fenpropathrin has a moderately high molecular weight of 349.4 g/mol. It shows a small solubility (0.0103 ppm) and a high octanol/ water partition coefficient ($K_{OW} = 1.00 \times 10^6$). Based on it octanol/water partition coefficient, it appears that fenpropathrin has the potential to bioaccumulate/ bioconcentrate. With a relatively low vapor pressure (1.39×10^{-8} mmHg), combined with its solubility, its calculated Henry's Law Constant is relatively low (6.2×10^{-7} atm-m^3/mol). In addition, its C_{water}/C_{air} is 38,752, which classifies it at "slightly volatile from a water surface" (USEPA 2008). The potential to volatilize for fenpropathrin may be attenuated by its tendency to bind to organic matter (*e.g.*, soils, sediments or organic matter in the water). For fenpropathrin, the log K_{OA} is 9.5 to 10.6 (EPISuite v.4.0 estimate to calculated), the log K_{OW} is 6.00 and the rate of transformation appears to be low in the environment and moderate in fish; it appears that fenpropathrin could have *a potential* to biomagnify in terrestrial food chains, based on the presumption made by Gobas *et al.* and Armitage & Gobas in articles published in 2003 and 2007, respectively (refer to **Table 40**). Even though EFED has not adopted an official reference or guideline to distinguish chemicals that biomagnify, Gobas *et al.* and Armitage & Gobas' presumption was utilized here as a general or broad reference to detect the potential for biomagnification in terrestrial food chains.

For fenpropathrin, the log K_{OA} range is 9.505 to 10.6 (calculated and EPISuite v.4.0 estimate), the log K_{OW} is 6 and the rate of transformation is slow in the environment and appears to be relatively slow in fish, with slow depuration; it appears that fenpropathrin may have *a potential* to biomagnify in terrestrial food chains, based on the presumption made by Gobas *et al.* and Armitage & Gobas, in 2003 and 2007 articles, respectively[61]. Even though the EFED has not adopted an official reference or guideline to distinguish chemicals that biomagnify, Gobas *et al.* and Armitage & Gobas' presumption was utilized here as a general or broad reference to identify the potential for biomagnification in terrestrial food chains.

Degradation and Metabolism

Fenpropathrin is stable to hydrolysis at acidic to neutral pH, but labile at alkaline pH, degrading relatively quickly (half-lives 14.3-17.1 days) to four major degradates (tetramethylcyclopropane carboxylic acid (TMPA), $CONH_2$-fenpropathrin, TMPA-carboxamide, and 3-phenoxybenzoic acid (PB-acid)) at pH 9. TMPA and PB-acid are themselves persistent, and (unlike the parent) are expected to be mobile in the soil due to the presence of a carboxylic acid moiety. Of these four degradates only $CONH_2$-fenpropathrin was detected in terrestrial field dissipation studies, though the additional degradates desphenylpropathrin and 4'-OH-fenpropathrin were also detected. Fenpropathrin also degrades via aqueous photolysis (half-life =0.125 days) and is relatively stable to soil photolysis, with a single major degradate ($CONH_2$-fenpropathrin) formed at >10% of applied radioactivity in the dark control only.

Mobility and Sorption

Fenpropathrin has low volatility, thus volatilization is not a significant loss or transport pathway. Fenpropathrin is classified as hardly mobile under the FAO system, with K_d values ranging from 64-810 mL/g, and K_{oc} values from 13870-85260 mL/g_{oc} in a supplemental study. The compound has low solubility in water (10.3 ppb at 25°C), and a high octanol-water partition coefficient (K_{ow} of 1.00×10^6).

Fenpropathrin can be spray applied by ground or aerially on agricultural settings. A buffer region is label recommended (150 ft for aerial applications that do not use ULV); however, under a high end drift scenario (*e.g.* small droplets and/ or high wind speed), substantial amounts of the chemical can reach adjacent bodies of water via spray drift. In addition, substantial fractions of the applied fenpropathrin should be available for runoff for several weeks to several months after application. Due to its low solubility (10.3 ppb) and high level of binding (K_{OC} values ranging from 114,640 to 303,212 L/kg) it appears that most fenpropathrin bifenthrin would remain associated to the soils during run-off events, and that the chemical would reach surface waters if the run-off event is accompanied by erosion; however, transport of the chemical when dissolved in water is not precluded. A recent study suggests that dissolved organic carbon (DOC) present in sediments may facilitate the desorption of sediment-sorbed pyrethroids (forming dissolved

[61] Armitage, J.M., & Gobas, F.A.P.C. 2007. A terrestrial food-chain bioaccumulation model for POPs. *Environmental Science and Technology, 41*, 4019-4025.

Gobas, F.A.P.C., B.C. Kelly and J.A. Arnot. 2003. Quantitative structure activity relationships for predicting the bioaccumulation of POPs in terrestrial food webs. QSAR Comb. Sci. 22:329-336.

pyrethroid-DOC complexes). Such enhanced desorption in the presence of DOC may enhance the mobility of pyrethroids in streams and by extension, in soils via runoff containing high amounts of DOC (e.g., Delgado-Moreno et al 2010).

Once fenpropathrin reaches surface water, the fate of the chemical is of concern since fenproathrin is toxic to fish and aquatic invertebrates. The Agency believes that a high percentage of fenpropathrin would remain bound to the sediments and would dissolve only very slowly into the water column. Organisms that live near the sediments may be particularly at risk. The sediments may serve as reservoirs or repositories of fenpropathrin, where it appears that it will persist.

Fenpropathrin is not likely to reach subsurface soil environments or ground waters. Various terrestrial field dissipation studies confirm that fenpropathrin remains mostly in the upper soil level.

Table 41. Summary of Fenpropathrin Environmental Fate Properties

Study	Value and unit[1]	Major Degradate[2]	MRID # (or Citation)	Study Classification, Comment
Abiotic Hydrolysis Half-Life	25ºC pHs 6-8: stable pH 5 and pH 7: stable pH 9: 14.3-17.1 days (SFO)	TMPA, $CONH_2$-fenpropathrin, TMPA-carboxamide, 3-PBA	131438, 141320, 42599901	Acceptable
Atmospheric Degradation Half-Life	0.599 days (hydroxyl)	N/A	N/A	Estimated EPISUITE v.4.1[62]
Direct Aqueous Photolysis Half-life	25ºC 0.125 days (SFO)	TMPA, dicarboxy-fenpropathrin 3-PBA	MRID 49491401	Supplemental. Up to 45.2% remaining at the end of the study. Sorption to flask walls occurred. Systems were staggered.
	24ºC Stable (buffer contained 8% acetonitrile). Samples exposed to sunlight in CA.	NA	MRID 42546401	Limited supplemental data (MRID 137769): 16.2 weeks (~113 days) in distilled water containing an emulsifier (PBA, TMPA and decarboxy-fenpropathrin were major). 2-7 weeks in natural river and sea waters fortified with 1 ppm humic acid. 1.6 days in 2% acetone solution.

[62] In order to make these estimates, there are certain assumptions made by the module of EPISUITE, which represent a typical hydroxyl and ozone reaction in the atmosphere (refer to AOPWIN module at http://www.epa.gov/opptintr/exposure/pubs/episuite.htm accessed 04/28/2015).

Study	Value and unit[1]	Major Degradate[2]	MRID # (or Citation)	Study Classification, Comment
Soil Photolysis	21ºC Relatively stable in silt loam (≤10% degradation in 30 days; samples were irradiated with natural sunlight in CA)	$CONH_2$-fenproathrin	137769, 42546402	In a supplemental study, 3.8-10.3 days in irradiated samples *vs.* 36.6-155 days in dark controls (light clay, SL & SCL). $CONH_2$-fenpropathrin observed in both irradiated and dark control samples. Samples were irradiated with natural sunlight.
Aerobic Soil Metabolism Representative Model Input Half-life	25ºC: Parent only: 155 day (SFO), silt loam Parent plus unextracted 248 day (SFO), silt loam	*Only minor degradates observed*	41525902	Acceptable
	20ºC Parent only: 387 day (DFOP), silt loam 718 day (DFOP), sandy loam 826 day (DFOP), loamy sand Parent plus unextracted 633 day (DFOP), silt loam 1060 day (DFOP), sandy loam 2030 day (DFOP), loamy sand	3-PBA, CO_2	49316001	Supplemental. Unextracted residues were greater than 10% applied radioactivity and a range of solvents was not utilized to fully extract all residues.
Anaerobic Soil Metabolism Representative Model Input Half-life	25ºC 186 days (SFO), loam	3-PBA	42546403	Acceptable
	20ºC 110 (DFOP), silt loam 187 (DFOP), loamy sand 269 (DFOP), sandy loam 129 (SFO), silt loam			Supplemental. Pesticide source was unknown and it was not confirmed that the soil was pesticide free. Unextracted residues were up to 23% in one soil.
Aerobic Aquatic Metabolism Representative Model Input Half-life	20ºC Parent only: 2140 (IORE), silt loam 297 (IORE), silt loam 88.7 (SFO), sand Parent plus unextracted: 48300 (IORE), silt loam 44600 (IORE), silt loam 818 (DFOP), sand	TMPA, 3-PBA, 4OH-fenpropathrin, CO_2	49316003	Supplemental. Redox was not reported. Unextracted residues >10% applied radioactivity and a range of solvents were not utilized to increase the amount of radioactivity extracted.
Anaerobic Aquatic Metabolism Representative Model Input Half-life	25ºC Parent only: 67.5 days (SFO), loam	TMPA	MRID 44370004	Supplemental. Purified water and agricultural soil were used in the study rather than natural water and sediment. Redox potentials of the water and soil were not measured separately.

Study	Value and unit[1]	Major Degradate[2]	MRID # (or Citation)	Study Classification, Comment
	25ºC Parent only: 79.7 days (SFO), loam	3-PBA	MRID 44370003	Supplemental. Purified water and agricultural soil were used in the study rather than natural water and sediment. Redox potentials of the water and soil were not measured separately.
	20ºC 1250 days (DFOP), silt loam	TMPA, 3-PBA, CO_2	MRID 49316004	Supplemental. Type of redox probe was not reported. Not enough information to determine whether system was oxic or suboxic.
Solid-water distribution coefficient (K_d)	K_d = 3783 L/kg, sandy clay loam (3.3% OC) 2730 L/kg, loamy sand (0.92% OC) 1698 L/kg, clay loam (3.3% OC) 3690 L/kg, sandy loam (0.56% OC) 2235 L/kg, clay, (1.2%OC)	N/A	MRID 49541801	Supplemental. Overall recoveries were outside acceptable limits (>110%). A desorption phase was not conducted.
Organic-carbon normalized distribution coefficient (K_{OC})	Mean K_{OC} = 236,750 L/kg_{OC} 114640 L/kg, sandy clay loam 296784 L/kg, loamy sand 136916 L/kg, clay loam 303212L/kg, sandy loam 186248 L/kg, clay			
Terrestrial Field Dissipation	144 days WA (apples) 8 days NY (apples) 14 days CA (grapes) 95 days MS (cotton) 17 days CA (bare)	$CONH_2$-fenpropathrin	MRID 41679601, 41525905, 41525904, 42311401, 42311402	Acceptable
Bioconcentration Factor (BCF) – Bluegill Sunfish	Bluegill Sunfish (Lepomis macrochirus) Total radioactivity BCF= 200 L/kg wet wt fillet 830 L/kg wet wt whole fish 1400 L/kg wet wt viscera	3-PBA, TMPA, others	MRID 00153802, 00161672, 00161673, 00163521	Supplemental. Fish were not exposed to a constant concentration of fenpropathrin. BCF values were reported based on total radioactivity which included residues of parent and degradates.
POTW Treatability Study	Removal percent for fenpropathrin: Primary Settling LR Aerobic Chamber 80.1% Anaerobic Digestion 45.5% Ultrafiltration 95.7%	MRID: 48762906	Supplemental; POTW treatability study of eight pyrethroids.	

Abbreviations: wt=weight, TRR=total residue recovered, OC=organic carbon; SFO=single first order; IORE=indeterminate order rate equation; DFOP=double first order in parallel

1 Half-lives were calculated using the single-first order (SFO) equation and nonlinear regression, unless otherwise specified. When the Representative Model Input Half-life is reported, values were calculated according to the most recent guidance recommendations for calculating degradation kinetics (http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-calculate-representative-half-life-values). The kinetic model used to calculate the

value is shown. This value may be different from the observed time to 50% decline but is a conservative single first order model input.
2 See Table 43 for an explanation of abbreviations for transformation products.

Terrestrial Field Dissipation

Results from five terrestrial field dissipation studies conducted in Washington, California, New York and Mississippi showed that fenpropathrin remains in the upper layers of soil (upper 7.5 or 15 cm). However, reported half-lives showed a wide range from 8 to 144 days. The registrant has provided no valid reason for the differences in the persistence of fenpropathrin under laboratory and field conditions or between similar terrestrial field dissipation studies. Detailed comparison of two apple orchard studies conducted in Washington and New York did not provide conclusive evidence for the differences in reported half-lives. The different half-lives for the field dissipation studies might be due to different environmental conditions that affect dissipation or degradation mechanisms such as soil photolysis or aerobic soil metabolism.

Although the major route of dissipation of fenpropathrin in the field remained unidentified, terrestrial field dissipation studies indicate that fenpropathrin dissipates at moderate rates in the field; fairly quickly in some instances (half-lives 8, 14 and 17 days, for studies conducted on cropped apple orchard, grapes and bareground, respectively) and more slowly in other instances (95 and 144 days in two other studies, on cotton and apples, respectively). The observed differences in the rate of dissipation of fenpropathrin in the field could be due to a number of variables such as geographical location, climatic conditions, and microbial population of the soil at different test sites; these variables affect the dissipation processes (such as photolysis, microbial degradation, and irreversible binding to the soil) some or all of which could be involved in the dissipation of the chemical in the field.

The data from the field studies clearly indicate that fenpropathrin and its degradate $CONH_2$-fenpropathrin are likely to remain in the upper layers of the soil and show no potential to leach in ground waters due to their high adsorption and low mobility in soil. However, residues of fenpropathrin and its major degradate may reach surface waters bound to soil particles during rain events accompanied by erosion.

Bioconcentration

Fenpropathrin residues accumulated in bluegill sunfish, with bioconcentration factors reflecting total radioactivity of 200x, 830x, and 1400x in fillet, whole fish and viscera, respectively. Accumulated residues depurated rapidly from the viscera, but relatively slowly from the fillet (65 and 5% depurated after 3 days, respectively).

In the tissue, [^{14}C]-residues were 42-81% fenpropathrin, 3.6-6.5% α-cyano-3-phenoxybenzyl-2-hydroxymethyl-2,3,3-trimethylcyclo-propanecarboxylate, 0.9-13.4% PBA, 0.8-7.8% 3-(4-hydroxyphenoxy)benzoic acid, 2.9-15.4% TMPA, 2.2-12.6% 2-carboxy-2,3,3-trimethylcyclopropanecarboxylic acid, and 0.3-2.5% 2-hydroxymethyl-2,3,3-trimethylcyclopropanecarboxylic acid.

These BCF values are lower than what would be predicted based on K_{OW} alone[63], suggesting that some metabolism or active elimination is occurring in fish. This may not be as likely to occur in aquatic invertebrates.

Transformation Products

Table 42 is a summary of degradate formation for fenpropathrin. **Table 43** provides the structures and abbreviatioons of these degradates. The following major transfoormation products (present at greater than 10% applied radioactivity) were observed in laboratory fate studies[64]:

- TMPA,
- CONH2-fenpropathrin,
- TMPA carboxamide,
- 3-PBA,
- 4-OH fenpropathrin,
- Dicarboxy fenpropathrin,
- Carbon dioxide.

TMPA and 3-PBA were present at up to 84% and 67% of applied radioactivity, respectively. CONH2-fenpropathrin was observed in upper soil layers in terrestrial field dissipation studies.

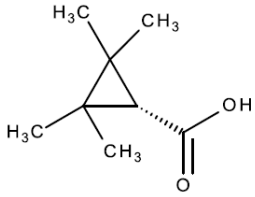
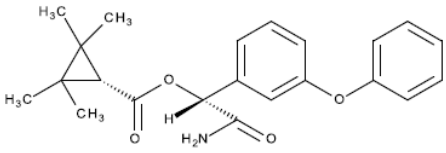
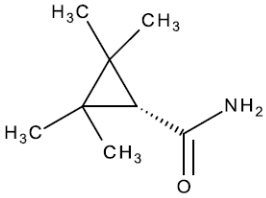
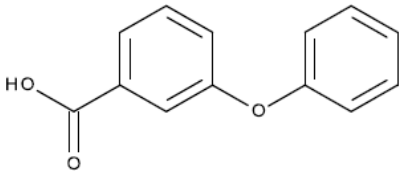
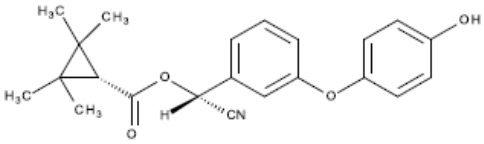
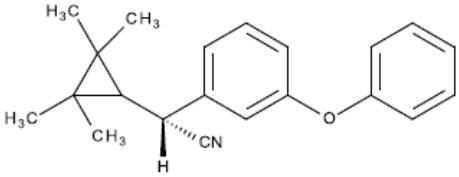
Table 42. Summary of major degradate formation from degradation of fenpropathrin in laboratory studies.[1]

Fate study MRID #	Maximum Percent applied radioactivity associated with each degradate						
	TMPA	$CONH_2$-Fenpropathrin	TMPA Carboxamide	3-PBA	4-OH fenpropathrin	Decarboxy-fenpropathrin	CO_2
Hydrolysis 42599901	43	13	13	64	--	--	--
Aqueous Photolysis 42546401/ 49491401	11	--	--	20	--	12	--
Soil Photolysis 42546402	--	11	--	--	--	--	0.1
Aerobic Soil 49316001/ 41525902	--	--	--	35	--	--	16
Anaerobic Soil 49316002/ 42546403	67	--	--	50	--	--	11
Aerobic Aquatic 49316003	46	--	10	25	16	--	13
Anaerobic Aquatic 44370003/ 44370004/ 49316004	84	--	--	67	--	--	5

1 Abbreviations are defined in Table 43

[63] KABAM estimated a BCF for fish ranging from 48051 to 57470 L/kg-ww.
[64] See Table 43 for an explanation of abbreviations for transformation products.

Table 43. Structures of Transformation Products of Fenpropathrin

Common Name	Chemical Name	Structure
TMPA	2,2,3,3-Tetramethylcyclopropanecarboxylic acid	
$CONH_2$-fenpropathrin	(RS)-α-Carbamoyl-3-phenoxybenzyl 2,2,3,3-tetramethylcyclopropanecarboxylate	
TMPA-carboxamide	2,2,3,3-Tetramethylcyclopropanecarboxamide	
3-PBA	3-Phenoxy-benzylaldehyde	
4'-OH-Fenpropathrin	(RS)-α-Cyano-3-(4-hydroxyphenoxy)benzyl 2,2,3,3-tetramethyl-cyclopropanecarboxylate	
Decarboxy fenpropathrin	(2R)-2-(3-phenoxyphenyl)- 2-(2,2,3,3-tetramethylcyclopropyl)acetonitrile	

Attachment IV. Comprehensive Aquatic Toxicity Profiles for Pyrethroids and Pyrethrins

Chemical Names	**PC Codes**
Pyrethrins	069001
Permethrin	109701
Bifenthrin	128825
Cyfluthrin	128831
Beta-cyfluthrin	118831
Lambda-cyhalothrin	128897
Gamma-cyhalothrin	128807
Cypermethrin	109702
Alpha-cypermethrin	209600
Zeta-cypermethrin	129064
Deltamethrin	097805
Esfenvalerate	109303
Fenpropathrin	127901

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Table 1. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Bifenthrin

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value	Citation or MRID # (Author, Date)	Study Classification (Comment)
Freshwater Fish and Amphibians				
Rainbow Trout *Oncorhynchus mykiss* (88.4%)	LC_{50} (Acute, 96-h, FT/M)	**0.15 µg a.i./L** (C.L.= 0.102-0.191; Slope = 3.53)	00163156 (Hoberg, 1983)	Supplemental
Bluegill Sunfish *Lepomis macrochirus* (88.4%)	LC_{50} (Acute, 96-h, FT/M)	0.35 µg a.i./L (C.L.= 0.31-0.30; Slope = 8.9)	00132536 (Hoberg, 1983)	Acceptable
Freshwater Invertebrates (Water Column)				
Water Flea *Daphnia magna* (88.4%)	LC_{50} (Acute, 48-h, FT/M)	1.5 µg a.i./L (C.L.= 1.3-1.9; Slope = 1.7)	00132537 (Surprenant, 1983)	Acceptable (no observed effects at 0.6 µg a.i./L)
Water Flea *Daphnia magna* (97%)	NOAEC LOAEC (Chronic, 21-d	0.0013 µg a.i./L 0.0029 µg a.i./L	41156501 (Burgess, 1989)	Acceptable Based on significant effects on reproduction and growth
Amphipod *Hyalella azteca* (93.6%)	EC_{50} (Acute, 96-h, FT/M)	**0.493 ng a.i./L** (C.L.= 0.42-0.58; Slope = 7.3)	49552201 (Bradley, 2013)	Acceptable (no observed effects up to 0.28 ng ai/L)
Freshwater Invertebrates (Sediment)				
Amphipod *Hyalella azteca* (95.7%)	(Subchronic, 10-d) NOAEC LOAEC NOAEC LOAEC NOAEC LOAEC	<u>Pore Water</u>:-[3] **0.05 ng a.i./L** 0.09 ng a.i./L <u>Sediment dry weight:</u> **0.25 µg a.i./kg-dw** 0.45 µg a.i./kg-dw <u>Sediment OC</u>: 12 µg a.i./kg-OC 21 µg a.i./kg-OC	48593601	Acceptable (Significantly reduced amphipod growth in formulated sediment.)
Amphipod *Hyalella azteca* (93.6%)	(Subchronic, 10-d) NOAEC LOAEC NOAEC LOAEC NOAEC LOAEC	<u>Pore Water</u>:-[3] 0.95 ng a.i./L 2.0 ng a.i./L <u>Sediment dry weight:</u> 7.0 µg a.i./kg-dw 15 µg a.i./kg-dw <u>Sediment OC</u>: 230 µg a.i./kg-OC 480 µg a.i./kg-OC	49368101	Acceptable (Significantly reduced growth in natural sediment)

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value	Citation or MRID # (Author, Date)	Study Classification (Comment)
Amphipod *Hyalella azteca* (TEP conventional polymer; 19.24%)	(Subchronic, 10-d) NOAEC LOAEC NOAEC LOAEC	<u>Sediment dry weight:</u> 0.35 µg a.i./kg-dw 0.54 µg a.i./kg-dw <u>Sediment OC</u>: 13 µg a.i./kg-OC 21 µg a.i./kg-OC	49695302 (Thomas, 2015)	Supplemental (Quantitative) (Significantly reduced amphipod survival in formulated sediment)
Amphipod *Hyalella azteca* (TEP nano polymer; 19.24%)	(Subchronic, 10-d) NOAEC LOAEC NOAEC LOAEC	<u>Sediment dry weight:</u> 0.25 µg a.i./kg-dw 0.49 µg a.i./kg-dw <u>Sediment OC</u>: 9.8 µg a.i./kg-OC 19 µg a.i./kg-OC	49695301 (Thomas, 2015)	Supplemental (Quantitative) (Significantly reduced amphipod survival in formulated sediment)
Amphipod *Hyalella azteca* (TEP nano polymer; 19.6%)	(Subchronic, 10-d) NOAEC LOAEC NOAEC LOAEC	<u>Sediment dry weight:</u> 0.13 µg a.i./kg-dw 0.23 µg a.i./kg-dw <u>Sediment OC</u>: 4.5 µg a.i./kg-OC 8.1 µg a.i./kg-OC	49462202 (Thomas, 2014)	Supplemental (Qualitative) (Significantly reduced amphipod survival and growth in formulated sediment)
Midge *Chironomus dilutus* (95.7%)	(Subchronic, 10-d) NOAEC LOAEC NOAEC LOAEC NOAEC LOAEC	<u>Pore Water</u>:[3] 20 ng a.i./L 37 ng a.i./L <u>Sediment dry weight:</u> 110 µg a.i./kg-dw 200 µg a.i./kg-dw <u>Sediment OC</u>: 4,800 µg a.i./kg-OC 8,700 µg a.i./kg-OC	48593602 (Picard, 2010)	Acceptable (Significantly reduced midge survival in formulated sediment)

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value	Citation or MRID # (Author, Date)	Study Classification (Comment)
Amphipod *Hyalella azteca* (93.6%)	Chronic Life Cycle (42-d) NOAEC LOAEC NOAEC LOAEC NOAEC LOAEC	<u>Pore Water</u>:[3] 0.97 ng a.i./L 2.1 ng a.i./L <u>Sediment dry weight:</u> 11 µg a.i./kg-dw 24 µg a.i./kg-dw <u>Sediment OC</u>: 230 µg a.i./kg-OC 500 µg a.i./kg-OC	49277501 (Picard, 2013)	Acceptable (Significant reduction of amphipod reproduction in natural sediment)
Midge *Chironomus dilutus* 93.6%)	Chronic Life Cycle (63-d) NOAEC LOAEC NOAEC LOAEC NOAEC LOAEC	<u>Pore Water</u>: [3] 6.9 ng a.i./L 14 ng a.i./L <u>Sediment dry weight:</u> 46 µg a.i./kg-dw 93 µg a.i./kg-dw <u>Sediment OC</u>: 1,600 µg a.i./kg-OC 3,300 µg a.i./kg-OC	49277502 (Picard, 2013)	Acceptable (Significant reduction of midge growth in formulated sediment)
Estuarine/Marine Fish				
Sheepshead Minnow *Cyprinodon variegatus* (88.4%)	LC_{50} (Acute, 96-h, FT/M)	**17.8 µg a.i./L** (C.L.= 14.6-21.1 µg/L)	00163101 (Barrows, 1986)	Acceptable (no observed effects up to 5.2 µg a.i./L)
Sheepshead Minnow *Cyprinodon variegatus* (93.6%)	115-d NOAEC 115-d LOAEC	**0.1 µg a.i./L** 0.14 µg a.i./L	49412101	Acceptable (Based on significant reduction in fecundity and increase in F0 time to hatch)
Estuarine/Marine Invertebrates (Water Column)				
Mysid Shrimp *Americamysis bahia* (88.4%)	LC_{50} (Acute, 96-h, FT/M)	**0.00397 µg a.i./L** (C.L. = 0.0031-0.0050)	00163102 (Barrows, 1986)	Acceptable (15% mortality observed at lowest test concentration of 0.0025 µg a.i./L)
Mysid Shrimp *Americamysis bahia* (93.6%)	LC_{50} (Acute, 96-h, FT/M)	0.00445 µg a.i./L (C.L.= 0.0025-0.0062; Slope = 3.9)	49060102 (Fournier, 2013)	Acceptable (5% mortality observed at 0.79 ng ai/L)
Mysid Shrimp *Americamysis bahia* (93.6%)	28-d NOAEC 28-d LOAEC	0.0016 µg a.i./L >0.0016 µg a.i./L	49412102 (Boeri & Ward, 1991)	Supplemental No significant adverse effects at the highest test concentration

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value	Citation or MRID # (Author, Date)	Study Classification (Comment)
Eastern Oyster, C*rassostrea virginica* (88.4%)	EC_{50} (Acute, 96-h, FT/M)	>2.15 µg a.i./L	00163103 (Ward, 1986)	Supplemental (< 50% inhibition of shell growth at all test concentrations)
Eastern Oyster, C*rassostrea virginica* (88.4%)	EC_{50} (Acute, 48-h, FT/M)	285 µg a.i./L	40383501 (Ward, 1987)	Acceptable (adverse effects observed on oyster larvae at ≥ 126 ppb)
Amphipod *Leptocheirus plumulosus* (96.4%)	Chronic Life Cycle (28-d) NOAEC LOAEC NOAEC LOAEC NOAEC LOAEC	Pore Water:[3] **<0.0006 µg a.i./L** 0.0006 µg a.i./L Sediment dry weight: **<5.4 µg a.i/kg-dw** 5.4 µg a.i/kg-dw Sediment OC: <132 µg a.i/kg-OC <132 µg a.i/kg-OC	46591501, 48762901	Supplemental (upgrade in review) Significantly reduced amphipod reproduction
Aquatic Plants				
Duckweed *Lemna gibba* (93.6%)	(7-d, SR/M) EC_{50} NOAEC	>330 µg a.i./L 330 µg a.i./L	49134901 (Soucy, 2013)	Acceptable (No significant effects observed at the limit concentration)
Freshwater Diatom *Navicula pelliculosa* (93.6%)	(96-h S/M) EC_{50} NOAEC	>370 µg a.i./L 370 µg a.i./L	49116101 (Soucy, 2013)	Acceptable (No significant effects observed at the limit concentration)
Freshwater Green Alga, *Pseudokirchneriella subcapitata.*	(96-h S/M) EC_{50} NOAEC	>380 µg a.i./L 380 µg a.i./L	49098201 (Soucy, 2013)	Acceptable (No significant effects observed at the limit concentration)
Marine Diatom *Skeletonema costatum* (93.6%)	(96-h S/M) EC_{50} NOAEC	>290 µg a.i./L 290 µg a.i./L	49098202 (Soucy, 2013)	Acceptable (No significant effects observed at the limit concentration)
Freshwater Cyanobacterium, *Anabaena flos-aquae*,	(96-h S/M) EC_{50} NOAEC	>430 µg a.i./L 430 µg a.i./L	49060101	Acceptable (No significant effects observed at the limit concentration)

Bolded endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.
[1] all test materials are TGAI unless otherwise noted.
[2] S= static; SR= static renewal; FT = flow through; M= measured concentrations
[3] Concentrations in pore water estimated using mean K_{OC} of 236800 L/kg-OC and % TOC in sediment from the study.

Table 2. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Deltamethrin

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Freshwater Fish and Amphibians				
Pumpkinseed Sunfish, *Lepomis gibbosus* (TGAI)	LC_{50} (Acute, 96-h)	0.58 (0.51 - 0.67)	00060721 (Knauf, 1977)	Supplemental (100% mortality ≥ 0.65 ppb)
Bluegill Sunfish *Lepomis macrochirus* (99.3%)	LC_{50} (Acute, 96-h, S/U)	1.4 (1.0 - 1.8)	00158275 (McAllister et al., 1986)	Acceptable (No sublethal effects ≤ 0.41 ppb)
Rainbow Trout, *Oncorhynchus mykiss* (99.3%)	LC_{50} (Acute, 96-h, S/U)	0.91 (0.66 - 1.3)	00158274 (McAllister & Bowman, 1986)	Acceptable (Sublethal effects ≥ 0.2 ppb)
(99.2%)	LC_{50} (Acute, 96h, S/M)	**0.15** (0.11-0.18)	48393201 (Sousa, 1990)	Supplemental (Sublethal effects ≥ 0.072 ppb)
(TEP, 25.8%)	LC_{50} (Acute, 96-h, S/M)	0.85 (0.72 – 1.0)	48258207 (Dorgerloh, 2008)	Acceptable (Sublethal effects ≥ 0.173 ppb a.i.)
(TEP, 2.5%)	LC_{50} (Acute, 96-h, FT/M)	0.25 (0.22 – 28)	41651013 (Sousa, 1990)	Acceptable (Sublethal effects ≥ 0.17 ppb a.i.)
(Metabolite, AE F108565)	LC_{50} (Acute, 96-h, S/M)	69 mg/L	48258209	Acceptable (Sublethal effects ≥ 22.5 ppm)
Fathead minnow, *Pimephales promelas* (95%)	NOAEC LOAEC (Chronic, ELS)	0.022 0.036	42114814 (Sousa, 1991)	Acceptable (Reduced growth)
(95%)	NOAEC LOAEC (Chronic, LC)	**0.017** 0.035	42786801 (Dionne, 1993)	Acceptable (reduced growth - females)
Freshwater Invertebrates (Water Column)				
Amphipod, *Hyalella azteca* (99.5%)	LC_{50} (Acute, 96-h, FT/M)	**0.2 ng a.i./L** (0.06-0.46)	49191301 (Bradley, 2013)	Acceptable (No sublethal effects ≤ 0.061 ng ai/L)
Water flea, *Daphnia magna* (>95%)	LC_{50} (Acute, 48-h, FT/M)	0.57 (0.44-0.79)	44928701 (Putt, 1999)	Supplemental (Sublethal effects ≥ 0.11 ppb)
(99.3%)	LC_{50} (Acute, 48-h, S/U)	3.5 (0.06-0.46)	00158276 (Forbis & Frazier 1986)	Acceptable (No sublethal effects ≤ 1.8 ppb)
(TEP 2.8%)	EC_{50} (Acute, 48-h, SR/M)	0.064 (0.052-0.077, slope= 2.9)	48258204 (Bruns, 2009)	Acceptable (Sublethal effects ≥ 0.027 ppb a.i.)
(TEP 2.5%)	EC_{50} (Acute, 48-h, SR/M)	0.11 (0.05-0.18)	41651014 (McNamara, 1990)	Acceptable (Sublethal effects ≥ 0.082 ppb a.i.)

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
(Metabolite AEF108565)	EC_{50} (Acute, 48-h, SR/M)	>83.9 mg/L	48258205 (Sowig & Gosch, 2001)	Acceptable (No sublethal effects ≤ 83.9 ppm)
Isopod, *Asellus aquaticus* (TEP, ~25%)	LC_{50} (Acute, 96-h, SR/M)	7.0 ng ai/L (3.9-17.0, Slope= 1.1)	48258215 Gries & van der Kolk. 2001)	Supplemental-Quantitative (No sublethal effects at 96-h ≤ 0.5 ng ai/L)
Water flea, *Daphnia magna* (95%)	NOAEC LOAEC (Chronic, 21d, LC)	0.0041 0.0089	42114813 (McNamara, 1990)	Acceptable (reduced growth)
Water flea, *Ceriodaphnia dubia*	NOAEC LOAEC (Chronic, 8-d)	0.0025 0.0050	Shen *et al.* 2012; [#157482]	Supplemental-Quantitative (reduced growth)
Freshwater Invertebrates (Sediment)				
Amphipod, *Hyalella azteca* (99.8%)	(Subchronic, 10d) Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC	**0.026 ng ai/L** [(3)] 0.055 ng ai/L [(3)] **12 µg ai/kg-OC** 25 µg ai/kg-OC	48593608 (Picard, 2010)	Acceptable (Reduced growth (weight), formulated sediment)
Amphipod, *Hyalella azteca* (99.5%)	(Subchronic, 10d) Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC	<0.25 ng ai/L [(3)] 0.25 ng ai/L [(3)] <110 µg ai/kg-OC 110 µg ai/kg-OC	49191302 (Picard, 2013)	Supplemental-Quantitative (Reduced growth (length) in all treatments, natural sediment)
Amphipod, *Hyalella azteca* (99.5%)	(Chronic, 42d LC) Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC	0.57 ng ai/L [(3)] 1.6 ng ai/L [(3)] 150 µg ai/kg-OC 730 µg ai/kg-OC	49263807 (Picard, 2013)	Acceptable (Reduced survival and reproduction; natural sediment)

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Midge, *Chironomus dilutus* (99.8%)	(Subchronic, 10d) Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC	 0.83 ng ai/L [(3)] 1.4 ng ai/L [(3)] 374 µg ai/kg-OC 609 µg ai/kg-OC	48593609 (Picard, 2010)	Supplemental-Quantitative (Reduced survival, formulated sediment)
Midge, *Chironomus dilutus* (99.8%)	(Chronic, 63d LC) Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC	 0.13 ng ai/L [(3)] 0.31 ai/L [(3)] 58 µg ai/kg-OC 140 µg ai/kg-OC	49263806 (Picard, 2010)	Acceptable (Significant effects on emergence, growth and time to death; formulated sediment)
Estuarine/Marine Fish				
Sheepshead minnow, *Cyprinodon variegatus* (99.2%)	LC_{50} (Acute, 96-h, FT/M)	**0.58** (0.35-0.90)	41651015 (Sousa, 1990)	Acceptable (No sublethal effects ≤ 0.35 ppb)
(TEP 25.4%)	LC_{50} (Acute, 96-h, SR/M)	0.36 (0.25-0.52, slope= 7.6))	42114811 (LeLievre, 1991)	Acceptable (No sublethal effects ≤ 0.25 ppb)
(99.5%)	NOAEC LOAEC (Chronic, 35-d)	**0.024** **0.049**	48988203 (Banman et al., 2012)	Acceptable (reduced growth)
Estuarine/Marine Invertebrates (Water Column)				
Mysid shrimp, *Americamysis bahia* (>95%)	LC_{50} (Acute, 96-h, SR/M)	**0.0037** (0.0016-0.0049)	42114810 (LeLievre, 1991)	Acceptable (Sublethal effects ≥ 0.78 ng/L)
(TEP, 2.8%)	LC_{50} (Acute, 96-h, SR/M)	0.0017	42114812 (LeLievre, 1991)	(Sublethal effects ≥ 0.57 ng/L)
(>99%)	NOAEC LOAEC (Chronic, 35d LC)	**0.47 ng ai/L** 0.73 ng ai/L	48988202 (Claude, 2012)	Acceptable (reduced survival day 0-35)
Eastern Oyster, *Crassostrea virginica* (99%)	EC_{50} (Shell Dep.) (Acute, 96-h, FT/M)	12.0	41651016 (Dionne, 1990)	Acceptable (No sublethal effects ≤ 3.4 ppb)
(TEP, 2.5%)	EC_{50} (Shell Dep.) (Acute, 96-h, FT/M)	17.9 (13.2-29.5)	41651017 (Dionne, 1990)	Acceptable (No sublethal effects ≤ 4 ppb)
Aquatic Plants				

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Duckweed *Lemna gibba* (99.5%)	(7-d S/M) EC_{50} NOAEC	>779 779	48988204 (Banman et al., 2012)	Acceptable (No significant adverse effects at the limit concentration)
Freshwater Diatom *Navicula pelliculosa* (99.6%)	(96-h S/M) EC_{50} NOAEC	**>3.1** **3.1**	49263802 (Banman et al., 2013)	Acceptable (No significant adverse effects at the limit concentration)
Freshwater Green Alga, *Selenastrum capricornutum* (99.2%)	(96-h S/M) EC_{50} NOAEC	>9,100 9,100	44977003 (Giddings, 1990)	Acceptable (No significant adverse effects at the limit concentration)
(TEP, 10.5%)	(96-h S/M) EC_{50} NOAEC	1,870 (1,840-1,900) <760	48258214 (Sowig et al., 2000)	Acceptable (Based on AUC)
(TEP, 25%)	(96-h S/M) EC_{50} NOAEC	440 (320-610) <310	44977004 (Giddings, 1990)	Acceptable (Significant adverse effects on cell density $\geq$ 310 ppb)
Marine Diatom *Skeletonema costatum* (99.6%)	(96-h S/M) EC_{50} NOAEC	>3.4 3.4	49263801 (Banman et al., 2013)	Acceptable (No significant adverse effects at the limit concentration)
Green Alga, *Scenedesmus Subspicatus* (2.4%)	(72-h S/U) EC_{50} NOAEC	724 mg/L (685-827) 320 mg/L	48258212 (Heusel, 1994)	Supplemental, Qualitative (Based on reductions in yield)
Freshwater algae, *Chlorella vulgaris* (98.7%)	(72-h S/M) EC_{50} NOAEC	>620 620	48258213 (Hoberg, 1992)	Supplemental, Quantitative (No significant adverse effects at the limit concentration)
Freshwater Cyanobacterium, *Anabaena flos-aquae* (99.6%)	(96-h S/M) EC_{50} NOAEC	>3.6 3.6	49263803 (Banman et al., 2013)	Acceptable (No significant adverse effects at the limit concentration)

Bolded endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.

[1] all test materials are TGAI unless otherwise noted.

[2] S= static; SR= static renewal; FT = flow through; M= measured concentrations

[3] Pore water NOAEC estimated from sediment-OC NOAEC and mean Koc of 449,000 mL/g-$_{OC}$.

[4] Units = µg a.i./L unless specified otherwise.

Table 3. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Permethrin

Table 3-1. Submitted Studies on Acute Toxicity of Permethrin to Fish

Species	% a.i.[(a)]	96-h LC_{50} (µg ai/L)	Reference, Date	Study Classification
Freshwater Fish				
Bluegill sunfish *(Lepomis macrochirus)*	TGAI	**0.79**	**MRID 00042128 January 1976**	**Supplemental**
Bluegill sunfish *(Lepomis macrochirus)*	95.7	2.52	MRID 00110663 June 21, 1976	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	100	6.1	MRID 00110657 November 1974	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	95.7	6.8	MRID 00043263 December 1979	Supplemental
Bluegill sunfish *(Lepomis macrochirus)*	94.4	13.3	EPA Beltsville 2343 May 23, 1978	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91.4	13.5	EPA Beltsville 1127 May 16, 1978	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	5.0[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	4.5[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	8.0[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	7.1[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	5.6[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	7.6[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	7.2[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	13.0[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	91	6.2[b]	MRID 40098001 1986	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	TGAI	6.8	MRID 00043263 1991	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	21	32	MRID 00097445 1991	Supplementary
Bluegill sunfish *(Lepomis macrochirus)*	TEP (2.9 + 14.3 PBO)	2.12	49540301 2014	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	TEP (24EC)	10.8	ESI, 1976	Supplemental

Species	% a.i.[(a)]	96-h LC_{50} (µg ai/L)	Reference, Date	Study Classification
Bluegill sunfish *(Lepomis macrochirus)*	TEP (24EC)	13	MRID 00110705 1977	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	TEP (10EC)	24	MRID 42584004 1992	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	TEP (38.5)	9	EPA Beltsville 2356 June 21, 1978	Acceptable
Bluegill sunfish *(Lepomis macrochirus)*	TEP (38.4)	33.4	ACC 096699 1978	Supplementary
Bluegill sunfish *(Lepomis macrochirus)*	TEP (38.5)	6.8[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	95	9.8	MRID 00110657 November 1974	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	94	5.3	MRID 00043265 December 1979	Supplemental
Rainbow trout *(Oncorhynchus mykiss)*	TGAI	2.1	MRID 00042126 1976	Supplemental
Rainbow trout *(Oncorhynchus mykiss)*	91	4.1[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	2.9[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	6.0[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	7.0[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	8.2[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	4.2[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	5.2[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	91	4.1[b]	MRID 40098001 1986	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	24EC	56	MRID 00042132 May 1977	Supplemental
Rainbow trout *(Oncorhynchus mykiss)*	26.2	32	MRID 43740601 March 24, 1995	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	10 EC	72	MRID 42584003 1992	Acceptable
Rainbow trout *(Oncorhynchus mykiss)*	38.4	20.9	MRID 00110657 1978	Supplemental
Coho Salmon *(Oncorhynchus kisutch)*	TGAI	17	MRID 00072846 June 1976	Acceptable

Species	% a.i.[(a)]	96-h LC_{50} (µg ai/L)	Reference, Date	Study Classification
Atlantic salmon (*Salmo salar*)	TGAI	1.5	MRID 00083085 June 1976	Acceptable
Brook trout (*Salvelinus fontinalis*)	92.5	3.2[b]	MRID 40098001 1986	Acceptable
Brook trout (*Salvelinus fontinalis*)	TGAI	3.9	MRID 00042127 March 1977	Supplemental
Brook trout (*Salvelinus fontinalis*)	57 EC	5.2[b]	MRID 40098001 1986	Supplemental
Brook trout (*Salvelinus fontinalis*)	13EC	2.3[b]	MRID 40098001 1986	Supplemental
Fathead minnow (*Pimephales promelas*)	91	5.7[b]	MRID 40098001 1986	Acceptable
Fathead minnow (*Pimephales promelas*)	TEP (38.5EC)	5.7[b]	MRID 40098001 1986	Acceptable
Fathead minnow (*Pimephales promelas*)	TGAI	3	MRID 00042129 1976	Acceptable
Channel catfish (*Ictalurus punctatus*)	91	7.2[b]	MRID 40098001 1986	Acceptable
Channel catfish (*Ictalurus punctatus*)	TGAI	5.4	MRID 00043735 June 1976	Acceptable
Carp (*Cyprinus carpio*)	TGAI	15	EF-S2 1976	Supplemental
Estuarine/Marine Fish				
Inland silversides (*Menidia beryllina*)	TGAI	6.2	MRID 41134801 March 23, 1989	Supplemental
Inland silversides (*Menidia beryllina*)	94.6	6.6	MRID 41874901 May 18, 1989	Acceptable
Sheepshead minnow *(Cyprinodon variegatus)*	93	7.8	MRID 40228401 1987	Supplemental
Sheepshead minnow *(Cyprinodon variegatus)*	TEP (10EC)	>300	MRID 42608201 1992	Supplemental
Atlantic Silverside *(Menidia menidia)*	93	**2.2**	MRID 40228401 EPA 1987	Supplemental
Striped mullet (*Mugil cephalus*)	93	5.5	MRID 40228401 EPA 1987	Supplemental

Value in **bold** selected for risk estimation.
[a] TGAI= technical grade active ingredient (% a.i. not specified); TEP = Typical End-Use Product
[b] In all cases for MRID 40098001, toxicity values are based on static exposure and nominal test concentrations.

Table 3-2. Submitted Studies on Chronic Toxicity of Permethrin to Fish

Species and Test Design	% a.i.	NOAEC/ LOAEC (µg ai/L)	Endpoints Affected	Reference, Date	Study Classification
Freshwater Fish					
Fathead minnow (*Pimephales promelas*) Full Life Cycle Test (egg to egg)	95.7	0.30 / 0.41	Significant reduction in fry survival @ 30 days. Only 3-8% of fry survived exposure to 0.41 ppb, compared to 85-95% in controls. No Effect on adult growth or number of eggs produced.	MRID 00110666 1977	Acceptable
Fathead minnow (*Pimephales promelas*) Fish Short-Term Reproduction Assay 890.1350	97.7	0.75 / 2.6	statistically significant effects on survival, cumulative egg production, eggsper female reproductive day, and both male and female GSI at 2.6 ppb	MRID 48702301 2012	(1)
African Clawed Frog (*Xenopus laevis*) Amphibian Metamorphosis Assay 890.1100	97.7	0.63 / >0.63	No significant treatment related effects at the highest test concentration	MRID 48988601 2012	(1)
Estuarine/marine Fish					
Sheepshead minnow *(Cyprinodon variegatus)*	93	<10 /10	Reduced survival (28 days)	NR 1994	Supplemental

(1) Studies submitted as part of the EPA Endocrine Disruption Screening Program, Tier 1 test battery. These are not classified according to 850 guideline study reviews in part because test design differences. However, they are considered scientifically sound and informative.

Table 3-3. Submitted Studies on Acute Toxicity to Aquatic Invertebrates (Water Column Exposure) for Permethrin

Species	% a.i. .[a]	48-h or 96-h LC_{50} or EC_{50} (µg ai/L)	Reference, Date	Study Classification
Freshwater Invertebrates				
Amphipod (*Hyalella azteca)*	97.8	**0.0066**	MRID 49513901 Nov. 2014	Acceptable
Amphipod (*Hyalella azteca)*	96.4	0.0070	49234302 Sept. 2013	Acceptable
Waterflea *(Daphnia magna)*	TGAI	0.32	MRID 00043736 October 1976	Acceptable
Waterflea (*Daphnia magna*)	TGAI	0.58	MRID 00110662 October 26, 1977	Acceptable
Waterflea (*Daphnia magna*)	95.7	0.04	MRID 00043736 December 1975	Acceptable
Waterflea *(Daphnia magna)*	94.4	0.7	EPA Beltsville 2420 July 8, 1979	Acceptable
Waterflea (*Daphnia magna*)	91	1.26 [b]	MRID 40098001 1986	Supplemental
Waterflea (*Daphnia magna*)	95.7	7.2	MRID 00110663 June 21, 1976	Acceptable
Waterflea (*Daphnia magna*)	TEP (25EC)	0.76	MRID 00110662 October 26, 1977	Acceptable
Waterflea (*Daphnia magna*)	TEP (25EC)	1.31	MRID 00042139 1977	Supplemental
Waterflea (*Daphnia magna*)	TEP (26.2)	3.3	MRID 43740602 1995	Acceptable
Waterflea (*Daphnia magna*)	TEP (10EC)	9.9	MRID 42584002 1992	Acceptable
Mayfly (*Hexagenia bilineuta*)	97	0.100	MRID 00047040 September 9, 1980	Acceptable
Crayfish (*Procambarus blandingii*)	89.1	210	MRID 00042136 1977	Supplemental
Scud (*Gammarus pseudolimnaeus*)	91	0.17[b,c]	MRID 40098001 1986	Acceptable
Midge *(Chironomus plumosus)*	91	0.56 [b]	MRID 40098001 1986	Supplemental
Pond snail (*Lymnaea stagnalis*)	TEP (25EC)	<25, 000	MRID 00042141 1986	Supplemental
Scud (*Hyalella azteca*)	100	0.0212	Anderson *et al.*2006 (ECOTOX Ref. # 90039)	Supplemental
Estuarine/Marine Invertebrates				
Mysid *(Americamysis bahia)*	93	0.019	MRID 40228401 1978	Supplemental
Mysid *(Americamysis bahia)*	93	0.046	MRID 40228401 1978	Supplemental

Species	% a.i. .[a]	48-h or 96-h LC_{50} or EC_{50} (µg ai/L)	Reference, Date	Study Classification
Mysid *(Americamysis bahia)*	93	0.02	MRID 40228401 1978	Supplemental
Mysid *(Americamysis bahia)*	90.8	0.075	MRID 43492902 October 1986	Acceptable
Brown Shrimp (*Penaeus aztecus*)	89	0.34	MRID 00042135 May 1977	Acceptable
Pink Shrimp (*Penaeus duorarum*)	93	0.22	MRID 40228401 1978	Supplemental
Pink Shrimp (*Penaeus duorarum*)	95.7	0.35	MRID 00110660 December 1975	Acceptable
Pink Shrimp (*Penaeus duorarum*	TEP (3.2 EC)	0.51	MRID 00110661 December 1975	Acceptable
Fiddler Crab (*Uca pugilator*)	95.7	2.39	MRID 00110660 December 1975	Acceptable
Fiddler Crab (*Uca pugilator*)	89	2.65	MRID 00042135 May 1977	Supplemental
Fiddler Crab (*Uca pugilator*)	TEP (3.2 EC)	7.6	MRID 00110661 December 1975	Acceptable
Stone Crab (*Menippe mercenaria*)	93	**0.018**	MRID 40228401 1978	Supplemental
Pacific Oyster (*Crassostrea gigas*)	TGAI	>1050	MRID 00042140 December 1977	Supplemental
Pacific Oyster (*Crassostrea gigas*)	TEP (10EC	6500b	MRID 42723301 1992	Acceptable
Eastern Oyster (*Crassostrea virginica*)	95.7	>536	MRID 00110660 December 1975	Supplemental
Eastern Oyster (*Crassostrea virginica*))	95.7	>407	MRID 00110660 December 1975	Supplemental
Eastern Oyster (*Crassostrea virginica*)	93	>1000	MRID 40228401 EPA 1978	Supplemental
Eastern Oyster (*Crassostrea virginica*)	97.8	>2.72 (shell deposition)	49511901 2014	

[a] TGAI= technical grade active ingredient (% a.i. not specified); TEP = Typical End-Use Product
[b] In all cases for MRID 40098001, toxicity values are based on static exposure and nominal test concentrations.
[c] 96-hour LC_{50}

Table 3-4. Submitted Studies on Chronic Toxicity to Aquatic Invertebrates (Water Column Exposure) for Permethrin

Species and Test Design	% a.i.	NOAEC/ LOAEC (µg ai/L)	Endpoints Affected	Reference, Date	Study Classification
Freshwater Invertebrates					
Waterflea (*Daphnia magna*) 21-d LC	98.6	0.039/0.084	Reproduction and growth	MRID 43745701 May 12, 1995	Acceptable
Waterflea (*Daphnia magna*) 28-d LC	94.4	0.28 / 0.56	Reproduction and adult survival	EPA Beltsville TN 2420 July 8, 1979	Supplemental
Waterflea (*Daphnia magna*)	TGAI	EC_{50} = 70	Reproduction (EC_{50} calculated for eggs)	MRID 00110662 October 26, 1977	Supplemental
Estuarine/Marine Invertebrates					
Mysid (*Americamysis bahia*)	95	0.011/0.024	Mortality	MRID 41315701 March 1989	Supplemental
Mysid (*Americamysis bahia*) 28-d LC	99.4	**0.0024/0.0046**	Reproduction (# offspring/female)	49554601 June, 2014	Acceptable

Table 3-5. Submitted Studies on Toxicity to Aquatic Invertebrates (Sediment Exposure) for Permethrin

Species and Test Design	% a.i.	NOAEC/ LOAEC (µg ai/L)	Endpoints Affected	Reference, Date	Study Classification
Freshwater Invertebrates					
Amphipod (*Hyalella azteca)* 10-d, Subchronic, Formulated Sediment	95.1	**<u>Pore Water:</u>** **(ng ai/L)** **4.2 / 7.4** **<u>Sediment</u>:** **(µg ai/kg-dw)** **7.4 / 13** (µg ai/kg-OC) 322/565	Amphipod growth (dry weight)	MRID 48593614 June 2010	Acceptable
Amphipod (*Hyalella azteca)* 10-d, Subchronic, Formulated Sediment	96.4	<u>Pore Water:</u> (ng ai/L) 13 / 30 <u>Sediment:</u> (µg ai/kg-dw) 7.4 / 13 (µg ai/kg-OC) 1027/2270	Amphipod growth (length)	MRID 49274302 Oct, 2013	Acceptable
Midge (*Chironomus dilutus*) 10-d, Subchronic, Formulated Sediment	95.1	<u>Pore Water:</u> (ng ai/L) <34 / 34 <u>Sediment:</u> (µg ai/kg-dw) <54 / 54 (µg ai/kg-OC) <2571/2571	Midge growth (dry weight)	MRID 48593615 June 2010	Supplemental
Amphipod (*Hyalella azteca)* 42-d, Chronic LC, Natural Sediment	97.7	<u>Pore Water:</u> (ng ai/L) 20 /33 <u>Sediment:</u> (µg ai/kg-dw) 54 / 92 (µg ai/kg-OC) 1600/2600	Amphipod reproduction (d 35)	MRID 48788301 March 2012	Acceptable

Species and Test Design	% a.i.	NOAEC/ LOAEC (µg ai/L)	Endpoints Affected	Reference, Date	Study Classification
Midge (*Chironomus dilutus*) 63-d, Chronic LC, Formulated Sediment	97.7	Pore Water: (ng ai/L) 6.9 / 15 Sediment: (µg ai/kg-dw) 10 / 22 (µg ai/kg-OC) 520/1200	Midge percent emergence	MRID 48788101 March 2012	Acceptable
Estuarine/Marine Invertebrates					
Saltwater Amphipod (*Leptocheirus plumulosus*) 28-d, Chronic LC Natural Sediment	97.7	Pore Water: (ng ai/L) 24 / 60 Sediment: (µg ai/kg-dw) 38 / 97 (µg ai/kg-OC) 1800/4600	Amphipod reproduction	MRID 49063101 Feb. 2013	Acceptable

Table 3-6. Submitted Studies on Toxicity to Aquatic Plants for Permethrin

Species	% a.i.	EC_{50} (ppb)	Identification number, date	Study classification[a]
Marine diatom (*Skeletonema costatum*)	93	92	MRID 40228401 1986	Acceptable
Blue-green alga (*Anabaena inequalis*)	N/A	1600, 5000, >100,000 and >100,000 for growth yield, growth rate, photosynthesis, and acetylene reduction, respectively	Stratton *et al.*, 1980; ECOTOX Ref # 4684	Supplemental
Marine diatom (*Skeletonema costatum*)	N/A	68 and 72 based on cell counts and absorbance, respectively	Walsh and Alexander, 1980; ECOTOX Ref # 5297	Supplemental
Duckweed (*Lemna gibba*)	97.8%	>3.2 (NOAEC = 3.2 ppb); No significant impacts on growth at highest test concentration	MRID 49398801 2014	Acceptable
Cyanobacteria (*Anabaena flos-aquae*)	97.8%	> 5.4 (NOAEC = 5.4 ppb; no significant effects at the highest test concentration)	MRID 49398802 2014	Acceptable
Freshwater Diatom (*Navicula pelliculosa)*	97.8%	> 5.4 (NOAEC = 2.7 ppb; Significant reductions in growth rate and yield at the highest test concentration)	MRID 49398803 2014	Acceptable
Freshwater Green alga (*Pseudokirchneriella subcapitata)*	97.8%	> 4.4 (NOAEC = 0.65 ppb; Significant reductions in growth rate and cell density at the 3 highest test concentrations	MRID 49398804 2014	Acceptable
Saltwater Diatom (Skeletonema costatum)	97.8%	> 4.4 (NOAEC = 1.4 ppb; Significant reductions in area under the curve cell density at the 2 highest test concentrations	MRID 49398805 2014	Acceptable

Table 4. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Pyrethrins

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Freshwater Fish				
Rainbow Trout, *Oncorhynchus mykiss* (57%)	LC_{50} (Acute, 96-h, FT/M)	**5.1** (3.1 – 5.7)	43082303 (Machado, 1994)	Acceptable (No sublethal effects ≤ 3.1 ppb)
(TEP; 6.0% Pyr + 60.3% PBO)	LC_{50} (Acute, 96-h, FT/M)	3.2 (3.1 – 3.8)	43082304 (Machado, 1994)	Acceptable (No sublethal effects ≤ 1.5 ppb)
Bluegill Sunfish, *Lepomis macrochirus* (57%)	LC_{50} (Acute, 96-h, FT/M)	10 (7.8 – 14)	43082301 (Machado, 1994)	Acceptable (No sublethal effects ≤ 5.4 ppb)
(TEP; 6.0% Pyr + 60.3% PBO)	LC_{50} (Acute, 96-h, FT/M)	3.4 (3.0 – 4.6)	43082302 (Machado, 1994)	Acceptable (No sublethal effects ≤ 1.7 ppb)
Fathead Minnow, *Pimephales promelas*	NOAEC LOAEC (Chronic, ELS)	**1.9** 3.0	43252701 (Machado, 1994)	Acceptable (% hatch, growth)
Freshwater Invertebrates (Water Column)				
Amphipod, *Hyalella azteca* (53.4%)	LC_{50} (Acute, 96-h, FT/M)	**0.76** (0.65 – 0.91)	49066401 (Bradley, 2013)	Acceptable (No sublethal effects ≤ 0.54 ppb)
Amphipod, (*Gammarus lacustris*)	LC_{50} (Acute, 96-h)	12 (8 – 17)	05009242 (Sanders, 1969)	Supplemental
Water Flea, *Daphnia magna* (57.5%)	EC_{50} (Acute, 48-h, FT/M)	11.6 (9.6 – 14.2 Slope = 10.3)	43082305 (Putt, 1994)	Acceptable (No sublethal effects ≤ 3.7 ppb)
(TEP; 6.0% Pyr + 60.3% PBO)	EC_{50} (Acute, 48-h, FT/M)	6.7 (5.7 – 7.9)	43082306 (Putt, 1994)	Acceptable (No sublethal effects ≤ 0.55 ppb)
Water Flea, *Daphnia magna*	NOAEC LOAEC (Chronic, 21-d)	0.86 2.0	43252702 (Putt, 1994)	Acceptable (Reduced # offspring)
Freshwater Invertebrates (Sediment)				

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
Midge, *Chironomus dilutus* (52.2%)	(Chronic, 63d LC) Pore Water: NOAEC LOAEC Sediment, dry wt. NOAEC LOAEC Sediment, OC NOAEC LOAEC	 **0.04 µg ai/L [(3)]** **0.10 µg ai/L [(3)]** **41 µg ai/kg-dw** **95 µg ai/kg-dw** **1,600 µg ai/kg-OC** **3,700 µg ai/kg-OC**	49508202 (Bradley, 2014)	Acceptable (significant reduction in % emergence)
Midge, *Chironomus riparius* (57.0%)	(Chronic, 28-d) Sediment, dry wt. NOAEC LOAEC	No endpoint (Invalid study)	48141101 (Thomas & Krueger, 2009)	Invalid (lack of analytical confirmation of test concentrations, formation of precipitates in stock solutions)
Amphipod, *Hyalella azteca* (52.2%)	(Chronic, 42d LC) Pore Water: NOAEC LOAEC Sediment, dry wt. NOAEC LOAEC Sediment, OC NOAEC LOAEC	 3.5 µg ai/L[(3)] 8.0 µg ai/L [(3)] 6,200 µg ai/kg-dw 14,000 µg ai/kg-dw 124 µg ai/g-OC 280 µg ai/g-OC	49508201 (Bradley, 2014)	Acceptable (significantly reduced survival)
Estuarine/Marine Fish				
Sheepshead Minnow, *Cyprinodon variegatus* (57.5%)	LC_{50} (Acute, 96-h, FT/M)	**16** (14.5-17.7)	43082307 (Machado, 1994)	Acceptable (No sublethal effects ≤ 7.4 ppb)
(TEP; 6.0% Pyr + 60.3% PBO)	LC_{50} (Acute, 96-h, FT/M)	3.8 (3.4 – 4.5, slope= 8.4)	43082308 (Machado, 1994)	Acceptable (No sublethal effects ≤ 1.6 ppb)
(53.5%)	NOAEC LOAEC (Chronic, 33-d)	**0.7** 1.7	48931401 (Lee, 2012)	Acceptable (reduced growth)
Estuarine/Marine Invertebrates (Water Column)				
Mysid shrimp, *Americamysis bahia* (57.5%)	EC_{50} (Acute, 96-h, FT/M)	**1.4** (1.1 – 1.8, slope= 4.1)	43082311 (Machado, 1994)	Acceptable (No sublethal effects ≤ 0.29 ppb)

Species (% a.i.) [1]	Endpoint (Duration, Design) [2]	Toxicity Value (C.L., Slope) in µg a.i./L[(4)]	Citation or MRID # (Author, Date)	Study Classification (Comment)
(TEP; 6.0% Pyr + 60.3% PBO)	EC_{50} (Acute, 96-h, FT/M)	0.14 (0.08 – 0.25)	43082312 (Machado, 1994)	Acceptable (No sublethal effects ≤ 0.08 ppb)
(53.5%)	NOAEC LOAEC (Chronic, 28-d)	**0.25** 0.64	49233202 (Lee, 2013)	Acceptable (reduced growth, reproduction)
Eastern Oyster *Crassostrea virginica* (57.5%)	EC_{50} (Acute, 96-h, FT/M)	86 (72 – 100)	43082309 (Dionne, 1994)	Acceptable (Sublethal effects ≥14 ppb)
(TEP; 6.0% Pyr + 60.3% PBO)	EC_{50} (Acute, 96-h, FT/M)	26 (21 – 32)	43082310 (Dionne, 1994)	Acceptable (Sublethal effects ≥3.1 ppb)
Aquatic Plants				
Duckweed (*Lemna gibba*) (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (7-d, SR/M)	**1,230** (928-1620) **480**	48874201 (Softcheck, 2012)	Acceptable (Reduced frond number, biomass)
Freshwater Cyanobacteria (*Anabaena flos-aquae)* (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (96-h, S/M)	>460 460	48874203 (Softcheck, 2012)	Acceptable (No treatment related effects up through the highest test concentration)
Freshwater Green Alga, (*Pseudokirchneriella subcapitata)* (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (96-h, S/M)	**105** (94-116) **29**	48874204 (Softcheck, 2012)	Acceptable (significant reduction in area under the curve)
Freshwater Diatom (*Navicula pelliculosa*) (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (96-h, S/M)	210 (161-275) 16	48874205 (Softcheck, 2012)	Acceptable (significant reduction in area under the curve)
Saltwater Diatom (*Skeletonema costatum*) (TEP; 5.9% Pyr + 56.6% PBO)	EC_{50} NOAEC (96-h, S/M)	128 (86-191) 36	48874206 (Softcheck, 2012)	Acceptable (significant reduction in area under the curve)

Bolded endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.

[1] all test materials are TGAI unless otherwise noted.

[2] S= static; SR= static renewal; FT = flow through; M= measured concentrations, N.C.= not calculable

[3] Pore water NOAEC estimated from sediment-OC NOAEC and mean Koc of 35,200 mL/g-$_{OC}$.

[4] Units = µg a.i./L total pyrethrins unless specified otherwise.

Table 5. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Cyfluthrin and *Beta*-cyfluthrin

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
Freshwater Fish				
Rainbow Trout *Oncorhynchus mykiss* (97.6%).	Acute (cyfluthrin)	LC_{50} = 0.209 (CI: 0.180-0.246) [slope = 6.7 (C.I.: 4.0 – 9.4)]	45426708	Supplemental due to unexplained variability in recovery of the parent compound (Very highly toxic)
Rainbow Trout *Oncorhynchus mykiss* (87%).	Acute (cyfluthrin)	LC_{50} = 0.59 (C.I.: 0.50 – 0.72)	00131502 Carlisle et al. 1983	Acceptable NOAEC = 0.25 ug/L
Rainbow Trout *Oncorhynchus mykiss* (2%).	Acute (cyfluthrin; TEMP 2EC)	LC_{50} = 0.295 (CI: 0.2-0.38)	41558002	Acceptable
Rainbow Trout *Oncorhynchus mykiss* (98%).	Acute (beta-cyfluthrin) FCR-4545	LC_{50} = 0.111 95 % CI: 0.0975-0.1241	45375001	Supplemental NOEC: <0.074 ug a.i./L (based on mortality ad sub-lethal effects) LOEC: 0.074 ug a.i./L Endpoints affected: Mortality and sub-lethal effects
Lepomis Macrochirus (Bluegill sunfish) (99.4%)	Acute (cyfluthrin) FCR-4545	LC_{50} = 0.28 (0.24-0.32) [slope= 6.76 (CI: 4.04-9.48)]	45375003	Supplemental NOAEC: 0.1 1 ppb a.i. (based on mortality and sub-lethal effects) LOAEC: 0.22 ppb a.i. Endpoints affected: Mortality and sub-lethal effects
Lepomis Macrochirus (Bluegill sunfish) (25%)	Acute (cyfluthrin; TEMPO 2EC)	LC_{50} = 0.647	41558001	Supplemental
Lepomis Macrochirus (Bluegill sunfish) (98%)	Acute (beta-cyfluthrin; FCR=454)	LC_{50} = 0.566 (CI: 0.422-0.646)	45426706	Supplemental NOEC: 0.141 ug/L (based on mortality) LOEC: 0.241 ug/L Endpoints affected: Mortality and sub-lethal effects
Lepomis Macrochirus (Bluegill sunfish) (97.6%)	Acute (cyfluthrin)	LC_{50} = 0.998 (CI: 0.845-1.567)	45426707	Acceptable NOEC: 509 pptr a.i. (based on mortality and sub-lethal effects) LOEC: 845 pptr a.i.

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
				Endpoints affected: Mortality and sub-lethal effects
Rainbow Trout *Oncorhynchus mykiss* (99.4%).	Acute (*beta*-cyfluthrin)	**LC_{50} = 0.068** [slope = 7.6 (C.I.: 4.7 – 10.5)]	45375002	Supplemental due to a very high level of variability in the measured concentrations (at all levels) NOEC: <0.039 ppb a.i. (based on mortality and sub-lethal effects) LOEC: 0.039 ppb a.i. Endpoints affected: Mortality and sub-lethal effects
Rainbow Trout *Oncorhynchus mykiss* (96%).	Chronic (cyfluthrin) FCR-1272		00145332 Carlisle, 1984 study no. 84-066-05.	Invalid
Rainbow Trout *Oncorhynchus mykiss* (96%).	Chronic (cyfluthrin)	NOAEC = 0.010 LOAEC = 0.018	00155898.	Supplemental. LOAEC based on reduced growth and behavioral effects
Rainbow Trout *Oncorhynchus mykiss* (87%).	Chronic (cyfluthrin)		00145333 Carlisle, 1984 study no. 83-666-05	Invalid
Fathead Minnow *Pimphales promelas* (99%)	Chronic (cyfluthrin) Tech.	NOAEC = 0.14 LOAEC = 0.25	41450401	Acceptable LC_{50} = 2.49 ug/L
Rainbow Trout *Oncorhynchus mykiss* (97.6%).	Acute (cyfluthrin)	LC_{50} = 0.302 (CI: 0.240-0.432)	45426705	Acceptable NOEC: 0.105 ug/L (based on sub-lethal effects) LOEC: 0.146 ug/L Endpoints affected: Mortality and sub-lethal effects
Rainbow Trout *Oncorhynchus mykiss* (98.1%).	Acute (*beta*-cyfluthrin) FCR-4545	LC_{50} = 0.085 95% C.I.: 72.2-101.3 pptr a.i.	45426703	Supplemental NOEC: 53 pptr a.i. LOEC: 78 pptr a.i. Endpoints affected: Mortality and sub-lethal effects
Freshwater Invertebrates				
Water Flea *Daphnia magna* (25%)	Acute (cyfluthrin; TEMPO 2EC)	EC_{50} = 0.025 (CI: 0.016-0.04) (slope could not be calculated)	41558003	Acceptable. (Very highly toxic)
Water Flea *Daphnia magna*	Acute (cyfluthrin)	LC_{50} = 0.144(CI: 0.1-0.233) [slope = 4.34]	42705801	.Acceptable NOEL = 0.028 ug/L

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
(98.6%)				
Water Flea *Daphnia magna* (Tech)	Acute (*beta*-cyfluthrin)	LC/EC_{50} = 0.29 (slope could not be calculated) 95% CI: 0.25-0.33 ppb a.i	45426701	Supplemental because the purity of the test material was not specified. NOEC: <0.20 ppb a.i. LOEC: 0.20 ppb a.i. (based on mortality and sub-lethal effects, same conclusions)
Water Flea *Daphnia magna* (98.3%)	Chronic (cyfluthrin) FCR-4545	NA	45426702	Invalid
Water Flea *Daphnia magna* (94.7%)	Chronic (cyfluthrin)	NOAEC = 0.0074 LOAEC = 0.0157	00151442	Acceptable. LOAEC based on reduced growth, survival, and number of young.
Water Flea *Daphnia magna* (2.9%)		NOAEC = 0.10 LOAEC = 0.30	48350610	INVALID
Midge *Chironomus tentans* (99% a.i.)	Sub-chronic (10-day cyfluthrin)	Pore water: NOAEC: 0.009 LOAEC: 0.018 LC_{50}: 0.039 (95% C.I.: 0.034-0.045 ug a.i./l)	46591507	Acceptable LOAEC based on survival
Amphipod *Hyalella azteca* (95.8%)	Sub-chronic (10-day; cyfluthrin)	Mean-measured (survival in µg ai/kg) NOAEC: 0.53 LOAEC: 1.1 LC_{50}: 4.8 OC-normalized mean-measured (survival in µg ai/kg TOC) **NOAEC: 22** LOAEC: 46 LC_{50}: 200 Freely dissolved pore water concentrations (survival in □g a.i./L): **NOAEC: 0.00012**	48593606	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
		LOAEC: 0.00025 LC_{50}: 0.0011		
Amphipod *Hyalella azteca* (95.8%)	Sub-chronic (10-day; cyfluthrin)	Mean-measured (survival in □g ai/kg) NOAEC: 61 LOAEC: 130 LC_{50}: 116 OC-normalized mean-measured (survival in µg ai/kg OC) NOAEC: 1967 LOAEC: 4194 LC_{50}: 3742 Freely dissolved pore water concentrations (survival in µg a.i./L): NOAEC: 0.011 LOAEC: 0.023 LC_{50}: 0.02	49209503	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.
Midge *Chironomus dilutus* (94.1%)	Sub-chronic (10-day; cyfluthrin)	Mean-measured (survival in µg ai/kg) NOAEC: <14 LOAEC: 14 LC_{50}: 88 OC-normalized mean-measured (survival in µg ai/kg OC) NOAEC: <609 LOAEC: 609 LC_{50}: 3,826 Freely dissolved pore water concentrations (survival in µg a.i./L): NOAEC: <0.003 LOAEC: 0.003 LC_{50}: 0.02	48593607	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
Amphipod *Hyalella azteca* (95.8%)	Chronic (42-day; cyfluthrin)	TWA, bulk sediment (µg ai/kg) NOAEC: 8.0 LOAEC: 20 TWA, OC-normalized (µg ai/kg-OC) NOAEC: 260 LOAEC: 630 TWA, Freely dissolved pore water concentrations (survival in µg a.i./L): NOAEC: 0.0014 LOAEC: 0.0034	49272613	Acceptable. For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.
Midge *Chironomus dilutus* (95.8%)	Chronic (Life-cycle; cyfluthrin)	Mean-measured (multiple* in µg ai/kg) NOAEC: 1.6 LOAEC: 3.1 OC-normalized mean-measured (multiple* in µg ai/kg OC) NOAEC: 70 LOAEC: 135 Freely dissolved pore water concentrations (multiple* in µg a.i./L): NOAEC: 0.0004 LOAEC: 0.0007	49272612	Acceptable. *multiple endpoints: male development rate (a growth endpoint, equivalent to emergence rate), combined development rate, male-to-female ratio For pore water concentrations, a Koc of 184,864 mL/g_{oc} was used based on an average of nine values from MRIDs 00131495, 00137544, 45022103, 49272602.
Gammarus pulex (*radiolabeled ^{14}C-cyfluthrin EC 050 Xylol, a.i.-content 54.2g/L)	Acute (^{14}C-cyfluthrin)	Initial measured overlying water (ng a.i./L) 7d-LC_{50}: >118	48350611	INVALID

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
Larvae of *Chironomus riparius* (11.5%)	Chronic (28-day; *beta*-cyfluthrin)	Overlying water TWA (emergence rate in µg a.i./L) NOAEC: 0.035 LOAEC: 0.087	48350612	INVALID
Estuarine Marine Fish				
Sheepshead Minnow *Cyprinodon variegatus* (87% a.i.)	Acute (cyfluthrin)	**LC_{50} = 4.05** (slope could not be calculated)	00146485	Acceptable. (Very highly toxic)
Sheepshead Minnow *Cyprinodon variegatus* (90.5% a.i.)	Chronic (cyfluthrin)	**NOAEC = 0.025** LOAEC = 0.084	00158781	Supplemental. LOAEC based on reduced juvenile survival.
Sheepshead Minnow *Cyprinodon variegatus* (90.5% a.i.)	Chronic (cyfluthrin) Tech.	**NOAEC = 0.027** LOAEC = 0.063	00158784	Supplemental
Estuarine/Marine Invertebrates				
Eastern oyster *Crassostrea virginica* (93%)	Acute	EC_{50} = 2.69	00158783	Acceptable NOEC < 0.9 ug/L LOEC 0.9 ug/L
Eastern oyster *Crassostrea virginica* (93%)	Acute		00146118 Barrows & Dillon 1984	Invalid
Leptocheirus plumulosus Amphipod (99%)	Acute	LC_{50} = 0.0033 (survival) (Slope NA)	46591506	Supplemental Based on ESTIMATED pore water concentrations (total radioactive residues): Mortality: LCso: 0.0033 NOAEC: 0.0026 ug a.i/L LOAEC: 0.0069 ug a.i/L Growth (dry weight): ECso: > 0.0069 ug a.i/L NOAEC: 0.0026 ug a.i/L LOAEC: 0.0069 ug a.i1L Based on organic carbon-normalized mean-measured sediment concentrations (total radioactive residues):

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
				Mortality: LCso: 407 ug a.i/kg TOC NOAEC: 317 ug a.i/kg TOC LOAEC: 854 ug a.i/kg TOC Based on mean-measured sediment concentrations (total radioactive residues): Mortality: LCso: 16.7 ug a.i/kg sediment NOAEC: 13 ug a.i/kg sediment LOAEC: 35 ug a.i/kg sediment
Mysid Shrimp *Mysidopsis bahia* (92%).	Acute (cyfluthrin) Baythroid	LC_{50} = 0.0024 (CI: 0.0019-0.0032) (slope could not be calculated)	40069501	Acceptable (Very highly toxic) NOEL <0.00069 ug/L
Mysid Shrimp *Mysidopsis bahia* (90.5%).	Acute (cyfluthrin)	**LC_{50} = 0.0064 (CI: 0.0046-0.0088)**	00149598 Johnson et al. 1985	Supplemental
Mysid Shrimp *Mysidopsis bahia* (>98% a.i.).	Acute (*beta*-cyfluthrin)	**LC_{50} = 0.0022 (CI: 0.0019-0.0027)** [slope = 5.5 (C.I.: 3.7 – 7.3)]	45426709	Acceptable NOEC: 0.0013 ug/L a.i. (based on mortality and sub-lethal effects) LOEC: 0.0023 ug/L a.i. Endpoints affected: Mortality and sub-lethal effects
Mysid Shrimp *Mysidopsis bahia* (>98%).	Acute (*beta*-cyfluthrin) FCR-4545	LC_{50} = 0.0023 95% C.I.: 2.0-2.8 pptr a.i.	45426704	Acceptable NOEC: 0.86 pptr a.i. LOEC: 1.5 pptr a.i. Endpoints affected: Mortality and sub-lethal effects
Mysid Shrimp *Mysidopsis bahia* (97% a.i.).	Chronic (cyfluthrin)	**NOAEC = 0.00017** LOAEC = 0.00040	00158785	Supplemental. LOAEC based on reduced growth and survival; this study is supplemental due to fluctuations in the test concentrations throughout the study.
Mysid Shrimp *Mysidopsis bahia* (NA)	Chronic (*beta*-cyfluthrin)	**NOAEC = 0.00007** LOAEC = 0.00017	N/A	N/A. Based on a '*beta*-cyfluthrin equivalent' using chronic data for cyfluthrin (0.00017 x 0.42 = 0.00007)
Mysid Shrimp *Mysidopsis bahia*	Chronic (*beta*-cyfluthrin)	NOAEC = 0.00041 LOAEC = 0.00083	49272611	Acceptable. LOAEC based on number of offspring produced per female.

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
(97% a.i.).				
Amphipod *Leptocheirus plumulosus* (99%)	28-day (chronic; ^{14}C-cyfluthrin)	Mean-measured (survival in µg ai/kg) NOAEC: 13 LOAEC: 35 LC_{50}: 16.7 OC-normalized mean-measured (survival in µg ai/kg OC) **NOAEC: 317** LOAEC: 854 LC_{50}: 407 Freely dissolved pore water concentrations (survival in µg a.i./L): **NOAEC: 0.0026** LOAEC: 0.0069 LC_{50}: 0.0033 ---------- Mean-measured (repro. in µg ai/kg) NOAEC: <1.4 LOAEC: 1.4 LC_{50}: 13.7 OC-normalized mean-measured (repro. in µg ai/kg OC) **NOAEC: <34** LOAEC: 34 LC_{50}: 334 Freely dissolved pore water concentrations (repro. in µg a.i./L): **NOAEC: <0.00018** LOAEC: 0.00018 LC_{50}: 0.0018	46591506 48762904	Supplemental. Reproduction endpoint was not reported. Acceptable. Reproduction addendum to previous study (MRID 46591506), which is now upgraded to acceptable.
Vascular Aquatic Plants				

Species (% a.i.)*	Acute/ Chronic (Test substance)	Toxicity Value (C.L., Slope) µg a.i./L	Citation or MRID #	Study Classification/ Comment
Duckweed (*Lemna* sp.)	Vascular (cyfluthrin)	NA	NA	No study was submitted.
Duckweed (*Lemna* sp.)	Vascular (*beta*-cyfluthrin)	NA	NA	No study was submitted.
Non-Vascular Aquatic Plants				
Green algae (*Pseudokirchneriella subcapita*) (98.7% a.i.)	Non-vascular (cyfluthrin)	EC_{50} >181	43984901	Acceptable. No effects at any concentration tested (Highly toxic)
Algae *Scenedesmus subspicatus* (94.1%)	Non-vascular (cyfluthrin) Baythroid 2 FCR-1272 Tech		41450402	invalid
Algae (*Scenedesmus subspicatus* CHODAT, 95.8% a.i.)	Non-vascular (cyfluthrin)	EC_{50} >2	48350623	Supplemental. No effects up to the limit of solubility (0.002 mg/L) (Very highly toxic)

Table 6. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Cypermethrin

Unless otherwise indicated, the test material for all studies is technical grade active ingredient cypermethrin.

Acute/ Chronic	**Species (% a.i.)** [1]	**Toxicity Value Used in Risk Assessment**	**Citation or MRID # (Author, Date)**	**Study Classification/ Comment**
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute	Rainbow Trout *Oncorhynchus mykiss* (92.9%)	96-hr LC_{50} = 0.80 µg a.i./L (C.L. 0.66 – 0.95 µg/L; slope – N/A moving average test)	00241598 (Hill, 1976)	Acceptable (Very highly toxic)
Acute	Bluegill sunfish *Lepomis macrochirus* (92.9%)	96-hr LC_{50} = 2.2 µg a.i./L (C.L. not available; slope: not available, geometric median survival period)	00241598 (Hill, 1977)	Acceptable (Very highly toxic)
Acute	Rainbow Trout *Salmo gairdneri* (99%) [3-phenoxy benzoic acid (degradate of cypermethrin)]	96-hr LC_{50} = 13.3 mg a.i./L (C.L. 11.2 – 15.8 mg a.i/L; slope – N/A moving average test)	00089037 (Hill, 1981)	Acceptable (Slightly toxic)
Acute	Bluegill sunfish *Lepomis macrochirus* (99%)[3-phenoxy benzoic acid (degradate of cypermethrin)]	96-hr LC_{50} = 36.3 mg a.i./L (C.L. 33.3 – 39.5 mg a.i/L; slope – N/A moving average test)	00089038 (Hill, 1981)	Acceptable (Slightly toxic)
Acute	Rainbow Trout *Salmo gairdneri* GFU 070 formulation (25.1%)	96-hr LC_{50} = 13 µg a.i./L (C.L. 10.7 – 15.4; slope: 7.37)	00088947 (Hill, 1981)	Acceptable (Very highly toxic)
Acute	Rainbow Trout *Oncorhynchus mykiss* (88.2%)	96-hr LC_{50} = 0.69 µg a.i./L (C.L. 0.60 – 0.82; slope: 7.7	41968208 (Overman, 1990)	Acceptable (Very highly toxic)
Acute	Rainbow Trout *Oncorhynchus mykiss* (91.5%)	96-hr LC_{50} = 0.90 µg a.i./L (C.L. 0.72 – 1.35; slope: not available, binomial method)	41968209 (Vaishnav, 1990)	Acceptable (Very highly toxic)
Acute	Rainbow Trout *Oncorhynchus mykiss* (98%) [Beta-Cypermethrin]	**96-hr LC_{50} = 0.39 µg a.i./L** (C.L. 0.0.27-0.8 µg/L; slope – N/A Binominal test)	44546027 (Sousa, 1998)	Acceptable (Very highly toxic)

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Acute	Rainbow Trout *Oncorhynchus mykiss* (98.4%)	96-hr LC_{50} = 1.10 µg a.i./L (C.L. 1.00 – 1.32 µg/L; slope – 9.15)	44546028 (Sousa, 1998)	Acceptable (Very highly toxic)
Acute	Bluegill sunfish *Lepomis macrochirus* (98%) [Beta-Cypermethrin]	96-hr LC_{50} = 1.2 µg a.i./L (C.L. 1.03 – 1.3 µg/L; slope – 8.59)	44546029 (Sousa, 1998)	Acceptable (Very highly toxic)
Acute	Bluegill sunfish *Lepomis macrochirus* (98%)	96-hr LC_{50} = 4.53 µg a.i./L (C.L. 4.0 – 5.3 µg/L; slope – NA, moving average method)	44546030 (Sousa, 1998)	Acceptable (Very highly toxic)
Acute	Bluegill sunfish *Lepomis macrochirus* (99%) [CL912554 – metabolite of alpha cypermethrin]	96-hr LC_{50} = >102.8 a.i./L (C.L. N/A; slope – NA)	47944022 (Zok, 2002)	Acceptable (Practically non-toxic)
Acute	Bluegill sunfish *Lepomis macrochirus* (99%) [CL206128 – metabolite of alpha cypermethrin]	96-hr LC_{50} = >103.2 a.i./L (C.L. N/A; slope – NA)	47944023 (Zok, 2002)	Acceptable (Practically non-toxic)
Acute	Rainbow Trout *Oncorhynchus mykiss* (98.4%) [alpha-cypermethrin]	96-hr LC_{50} = 2.2 µg a.i./L (C.L. 1.4– 4.3 µg/L; slope – N/A, binomial method)	Zok, 2005 (Sousa, 1998)	Acceptable (Very highly toxic)
Acute	Rainbow Trout *Oncorhynchus mykiss* (98.4%) – Cypermethrin + Piperonyl butoxide (93.7% in 1:10 ratio)	96-hr LC_{50} = 0.468 µg a.i./L (based on measured cypermethrin concentrations) (C.L. 0.398 – 0.551 µg/L; slope – NA, binomial method)	49642301 (Brougher, 2015)	Acceptable (Very highly toxic)
Chronic	Fathead Minnow *Pimephales promelas* (92.9-93.2%)	**30-d NOAEC = <u>0.051 µg a.i./L</u>** 30-d LOAEC = 0.077 µg a.i./L	40641701 (Tapp, 1998)	Supplemental Significant reduced F_0-generation survivors (30-d post-hatch and number of larvae released)
Freshwater invertebrates (water column exposure)				

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Acute	Water flea *Daphnia magna* (91.5%) Cypermethrin GFU 034/A (formulated cypermethrin), (36%)	 48-hr EC_{50} = 1.01 ug a.i/L; (C.L. 0.80 – 1.31 ug a.i/L) 48-hr EC_{50} = 1.56 ug a.i/L; (C.L. 1.17 – 2.10 ug a.i/L)	00062793 (Edwards, 1980)	Acceptable (Very highly toxic)
Acute	Mayfly *Baetis rhodani* (% a.i not reported)	96-hr LC_{50} = 0.0092 µg a.i./L (C.L. not reported)	00070562 (Edwards, 1980)	Acceptable (Very highly toxic)
Acute	Mayfly *Cleon dipterum* Freshwater shrimp *Gammerus pulex* (98.1%)	96-hr LC_{50} = 0.02 µg a.i./L; (C.L. 0.01-0.070 µg/L) 96-hr LC_{50} = 0.009 µg a.i./L; (C.L. 0.007-0.01 µg/L)	00089041 (Stephenson, 1980)	Acceptable (Very highly toxic)
Acute	Pink shrimp *Penaeus duorarum* (91.5%)	48-hr EC_{50} = 0.043 µg a.i./L;(C.L. 0.0.036 – 0.053 ug/L)	00089043 (Jaber, 1981)	Acceptable (Very highly toxic)
Acute	Fiddler crabs *Uca pugilator* (91.5%)	48-hr EC_{50} = 0.197 µg a.i./L (C.L. 0.162 – 0.243 ug/L)	00089045 (Jaber, 1981)	Acceptable (Very highly toxic)
Acute	Water flea *Daphnia magna* (73%) [3-phenoxybenzoic acid (degradate of cypermethrin)]	48-hr EC_{50} = 111 mg a.i/L;(C.L. 82 – 147 mg a.i/L)	00089046 (Edwards, 1980)	Acceptable (Practically non-toxic)
Acute	Water flea *Daphnia magna* (99%) [3-phenoxybenzoic acid (degradate of cypermethrin)]	48-hr EC_{50} = 89 mg a.i/L;(C.L. 51 - 104 mg a.i/L)	00152739 (Everett, 1983)	Acceptable (Slightly toxic)
Acute	Water flea *Daphnia magna* (92.3%)	48-hr EC_{50} = 0.1 ug a.i/L;(C.L. 0.067 – 0.148 ug a.i/L)	41968210 (Ward, 1991)	Acceptable (Very highly toxic)

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Acute	Water flea *Daphnia magna* (>95%) [Beta-cypermethrin]	48-hr EC_{50} = 0.42 ug a.i/L;(C.L. 0.36 – 0.50 ug a.i/L)	44546031 (Putt, 1998)	Acceptable (Practically non-toxic)
Acute	Water flea *Daphnia magna* (>95%)	48-hr EC_{50} = 0.48 ug a.i/L;(C.L. 0.39 – 0.60 ug a.i/L)	44546032 (Putt, 1998)	Acceptable (Practically non-toxic)
Acute	Water flea *Daphnia magna* (99%) [Reg No. 4080830 – metabolite of alpha cypermethrin]	48-hr EC_{50} = 58.2 mg a.i/L;(C.L. 49.9 – 70.0 mg a.i/L; slope: N/A, moving average method)	47944024 (Jatzek, 2001)	Acceptable (Slightly toxic)
Acute	Water flea *Daphnia magna* (99%) [CL 206128 – metabolite of alpha cypermethrin]	48-hr EC_{50} = 30.8 mg a.i/L (C.L. 11.4 – 178 mg a.i/L; slope: 2.00)	47944025 (Jatzek, 2001)	Acceptable (Slightly toxic)
Acute	Water flea *Daphnia magna* (99%) [CL 206969 – metabolite of alpha cypermethrin]	48-hr EC_{50} = 0.886 mg a.i/L (C.L. 0.287 – 1.77 mg a.i/L; slope: N/A, binomial test)	47944026 (Jatzek, 2002)	Supplemental (Highly toxic)
Acute	Water flea *Daphnia magna* (99%) [alpha-cypermethrin]	48-hr EC_{50} = 0.067 µg a.i/L (C.L. 0.043 – 0.108 µg a.i/L; slope: 4.72)	47944208 (Funk, 2005)	Acceptable (Very highly toxic)
Acute	Amphipod *Hyalella azteca* (95.0%)	**96-hr EC_{50} = <u>0.00056 µg a.i./L</u>** (C.L. 0.00045-0.00071 µg/L)	49274301 (Bradley, 2013)	Acceptable (Very highly toxic)
Chronic	Water flea *Daphnia magna*	**<u>21-day NOAEC = 0.0041 µg/L</u>** <u>21-day LOAEC = 0.0081</u>	47885103 (Cafarella, 2008)	Acceptable Significant reduction in reproduction and dry weight
Chronic	Water flea *Daphnia magna* (99.7%)	21-day NOAEC = 0.0372 µg/L 21-day LOAEC = 0.0744	47944028 (Bergtold, 2007)	Supplemental Decline of treatment concentrations throughout the course of the study.
Freshwater benthic invertebrates (sediment exposure)				

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Sub-chronic	Midge *Chironomus dilutus* (99.8%)	Based on Pore Water Concentrations:[2] 10-D NOAEC <0.003 µg a.i./L 10-D LOAEC = 0.003 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC <400 µg a.i./kg-TOC 10-D LOAEC = 400 µg a.i./kg-TOC	46591504 (Putt, 2005)	Acceptable The survival NOAEC as the primary endpoint was not established, as treatment-related reductions in survival were indicated at all levels. Natural sediment was used.
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] 10-D NOAEC 0.0006 µg a.i./L 10-D LOAEC = 0.001 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC 92 µg a.i./kg-TOC 10-D LOAEC = 170 µg a.i./kg-TOC	47946601 (Picard, 2009)	Acceptable The growth (dry weight) NOAEC as the primary endpoint was not established, as treatment-related reductions in dry weight were indicated at all levels. Natural sediment was used.
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] 10-D NOAEC: <0.0004 µg a.i./L 10-D LOAEC = 0.0004 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC: <61 µg a.i./kg-TOC 10-D LOAEC = 61 µg a.i./kg-TOC	47946602 (Picard, 2009)	Acceptable The growth (dry weight) NOAEC as the primary endpoint was not established, as treatment-related reductions in dry weight were indicated at all levels. Formulated sediment was used.

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] 10-D NOAEC: 0.002 µg a.i./L 10-D LOAEC = 0.004 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC: 300 µg a.i./kg-TOC 10-D LOAEC = 530 µg a.i./kg-TOC	47946603 (Picard, 2009)	Acceptable The growth (dry weight) NOAEC as the primary endpoint was not established, as treatment-related reductions in dry weight were indicated at all levels. Natural sediment was used designated California (CA) Sediment 2.
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] 10-D NOAEC: <0.002 µg a.i./L 10-D LOAEC = 0.002 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC: <286 µg a.i./kg-TOC 10-D LOAEC = 286 µg a.i./kg-TOC	47946604 (Picard, 2009)	Acceptable The growth (dry weight) NOAEC as the primary endpoint was not established, as treatment-related reductions in dry weight were indicated at all levels. Natural sediment was used designated California (CA) Sediment 1.
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] 10-D NOAEC: 0.003 µg a.i./L 10-D LOAEC = 0.007 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC: 375 µg a.i./kg-TOC 10-D LOAEC = 984 µg a.i./kg-TOC	47946605 (Picard, 2009)	Acceptable The growth (dry weight) NOAEC as the primary endpoint was not established, as treatment-related reductions in dry weight were indicated at all levels. Natural sediment was used designated California (CA) Sediment 3.

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] **10-D NOAEC <u><0.00005 µg a.i./L</u>** 10-D LOAEC = 0.00005 µg a.i./L Based on OC-normalized sediment concentrations: **10-D NOAEC <7.7 <u>µg a.i./kg-TOC</u>** 10-D LOAEC = 7.7 µg a.i./kg-TOC	48593603 (Picard, 2010)	Supplemental The survival NOAEC as the primary endpoint was not established, as treatment-related reductions in survival were indicated at all levels. Formulated sediment was used. Sediment at 10°C
	Amphipod *Hyalella azteca* (93.0%)	Based on Pore Water Concentrations:[2] 10-D NOAEC 0.0004 µg a.i./L 10-D LOAEC = 0.0008 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC: 57 µg a.i./kg-TOC 10-D LOAEC = 112 µg a.i./kg-TOC	48593604 (Picard, 2010)	Acceptable Survival was the primary endpoint. Formulated sediment was used. Sediment at 16°C
	Midge *Chironomus dilutus* (93%)	Based on Pore Water Concentrations:[2] 10-D NOAEC <0.006 µg a.i./L 10-D LOAEC = 0.006 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC <780 µg a.i./kg-TOC 10-D LOAEC = 780 µg a.i./kg-TOC	48593605 (Picard, 2010)	Supplemental The growth NOAEC was not established, as treatment-related reductions in growth were indicated at all levels. Growth is a required endpoint for this study type with midges. Formulated sediment was used.

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
	Amphipod *Hyalella azteca* (95.2%)	Based on Pore Water Concentrations:[2] 10-D NOAEC <0.002 µg a.i./L 10-D LOAEC = 0.002 µg a.i./L Based on OC-normalized sediment concentrations: 10-D NOAEC: <333 µg a.i./kg-TOC 10-D LOAEC = 333 µg a.i./kg-TOC	49335702 (Picard, 2014)	Acceptable The growth (length) NOAEC as the primary endpoint was not established, as treatment-related reductions in length were indicated at all levels. Natural sediment was used.
Chronic	Midge *Chironomus tentans* (99.8%)	Based on Pore Water Concentrations:[2] **60-D NOAEC <0.0003 µg a.i./L** 60-D LOAEC = 0.0003 µg a.i./L Based on OC-normalized sediment concentrations: **60-D NOAEC <48 µg a.i./kg-TOC** 60-D LOAEC = 48 µg a.i./kg-TOC	48762903 amend to 46725701 (Putt, 2012)	Supplemental/Qualitative Significant reduction in female developmental rate and number of eggs per female. Was not upgraded to 'acceptable' from "supplemental' with the submission for reproduction data and replicate data for other endpoints since the NOAEC could not be established. Natural sediment was used.
Estuarine/marine fish (water column exposure)				
Acute	Sheepshead Minnow *Cyprinodon variegatus* (91.5 %)	**96-hr LC_{50} = 0.95 µg a.i./L** (C.L. 0.48-1.9 µg/L)	00090075 (Jaber, 1981)	Acceptable (Very highly toxic)
Acute	Sheepshead Minnow *Cyprinodon variegatus* (88.2%)	96-hr LC_{50} = 2.39 µg a.i./L (C.L. 2.12 – 2.67 µg/L; slope = 13.0)	41968211 (Overman, 1990)	Acceptable (Very highly toxic)
Acute	Sheepshead Minnow *Cyprinodon variegatus* (91.5%)	96-hr LC_{50} = 3.42 µg a.i./L (C.L. 1.89- 4.07 µg/L)	41968212 (Chandler, 1990)	Acceptable (Very highly toxic)
Acute	Sheepshead Minnow *Cyprinodon variegatus* (98.4%)	96-hr LC_{50} = 2.70 µg a.i./L (C.L. 2.10 – 4.20 µg/L)	44546033 (Dionne, 1998)	Acceptable (Very highly toxic)

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Acute	Beta cypermethrin Sheepshead Minnow *Cyprinodon variegatus* (98.0%)	96-hr LC_{50} = 2.40 µg a.i./L (C.L. 2.18 – 2.93 µg/L)	44546034 (Sousa, 1998)	Acceptable (Very highly toxic)
Chronic	NA	Estimated Chronic **NOAEC = <u>0.125 µg a.i./L</u>**	Estimated from 90075	Estimated from a high uncertainty analysis using Sheepshead minnow acute data and ACR of 7.6 from freshwater fish acute and chronic data (MRIDs 44546027 and 40641701)
Estuarine/marine invertebrates (water column exposure)				
Acute	Pacific oyster *Crassostrea gigas* (95.9%)	48-hr EC_{50} = >2.27 mg a.i/L (C.L. N/A)	00070562 (Thompson, 1981)	Supplemental Concentrations not measured, noted to be greater than the solubility limit
Acute	Eastern oyster *Crassostrea virginica* (91.5%)	98-hr EC_{50} = 370 ug a.i/L (C.L. 245 – 556 ug a.i/L	00089049 (Jaber, 1981)	Acceptable
Acute	Mysid Shrimp *Americamysis bahia* (95.9%)	**96-hr LC_{50} = <u>0.0054 µg a.i./L</u>** (C.L. 0.005-0.00607 µg/L)	42444601 (Ward *et al*, 1992)	Acceptable (Very highly toxic)
Acute	Mysid Shrimp *Americamysis bahia* (98.4%)	96-hr LC_{50} = 0.0055 µg a.i./L (C.L. 0.005-0.007 µg/L)	44561210 (Putt, 1998)	Acceptable (Very highly toxic)
Acute	Beta cypermethrin Mysid Shrimp *Americamysis bahia* (98.4%)	96-hr LC_{50} = 0.0059 µg a.i./L (C.L. 0.005-0.0067 µg/L)	44561209 (Putt, 1998)	Acceptable (Very highly toxic)
Chronic	Beta cypermethrin Mysid Shrimp *Americamysis bahia* (>95%)	28-d NOAEC = 0.0015 µg a.i./L 28-d LOAEC = 0.0033 µg a.i./L	44546035 (Sousa, 1992)	Acceptable Significantly survival and reproduction
Chronic	Mysid Shrimp *Americamysis bahia* (98.1%)	**28-d NOAEC = <u>0.000781 µg a.i./L</u>** 28-d LOAEC = 0.00197 µg a.i./L	42725301 (Wheat, 1992)	Acceptable Significantly reduced female body weight
Estuarine/marine benthic invertebrates (sediment exposure)				

Acute/ Chronic	Species (% a.i.) [1]	Toxicity Value Used in Risk Assessment	Citation or MRID # (Author, Date)	Study Classification/ Comment
Chronic	Amphipod *Leptocheirus plumulosus* (99.8%)	Based on Pore Water Concs:[2] **28-d NOAEC = 0.0002 µg a.i./L** 28-d LOAEC = 0.0008 µg a.i./L Based on OC-normalized Sediment Concs: **28-d NOAEC = 34 µg a.i/kg-TOC** 28-d LOAEC = 110 µg a.i/kg-TOC	48762902 amend to 46591503 (Putt, 2012)	Acceptable Significantly reduced amphipod reproduction. Upgraded to 'acceptable' from 'supplemental' with the submission of reproduction raw data and replicate data for other endpoints. Natural sediment was used.
Aquatic plants				
Vascular	Alpha-Cypermethrin *Lemna gibba* (99.2)	**7-D EC50 >1.62 µg a.i./L** **7-D NOAEC = 1.62 µg a.i./L**	47944031 (Hoffmann, 2009)	Supplemental Numerous deviations impacted acceptability of the study.
Non-vascular	Cyanobacteria (*Anabaena flos-aquae*) (99.2%) [alpha cypermethrin]	96-hr EC50= >27.1 µg a.i./L 96-hr NOAEC = 27.1 µg a.i./L	47944029 (Hoffman, 2009)	Supplemental Exceedance of recommended light intensity.
	Freshwater diatom (*Navicula pelliculosa)* (99.2%) [alpha cypermethrin]	96-hr EC50= >71.9 µg a.i./L 96-hr NOAEC = 71.9 µg a.i./L	47944030 (Hoffman, 2009)	Supplemental Exceedance of recommended light intensity.
	Marine diatom (*Skeletonema costatum)* (99.2%) [alpha cypermethrin]	96-hr EC50= >33.5 µg a.i./L 96-hr NOAEC = 33.5 µg a.i./L	47944032 (Hoffman, 2009)	Acceptable
	Pseudokirchneriella subcapitata (98.3 g/L) [Alpha-Cypermethrin]	**72-hr EC50= 25 mg a.i./L** **72-hr NOAEC = 0.06 mg a.i./L**	47944209 (Hoffmann, 2007)	Supplemental Test duration was not achieved
	CL912554 Metabolite of Alpha-Cypermethrin (99%)	72-hr EC50= 28 mg a.i./L 72-hr NOAEC = 12.7 mg a.i./L	47944035 (Werner, 2002)	Supplemental Test duration was not achieved
	CL206128 Metabolite of Alpha-Cypermethrin (99%)	72-hr EC50= 37 mg a.i./L 72-hr NOAEC = 6.21 mg a.i./L	47944036 (Werner, 2002)	Supplemental Test duration was not achieved

TGAI=technical grade active ingredient; LC_{50} = median lethal concentration; NOAEL=no observable adverse effect level; a.i. active ingredient; NA = Not applicable; ACR = acute to chronic ratio.

Bolded and underlined endpoint values represent the most sensitive values for a given taxa that are used in risk estimation.

[1] All test materials are TGAI unless otherwise noted.

[2] Concentrations in pore water estimated using mean Koc of 141700 L/kg.

Table 7. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Esfenvalerate

Information on the toxicity of esfenvalerate to selected taxa is based on both esfenvalerate and fenvalerate. Esfenvalerate contains more of the insecticidally active isomer; however, some fenvalerate toxicity endpoints are lower than esfenvalerate endpoints for other taxa. Ultimately, organisms exposed to esfenvalerate in water are exposed to a mixture of isomers.

A comprehensive list of available aquatic toxicity data is found in **Tables 7-1-7-3**. A summary description of data from most of the studies is found in the problem formulation (2010) and notations for studies can also be found in the following table comments and footnotes. New studies submitted since the problem formulation filled some previous data gaps, chiefly for chronic toxicity to fish and aquatic invertebrates, including TEP (typical end-use product) toxicity and toxicity to sediment-dwelling organisms and aquatic plants; summaries of new data follow the tables. Any new information found in the open literature likely to be used in risk estimation or characterization is also included.

Table 7-1. Summary of Aquatic Toxicity Data for Esfenvalerate and Fenvalerate that may be Used Quantitatively

Species Test Substance (% a.i./Isomer)	**Endpoint (Duration)**	**Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)**	**Citation or MRID # (Author, Date)**	**Study Classification/ (Comment)**
Freshwater Fish				
Air-breathing Catfish, 3 spp.: *Clarias batrachus* *Channa punctatus* *Heteropneustes fossilis* Fenvalerate TEP (20%)	LC_{50} (96-hr)	1.35 -3.19 µg/L 1.02-2.93 µg/L 0.65-1.78 µg/L	#E158268 (Datta, *et al*., 2011, in ECOTOX Biblio.) Supplemental/ Quantitative	The range of LC_{50}s represents studies done with and without 0.5 ml/L of acetone. For the endpoints in which acetone was used (the lower endpoint of the range for each species), caution should be used since the acetone concentration was 5x the recommended level of 0.1 ml/L. Since there was no control mortality, the data may be used, but some uncertainty exists.
Bluegill, *Lepomis macrochirus* Fenvalerate (94%)	LC_{50} (96-hr)	0.47 (0.38 – 0.60; nominal) Slope = 7.89	85723 (1980) Acceptable	The test was conducted under static conditions and esfenvalerate concentrations are difficult to maintain in static tests. However, reviewers noted a lessened concern since fenvalerate was used.
Bluegill, *L. macrochirus* TEP (32% all isomers)	LC_{50} (96-hr)	0.69 µg/L (nominal)	41215202 Supplemental-quantitative for spray drift	NOAEC = 0.32 µg/L Nominal based, Concentrations measured but there was contamination of samples so only nominal concentrations could be used. As this is a TEP test, it may still be used

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
				quantitatively to assess exposure to spray drift only.
Bluegill, *L. macrochirus* TEP (WP) (44% ss-isomer, 51% all isomers)	LC_{50} (96-hr)	0.23 (0.19-0.30) µg/L Slope = 6.79 (3.29 – 10.29)	43358312 Acceptable	NOAEC <0.043µg/L Solvent was acetone and solvent concentration was slightly higher than 0.1 mL/L for flow through tests. Sublethal effects observed at all test concentrations including erratic swimming, lethargic, rapid respiration, lying on the bottom, gasping for air, vertical position at bottom of tank, partial loss of equilibrium, and dark coloration. Calibration curve did not span the concentrations measured.
Bluegill, *L. macrochirus* TGAI (90.9% active isomer)	LC_{50} (96-hr)	0.142 (0.106 to 0.191)	48927403 Acceptable	Very Highly Toxic
Channel Catfish, *Ictalurus punctatus* TEP (Pydrin 2.4 EC, 2.4 lbs ai/gallon)	LC_{50} (96-hr)	1.02 (0.87-1.2)	121829 (1975) Acceptable	Pydrin 2.4 EC. Xylene solvent. One page DER.
Fathead Minnow, *Pimephales promelas* TGAI (96.0% active isomer)	NOAEC LOAEC (Life-Cycle, 260-d)	0.09 0.21	Accession # 97000 (Windberg 1978) Acceptable	(based on number of spawns per female, survival and growth of fry)
Fathead Minnow, *P. promelas* TGAI (90.9% active isomer)	NOAEC LOAEC (Life-Cycle, 31-wk)	0.017 0.036	49289201 Acceptable	(based on spawning frequency) Other endpoints affected in the study were: F_0 4-week survival, F_0 8-week survival, F_0 24-week survival and F_0 24-week male wet weight.
Rainbow Trout, *Oncorhynchus mykiss* TEP (WP) (44% SS, 51% all isomers)	LC_{50} (96-hr)	0.07 (0.06-0.09) Slope = 7.0 (3.2-10.7)	43358311 Acceptable	Very Highly Toxic NOAEL <0.0266 µg/L Sublethal effects observed at all treatment levels and include erratic swimming, gasping for air, and lying on the bottom.
Rainbow Trout, *O. mykiss* TGAI (90.9% active isomer)	LC_{50} (96-hr)	0.15 (0.11-0.21) Slope = 7.7 (2.2-13.2)	48831602 Acceptable	Very Highly Toxic
Estuarine/Marine Fish				
Sheepshead minnow	LC_{50} (96-hr)	>6.0	48831603 Supplemental/ Quantitative	A definitive endpoint was not reached, but since the highest treatment level was near the estimated solubility limit

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
(*Cyprinodon variegatus* TGAI (90.9% active isomer)				(2-6 ug/L – cited in 2010 Registration Review problem formulation document), the study showed that mortality would not be likely from environmental exposures. However, since there were signs of toxicity at the highest two treatment levels, some uncertainty exists.
Sheepshead minnow, *C. variegatus* TEP (DPX-656, 8.4EC) (8.4% w/w, all isomers)	LC_{50} (96-hr)	>9.23	49212901 Supplemental/ Quantitative	A definitive endpoint was not reached, but since the highest treatment level was near the estimated solubility limit (2-6 ug/L – cited in 2010 Registration Review problem formulation document). The study showed that mortality would not be likely from environmental exposures.
Sheepshead minnow, *C. variegatus* TGAI (90.9% active isomers)	NOAEC LOAEC (Life-Cycle, 19-wk)	0.63 1.3	49289202 Acceptable	(based on hatching success and F_0 19-week length) Other F_0 generation endpoints affected were 4-week post hatch survival, F_0 4-week post hatch length, 19-week post-hatch female wet weight, and clinical signs of toxicity. F_1 Generation: NOAEC/LOAEC: 0.65/1.6 µg a.i./L (based on hatching success and 4-week survival) Other F_1 generation endpoints affected during the study were clinical signs of toxicity.
Freshwater Invertebrates (Water Column Exposure)				
Amphipod, *Hyalella azteca* TGAI (100% all isomers)	LC_{50} (96-hr)	0.000848 (0.000797-0.000903)	49209501 Acceptable	Very Highly Toxic
Water Flea, *Daphnia magna* TGAI (97.6% all isomers)	EC_{50} (48-hr)	0.049 (0.024 – 0.082) µg/L	41891914 Acceptable	NOAEC = 0.03 µg/L Individual concentrations ranged from 17-35% nominal.
Water Flea, *D. magna* TGAI (98.6% all isomers 82.8% ss-isomer, 15.8% other isomers)	EC_{50} (48-hr)	= 0.24 (0.19 – 0.30) µg/L Slope = 3.011	42492602 Acceptable	NOAEC = 0.044 µg/L

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[1] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Water Flea, *D. magna* TEP (8.4EC [80 g/L]) (8.4% all isomers)	EC_{50} (48-hr)	0.089 (0.0518-0.241) Slope = 1.41 (0.821-2.00)	49140403 Acceptable	EC_{50} for formulation: 1.05 (0.614-2.82) µg formulation/L
Water Flea, *D. magna* TGAI (98.6% ss-isomers)	NOAEC LOAEC (Chronic, 21-d)	0.052 0.079	40444001 Acceptable	(based on total number of young, young/day, and growth) 48-hr EC_{50} = 0.9 (0.7 – 1.16) µg/L NOAEC/LOAEC = 0.15/0.45 µg a.i./L based on mortality. 80 and 100% mortality occurred at 0.25 at 0.50 µg a.i./L, respectively.
Freshwater Invertebrates (Sediment Exposure)[3]				
Amphipod, *H. azteca* TGAI (99.6% purity using formulated sediment)	<u>Pore Water:</u> NOAEC LOAEC <u>Sediment, OC Normalized:</u> NOAEC LOAEC (Sub-Chronic, 10-d)	0.70 ng ai/L freely-dissolved pore water 1.2 ng ai/L freely-dissolved pore water 176 µg ai/kg TOC 314 µg ai/kg TOC	48593610 Acceptable	NOAEC/LOAEC = 176/314 µg ai/kg TOC (0.70/1.2 ng ai/L freely-dissolved pore water) based on 10-d survival and growth as dry weight) LC_{50} = 379 µg ai/kg TOC (1.5 ng ai/L freely-dissolved pore water; 7.95 µg ai/kg sediment) 95% C.I.: 339-421 µg ai/kg TOC (1.4-1.7 ng ai/L freely-dissolved pore water; 7.11 -8.85 µg ai/kg sediment) Slope: 4.47 (3.62-5.32) (based on 10-d survival) LC_{50} = 438 µg ai/kg TOC (1.7 ng ai/L freely-dissolved pore water; 9.2 µg ai/kg sediment) 95% C.I.: 324-586 µg ai/kg TOC (1.3-2.3 ng ai/L freely-dissolved pore water; 6.8-12.3 µg ai/kg sediment) Slope: N/A (based on growth as dry weight) DER was amended on 05/04/2016 (DP Barcode: 428762)
Amphipod, *H. azteca* TGAI (90.9 % active isomer purity using formulated sediment)	<u>Pore Water:</u> NOAEC LOAEC <u>Sediment, OC Normalized:</u> NOAEC	0.56 ng ai/L freely-diss. pore water 1.2 ng ai/L freely-diss. pore water	49274303 Acceptable	NOAEC/LOAEC = 140/310 µg ai/kg OC (0.56/1.2 ng ai/L freely-diss. pore water; 4.4/9.5 µg a.i./kg sediment) (based on 10-d survival and length) LC_{50} = 661 µg ai/kg OC (2.61 ng ai/L freely-dissolved pore water; 20.4 µg ai/kg sediment)

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
	LOAEC (Sub-Chronic, 10-d)	140 µg ai/kg OC 310 µg ai/kg OC		95% C.I.: 557-761 µg ai/kg OC (2.20-3.01 ng ai/L freely-diss. pore water; 17.2-23.5 µg ai/kg sediment) Slope: 4.13 (3.05-5.20) (based on 10-d survival) LC_{50} = 1530 µg ai/kg OC (6.07 ng ai/L freely-dissolved pore water; 47.4 µg ai/kg sediment) 95% C.I.: 1230-1900 µg ai/kg OC (4.90-7.55 ng ai/L freely-diss. pore water; 38.2-58.9 µg ai/kg sediment) Slope: N/A (based on growth)
Amphipod, *H. azteca* TGAI (100% all isomers)	<u>Pore Water:</u> NOAEC LOAEC <u>Sediment, OC Normalized:</u> NOAEC LOAEC (Chronic, 42-day)	0.83 ng ai/L freely-diss. pore water 0.1.6 ng ai/L freely-diss. pore water 210 µg a.i./kg OC 410 µg a.i./kg OC	49054201 Acceptable	NOAEC/LOAEC = 0.83/1.6 ng ai/L freely-dissolved pore water (210/410 µg a.i./kg OC; 7.9/15 µg a.i./kg) (based on 28- and 42-day length) NOAEC/LOAEC = 3.4/7.2 ng ai/L freely-dissolved pore water (860/1800 µg a.i./kg OC; 32/65 µg a.i./kg) (based on 42-day survival and 42-day cumulative offspring,) NOAEC/LOAEC = 7.2/15 ng ai/L freely-dissolved pore water (1800/3800 µg a.i./kg OC; 65/140 µg a.i./kg) (based on 42-day offspring per female) No significant effect was measured in 42-day male:female ratio in the highest treatment.
Midge, *Chironomus tentans* TGAI (A.alpha Fenvalerate [phenoxyphenyl ring-U- 14C] (14C] DPX-GB800, [14C] esfenvalerate, DPX-GB800 (resolved S,S isomer) radiolabeled study with 66.5% radiochemical purity using natural sediment)	<u>Pore Water:</u> NOAEC LOAEC <u>Sediment, OC Normalized:</u> NOAEC LOAEC (Sub-Chronic, 10-d)	10 ng a.i./L freely-diss. pore water 18 ng a.i./L freely-diss. pore water 2,550 ug a.i./kg TOC 4,550 ug a.i./kg TOC	46591505 Acceptable	NOAEC/LOAEC = 0.010/0.018 ug a.i./L freely-dissolved pore water (2,550/4,550 ug a.i./kg TOC) EC_{50} = 0.033 µg a.i./L freely-dissolved pore water (8,180 ug a.i./kg TOC) 95% C.L: 0.027-0.039 ug a.i./L (6,910-9,820 ug a.i./kg TOC) Slope: 2.01 ± 0.165 (based on dry weight) NOAEC/LOAEC: 0.018/0.034 ug a.i./L freely-dissolved pore water (4550/8550 ug a.i./kg TOC) LC_{50}: 0.074 µg a.i./L freely-dissolved pore water (18,500 ug a.i./kg TOC) 95% C.L: 0.063-0.087 ug a.i./L (15,800-22,000 ug a.i./kg TOC)

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
				Slope: N/A (based on mortality)
Midge, *Chironomus dilutus* TGAI (99.6% all isomers; using formulated sediment)	Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC (Sub-Chronic, 10-d)	<10 ng ai/L freely-diss. pore water 10 ng ai/L freely-diss. pore water <2600 µg ai/kg TOC 2600 µg ai/kg TOC	48593611 Acceptable	NOAEC/LOAEC = <10/10 ng ai/L freely-dissolved pore water (<2600/2600 µg ai/kg TOC; <58/58 µg a.i./kg sediment) EC_{50} = 36 ng ai/L freely-dissolved pore water (9100 µg ai/kg TOC; 200 µg ai/kg sediment) 95% C.I.: 30-44 ng ai/L (7600-11000 µg ai/kg TOC; 170-240 µg ai/kg sediment) Slope: N/A (based on ash-free dry weight) NOAEC/LOAEC = 23/40 ng ai/L estimated freely-dissolved pore water (5900/10,000 µg ai/kg TOC; 130/200 µg a.i./kg sediment) EC_{50} = 83 ng ai/L freely-dissolved pore water (21,100 µg ai/kg TOC; 460 µg ai/kg sediment) 95% C.I.: 68-99 ng ai/L (17000-25000 µg ai/kg TOC; 370-550 µg ai/kg sediment) Slope: 3.25 (2.4-4.1) (based on survival) DER was amended on 05/04/2016 (DP Barcode: 428762)
Midge, *C. dilutus* TGAI (90.9% active isomers; 100% all isomers)	Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC (Life-Cycle, 57-d)	0.60 ng ai/L freely dissolved pore water 1.5 ng ai/L freely dissolved pore water 0.15 µg ai/kg-OC 0.38 µg ai/kg-OC	49082601 Acceptable	NOAEC/LOAEC = 0.60/1.5 ng ai/L freely dissolved pore water (0.15/0.38 µg ai/kg-OC; 2.0/5.0 µg ai/kg-sediment) (based on day-20 survival) NOAEC/LOAEC= 1.5/3.7 ng ai/L freely dissolved pore water (0.38/0.94 µg ai/kg-OC; 5.0-12 µg ai/kg-sediment) (based on male:female ratio) NOAEC/LOAEC= 3.7/>3.7 ng ai/L freely dissolved pore water (0.94/>0.94 µg ai/kg-OC; 12/>12 µg ai/kg-sediment) (based on development rate, mean days to death, egg masses/mated female, eggs/egg mass, eggs/mated female and days to oviposition)

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
				No significant effect was measured in day-20 ash-free dry weight in the highest treatment.
Estuarine Marine Invertebrates (Water Column Exposure)				
Eastern Oyster, *Crassostrea virginica* TGAI (90.9% active isomer)	Oyster Shell Deposition IC_{50} (96-hr)	>10 (N/A) Slope: N/A	49008801 Acceptable	Practically non-toxic
Mysid Shrimp, *Mysidopsis bahia* TGAI (>99% 14C-ASANA, DPX-GB800)	NOAEC LOAEC (Chronic, 28d)	0.00037 0.00081	40414101 (1987) Not Reviewed	(based on survival and reduced offspring/female/reproductive day) 13% reduction in survival in the 0.00081 µg ai/L treatment. NOAEC/LOAEC: 0.00037/0.00081 µg ai/L (based on male and female reduced dry weight) 24-39% reduction in dry weight. The review for this study was not found. A preliminary review did not show any obvious errors. However, the study was not re-reviewed since a similar study with a slightly more sensitive endpoint was available. The results of this study appear to agree with the newer study results (MRID 49140407).
Saltwater Mysid, *M. bahia* TGAI (90.9% active isomer)	LC_{50} (96-hr)	0.00466 (0.00394-0.00539) Slope: 7.15 (4.68-9.61)	49140405 Acceptable	Also says 100% total isomers by analysis (purity) -- says a primary stock solution at a nominal concentration of 100 ug a.s./mL adjusted for a purity of 90.9%, was prepared.
Saltwater Mysid, *M. bahia* TEP (8.4EC formulation, 8.4% w/w DPX-YB656, 8.4% active isomer)	LC_{50} (96-hr)	0.00339 (0.00273 - 0.00423) Slope: 4.45 (2.96-5.93)	49140406 Acceptable	
Saltwater Mysid, *M. bahia* TGAI (96.3% Chlorophenyl-14C Esfenvalerate (DPX-YB656), adjusted to 100%	NOAEC LOAEC (Chronic, 28-d)	0.00017 0.00025	49140407 Acceptable	NOAEC/LOAEC = 0.17/0.25 ng ai/L (based on offspring/female) NOAEC/LOAEC = 0.25/0.47 ng ai/L (based on time-to-first-brood) No significant effects were measured in F_0 survival or male or female length or weight in the highest treatment.

Species Test Substance (% a.i./Isomer)	Endpoint (Duration)	Toxicity Value (95% C.I.) in µg a.i./L[(1)] Slope (if applicable)	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
active isomers during preparation)				
Estuarine Marine Invertebrates (Sediment Exposure)[(3)]				
Amphipod, *Leptocheirus plumulosus* TGAI (95.8% Radiopurity, SS-isomer)	Pore Water: NOAEC LOAEC Sediment, OC Normalized: NOAEC LOAEC (28-d)	3.3 ng ai/L freely diss. pore water 10.3 ng ai/L freely diss. pore water 830 ug a.i./kg TOC 2600 ug a.i./kg TOC	46620401 48762905 Acceptable	NOAEC/LOAEC: 0.0033/0.0103 ug a.i./L freely-dissolved pore water (830/2600 ug a.i./kg TOC, 50/125 ug a.i./kg sediment) (based on dry weight, reproduction and survival) EC_{50}: >0.010 µg a.i./L freely-dissolved pore water (>2600 ug a.i./kg TOC) (based on dry weight) LC_{50}: 0.009 µg a.i./L freely-dissolved pore water (2359 ug a.i./kg TOC) 95% C.L: 0.008-0.010 ug a.i./L (2020-2810 ug a.i./kg TOC) Slope: N/A (based on mortality) MRID 46620401 was an amendment to MRID 48562905.
Aquatic Plants (Non-vascular)				
Freshwater Algae, *Pseudokirchneriella subcapita* TGAI (90.9% active isomer 100.0% total isomers)	EC_{50} NOAEC LOAEC (96-hr) Static	>5.6 µg a.i./L 5.6 µg a.i./	48927404 Acceptable	(based on yield, growth rate and AUC)
Aquatic Plants (Vascular)				
Duckweed, *Lemna gibba* TGAI (90.9% active isomer 100.0% total isomers)	EC_{50} NOAEC (7-d)	>8.6 µg a.i./L = 8.6 µg a.i./L	48831601 Acceptable	(based on frond number yield, growth, final biomass and biomass growth rate[1])

Abbreviations: a.i. active ingredient; AUC = area under the curve; Conc. = concentration; C.I. = confidence interval; EC = emulsifiable concentrate; LC_{50} = median lethal concentration; LOAEC = lowest-observable adverse effect concentration; LOD = limit of detection; LOQ = limit of quantitation; NOAEC = no-observable adverse effect concentration; OC or TOC = organic carbon or total organic carbon (i.e., the concentration was adjusted to the amount of organic carbon present); TEP = typical end use product; TGAI = technical grade active ingredient; WP = wettable powder;
All toxicity endpoints are reported in percent active ingredient (a.i.) unless otherwise stated.

[1] All toxicity endpoints are reported in terms of a.i., concentrations are expressed in µg a.i./L, unless otherwise specified.
[2] Freely dissolved pore water endpoints estimated from sediment organic-carbon normalized concentration and a Koc of [VALUE] L/kg-OC, as: Mean measured bulk sediment cone. *(ug a.i./kg-d.w.)* / [Fraction TOC *(kg OC/kg-dw)* * Koc (L/kg-OC)].
[3] This is the reference number of this study in the ECOTOX database (USEPA, 2016).

Table 7-2. Summary of Aquatic Mesocosm Data for Esfenvalerate and Fenvalerate

Taxa Observed	Types of Observations	Effects Measured at Each Treatment Level	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
Freshwater Ecosystem				
Fish and aquatic invertebrates: Fathead minnow, *Pimphales promelas* Daphnia, *Ceriodaphnia dubia* Midge, *Chironomus tentans*	After simulated storm event in an agricultural drainage ditch, aqueous and sediment samples were taken at 0.5, 3, and 24 hours and 28 days post application at 0, 20, 80, 200, and 600 meters downstream (also at 56 days for sediment), plus reference upstream samples at 10 meters (m). These were analyzed for esfenvalerate residues and used in aqueous and sediment toxicity tests with fish and invertebrates.	Fish and Daphnia: 0 and 20 m at 0.5 and 3 hours post application: Survival of *C. dubia* and *P. promelas* was 0% 80 m at 3 hours post application: Survival of *C. dubia* was 0% *P. promelas* was 17.5 % All other times and distances (200 and 600 m and up to 24h for fish and daphnia): Survival was ≥72.5% with the exception of *C. dubia* at 80 m 24 hours post application (45 ± 44%) and *P. promelas* at 80 m 28 days post application (60 ± 25.8 %). Midge up to 28d: Survival and growth of *Chironomus tentans* was significantly lower than control at the injection site only at all sampling times. Survival was highest 3 hours post application (25 ±16%) and declined through Day 56 to 6.3 ± 7.4%. Plants: Pesticides were also measured in plant material at 20, 80, 200 and 6000 m from the injection site at 3 hours, 24 hours, 28 days, and 56 days post application. Concentrations in plant material were highest at 20 m, 3 hours post application (2010.34 ppb) and declined with distance and time.	Bouldin *et al.* (2004) Open Literature Study	A storm event (0.64 cm on a 20.23-ha field) producing runoff with esfenvalerate was simulated in an agricultural drainage ditch. The highest concentration of esfenvalerate was detected at the injection point (0 m) at 3 hours post application. The application rate that the runoff event was expected to simulate was not reported, and likely the amount of esfenvalerate that would reach surface water via runoff would vary with environmental conditions. The water velocity in this study was measured at 0.04 m/s, so it is not known how these results, especially for sediments, would compare to a faster moving system. However, it still provides an indication of the potential effects of esfenvalerate in an aquatic system.
Water flea, *Daphnia magna*	*D. magna* were exposed to control, 0.03, 0.1, 0.3, 0.6,	3.2 ppb: 100% mortality by Day 8 post-exposure at both feeding levels.	Pieters *et al.* (2005)	Authors investigated the effects of fenvalerate under field conditions (including food restriction). The main goal of

Taxa Observed	Types of Observations	Effects Measured at Each Treatment Level	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
	1.0, and 3.2 ppb fenvalerate concentrations (nominal) for 24 hours under two different feeding regimes (low and high). The effect on the intrinsic rate of increase was measured over the course of 21 days post-exposure.	Low feeding level: Mortality was higher at the low than high feeding level in all test concentrations above 0.1 ppb. Low food conditions significantly increased age at first reproduction and decreased mean brood number, mean brood size, and cumulative reproduction per living female by the end of the test (Day 21).	Open Literature Study	this study was to examine the effects of low food conditions on life history characteristics of *Daphnia magna*, especially the intrinsic rate of increase, during pulses of pesticide exposure. As a result, the intrinsic rate of increase was significantly lower in the low food concentration test groups, indicating that greater detrimental population effects would be expected under these conditions.
Phytoplankton, zooplankton, macro-invertebrate, and juvenile fish populations from multiple zones (benthic, littoral, open water)	**Throughout Study:** Observations **End of Study:** Measurements made on relative health of fish populations	Low Treatment: 232.5 mg ai/pond: – no effects to insects; Medium Treatment: 4,125 mg ai/pond: – some insects eradicated, almost immediate effects to invertebrates, most notably benthic – reduction in small fish High Treatment: 23,270 mg ai/pond: – results similar to medium treatment All Treatments: No significant changes to fish relative health, but food source may be affected. No effects on phytoplankton or emergent aquatic vegetation.	41573901	Study submitted to EFED as a rebuttal to a presumption of hazard to aquatic systems resulting from a worst case exposure scenario assumed. Treatments were meant to simulate exposure to aquatic systems through both drift and runoff, where 10 drift events and five runoff events were simulated to provide total esfenvalerate loads. The results indicated that, "esfenvalerate use will have a significant influence on the populations of certain aquatic zooplankton and macroinvertebrates. The resulting decline in these populations at times that coincide with fish reproduction (bluegill) will represent a decrease in a significant food base which will affect fish larval growth and possibly year-class strength." The comparative applicability of this study to aquatic environments outside of the study area was questioned because changes in aquatic chemistry during the study (increased alkalinity and rising pH from supplemental

Taxa Observed	Types of Observations	Effects Measured at Each Treatment Level	Citation or MRID # (Author, Date)	Study Classification/ (Comment)
				fertilization) appeared to affect esfenvalerate exposure potential and may have masked higher toxicity concerns for this synthetic pyrethroid.

Table 7-3. Summary of Submitted Aquatic Toxicity Data for Esfenvalerate and Fenvalerate that may be Used Qualitatively, Were Open Literature Studies, or are Unacceptable

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
Acute Freshwater Fish						
Acute	Bluegill Sunfish *L. macrochirus* Static	TEP (30% All isomers)	96-hr LC_{50} = 4.9 µg/L	Mortality	Test No. 2354 No DER	Only one page summary available. Conducted at Harrison Lake National Fish.
Acute	Bluegill Sunfish *L. macrochirus* Static	TGAI (92.1% All isomers)	96-hr LC_{50} = 0.63 µg/L	Mortality	Test No. 2355	Conducted at Harrison Lake National Fish.
Acute	Bluegill Sunfish *L. macrochirus* Static	TGAI (92.1% All isomers)	96-hr LC_{50} = 1.01 µg/L	Mortality	Test No 2359	Conducted at Harrison Lake National Fish. Open Literature
Acute	Bluegill Sunfish *L. macrochirus* Static	TEP (30% All isomers)	96-hr LC_{50} = 4.3 µg/L	Mortality	Test No. 2360 No DER	Only one page summary available. Conducted at Harrison Lake National Fish.
Acute	Bluegill Sunfish *L. macrochirus* Static	TGAI (95% All isomers)	96-hr-LC_{50} = 0.64 (0.55-0.75) µg/L	Mortality	121828 (1975) Supplemental-qualitative DER Amendment	One page DER.
Acute	Bluegill Sunfish *L. macrochirus* Static	TGAI (NS All isomers)	96-hr LC_{50} = 0.42 (0.30 – 0.59) µg/L	Mortality	121830 (1976) Supplemental-qualitative DER Amendment	One page DER. Not enough information in the MRID to evaluate study. Purity of the test substance was not provided. The test was conducted under static conditions and the concentrations were not measured.
Acute	Bluegill Sunfish *L. macrochirus* Static	TGAI (98.8% All isomers 82.8% SS-isomer)	96-hr LC_{50} = 0.26 (0.19- 0.36) µg/L Slope= 4.15 (2.17-6.13)	Mortality	MRID Missing (Forbes, 1985) Supplemental	On 06/25/1986 a DER was issued classifying the study as acceptable, but no MRID was given, but a notation stating that it was associated with

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
			NOAEC/LOAEC = 0.056/0.10 µg/L Nominal			MRID 41233001 (a rainbow trout study). Later, on 09/15/1995, a new use assessment for sorghum stated that it was considered supplemental due to lack of measured concentrations. No DER addendum was found. The original study was not re-reviewed at this time since it was not the most sensitive endpoint. Some uncertainty exists regarding the actual exposure concentrations, but otherwise it is scientifically sound. Another bluegill study (43358312) has a very similar endpoint and the two data points agree.
Acute	Bluegill Sunfish *L. macrochirus* Static	TGAI (97.6% All isomers)			41891912 (1991) Invalid 09/25/1991	Test concentrations were 22-200% of nominal. The actual concentrations to which bluegill sunfish were exposed is unknown. Sublethal effects at all test concentrations. Age of test organisms not reported.
Acute	Channel Catfish *I. punctatus* Static	TGAI (95% All isomers)	96-hr LC_{50} = 0.81 (0.68-0.97) µg/L	Mortality	71642 (1975) Supplemental-qualitative DER Amendment	One page DER. Not enough information in the MRID to fully evaluate study.
Acute	Fathead Minnow *P. promelas* Static	TGAI (98% All isomers)	96-hr LC_{50} = 0.18 µg/L NOAEC = 0.13 µg/L nominal	Mortality	41215201 (1984) Supplemental-qualitative 05/24/1993	Analytical results indicated that test material was not stable. DO was 38-63%.

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
Acute	Rainbow Trout *O. mykiss* Static	TGAI (NS All isomers)	96-hr LC_{50} = 1.2 (0.95-1.5) µg/L	Mortality	121830 (1976) Supplemental-qualitative DER amendment	Aerated, fish were 20g, mortality data not legible. One page DER. Purity of the test substance was not provided.
Acute –	Rainbow Trout *O. mykiss*	TGAI (95% All isomer)s	96-hr LC_{50} > solubility	Mortality	121833 (1975) Supplemental-qualitative NS	One page DER. The test was conducted by the U.S. FWS in Columbia, MO.
Acute	Rainbow Trout *O. mykiss* Static	TGAI (98.8% SS-isomer)	96-hr LC_{50} = 0.26 (0.20- 0.38) µg/L Slope=5.96 (1.98-9.93) NOAEC/LOAEC = 0.1/0.18 µg/L Nominal	Mortality	41233001 (1985) Supplemental-qualitative 05/24/1990	Esfenvalerate measured in solvent control and measured concentrations were highly variable. The reviewer speculated that contamination occurred during shipping. Esfenvalerate was prepared in acetone which causes racemization. Part of the appendix is missing. Some bottle caps were loose when samples were received.
Acute	Rainbow Trout *O. mykiss* Static	TEP (EC) (32% All isomers)	96-hr LC_{50} = 0.51 µg/L NOAEC = 0.18 µg/L nominal	Mortality	41233002 (1985) Supplemental-qualitative 05/24/1993	Esfenvalerate measured in solvent control. The Table containing the analytical results may have been from another test using the same test material. Percent a.i. in test material was not given in report. Data missing from appendix.
Acute	Rainbow Trout *O. mykiss* Flow through	TGAI (97.6% All isomers)		Mortality	41891913 (1991) Invalid 09/25/1991	Test concentrations were 30-72% of nominal. The actual concentrations to which rainbow trout were exposed is unknown. Mortality

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
						at all test concentrations. Level of solvent not known. Pretest mortality not reported. Age of test organisms not reported.
Chronic Freshwater Fish						
Chronic	Fathead Minnow *P. promelas* Flow through	TGAI (96% Assumed all isomers)		Number of spawns per female, survival and growth of fry	Acc No. 97000 (1978) Unacceptable DER Amendment	There were difficulties in maintaining the desired test concentrations. Test days 42-63, measured concentration decreased as fish size and the quantity of food introduced in the test tank increased. The concentration of the stock solution was doubled on day 63. All test concentrations were higher than the solubility and many samples had measured concentrations below the minimum detectable level.
Chronic	Rainbow Trout, Donaldson trout, *O. mykiss*	TGAI (100% All isomers)	70-d LC_{50} = 0.101 µg/L	Mortality	(Curtis *et al.*, 1985) (ECOTOX #12019) (3) Supplemental information	Open Literature study. Data from long-term toxicity study. Not comparable to acute endpoint and not formally reviewed.
Acute Estuarine/Marine Fish						
Acute	Atlantic silverside *Menidia menidia* Flow-through	TGAI (100% All isomers)	96-hr LC50 = 0.31 (0.21-0.40) µg/L Slope not available Measured	Mortality	40228401 (1986) Qualitative Study Summary	The source of these data is a listing of estuarine/marine studies on pesticides compiled by the USEPA (Mayer. 1986. *Acute Toxicity Handbook of Chemicals to Estuarine Organisms,*

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
						Prepared for the Office of Pesticides and Toxic Substances, Prepared by Environmental Research Laboratory-Gulf Breeze EPAl6001X-26/23 1.). The raw data for these studies are not available and many of the details of the study are not known. The study was initially classified as core (Bryceland, 1999).
Acute	Sheepshead minnow *C. variegates* Flow-through	TGAI (100% All isomers)	96-hr LC_{50} > Solubility	Mortality	40228401 (1986) Qualitative Study Summary	The source of these data is a listing of estuarine/marine studies on pesticides compiled by the USEPA (Mayer. 1986. *Acute Toxicity Handbook of Chemicals to Estuarine Organisms*, Prepared for the Office of Pesticides and Toxic Substances, Prepared by Environmental Research Laboratory-Gulf Breeze EPAl6001X-26/23 1.). The raw data for these studies are not available and many of the details of the study are not known. The study was initially classified as core (Bryceland, 1999).
Acute	California Grunion *Leuresthes tenuis* Flow-through	TGAI (100% All isomers)	96-hr LC50 = 0.29 (0.21-0.37) Slope not available Measured	Mortality	40228401 (1986) Qualitative Study Summary	The source of these data is a listing of estuarine/marine studies on pesticides compiled by the USEPA (Mayer.

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
						1986. *Acute Toxicity Handbook of Chemicals to Estuarine Organisms*, Prepared for the Office of Pesticides and Toxic Substances, Prepared by Environmental Research Laboratory-Gulf Breeze EPAl6001X-26/23 1.). The raw data for these studies are not available and many of the details of the study are not known. The study was initially classified as core (Bryceland, 1999).
Acute Freshwater Invertebrates						
Acute	Water Flea *D. magna* Static	TGAI (98.6% SS-isomer)	48-hr LC_{50} = 0.9 (0.7-1.2) µg/L Slope not specified NOAEL/LOAEL = 0.11/0.19 µg/L nominal	Mortality	40444002 (1987) Supplemental-qualitative DER amendment	Concentrations were not measured. This study was originally found to be acceptable (DER 03/8/1988). Static studies with measured concentrations show highly variable test concentrations. Therefore, in order to be confident in the test concentration the concentrations should be measured for this compound.
Acute	Water Flea *D. magna* Static-renewal	TEP (EC) (9.7% All isomers 8.4% SS-isomer)	48-hr EC_{50} = 0.33 µg/L NOAEC = 0.067 µg/L measured	Mortality	42492601 (1992) Supplemental-qualitative 05/21/1993	Water flowed through aquarium with fathead minnows before use. Measured concentrations of total isomers ranged from 55-84% of nominal.
Acute	Water Flea *D. magna*	TGAI (NS	48-hr EC_{50} < 1.6 µg/L	Mortality	121830 (1976)	One page DER. Purity of the test

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
	Static	All isomers)			Supplemental-qualitative DER Amendment	substance was not provided.
Acute	Midge *C. plumosus* NS	TGAI (NS All isomers)	48-hr EC_{50} >10 µg/L	Mortality	121830 (1976) Supplemental-qualitative DER Amendment	One page DER. USFWS. Purity of the test substance was not provided.
Acute	Water Flea *D. magna* Static	TEP (8.4% SS-isomer)	48-hr EC_{50} = 0.008 µg/L measured	NA	41798301 (1991) Supplemental-qualitative (Borges *et al.*, 2008; Bryceland, 1999)	Unidentified contaminant and low analytical recoveries. Racemization was observed. Solvent DMF. This study was reported to be supplemental in recent risk assessments (Borges *et al.*, 2008; Bryceland, 1999). However, the memo in 1992 indicates that Dupont agreed to repeat this study due to variable analytical results, racemization, and possible contamination of water (Memo to RD 02/18/1992)
Acute	Water Flea *D. magna*	TEP/ WP (51.0% All isomers 44.4% SS-isomer)		Mortality	43758313 (1994) Unacceptable DER Amendment	Static-renewal. Source of water was filtered fish tank water. This study is invalid because of 1) contamination of 10 out of 16 initial test concentration samples; 2) addition of hexane rinsings of beakers to final test concentration samples; 3) a calibration curve that does not span the range of test concentrations; 4) the

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. (1)	Effect	MRID (Year) Classification Date of DER	Comments
						use of filtered, fish tank water.
Chronic Freshwater Invertebrates						
Life-Cycle	Water Flea *D. magna* Static	TGAI (94% All isomers)			109887 (1979) Invalid 06/25/1986	Greater than 80% mortality in controls.
Acute Estuarine/Marine Invertebrates						
Acute	Mysid shrimp *M. bahia* Static Nominal	TGAI (NS All isomers)	96-hr LC_{50} = 0.038 (0.030 – 0.048) µg/L	Mortality	144839 (1980) Supplemental information.	Only summary information in study report; data not available for review. Other studies with more sensitive endpoints available.
Acute	Pink Shrimp *Panaeus duorarum* Flow-through	TGAI (100% All-isomers)	96-hr LC_{50} = 0.84 µg/L	Mortality	40228401 (1986) Qualitative Study Summary	The source of these data is a listing of estuarine/marine studies on pesticides compiled by the USEPA (Mayer. 1986. *Acute Toxicity Handbook of Chemicals to Estuarine Organisms*, Prepared for the Office of Pesticides and Toxic Substances, Prepared by Environmental Research Laboratory-Gulf Breeze EPAl6001X-26/23 1.). The raw data for these studies are not available and many of the details of the study are not known. The study was initially classified as core (Bryceland, 1999).
Acute	Grass shrimp *Palaemonetes pugio* Static-renewal	Fenvalerate	96-hr LC_{50} = 0.044 µg/L	Mortality	Baughman et al. 1989	Study approved by ECOTOX but not yet reviewed by EFED. This study was identified in the 2010 problem formulation as being a study that

Study Type	Test Species *Genus Species* Study Notation	TGAI/ TEP (% ai Isomer)	Toxicity Endpoint (95% C.I.) Slope Expressed in terms of a.i. [1]	Effect	MRID (Year) Classification Date of DER	Comments
						would be included in the assessment. However, since that writing, more sensitive endpoints are now available and so the study was not reviewed.
Acute	Grass shrimp *P. pugio* Static-renewal	Fenvalerate EC	96-hr LC_{50} = 0.007 µg/L	Mortality	Baughman et al. 1989	Study approved by ECOTOX but not yet reviewed by EFED. This study was identified in the 2010 problem formulation as being a study that would be included in the assessment. However, since that writing, more sensitive endpoints are now available and so the study was not reviewed.
Acute	Pink shrimp *P. duorarum*	Fenvalerate	96-hr LC_{50} = 0.012 µg/L	Mortality	Cripe 1994	Study approved by ECOTOX but not yet reviewed by EFED. This study was identified in the 2010 problem formulation as being a study that would be included in the assessment. However, since that writing, more sensitive endpoints are now available and so the study was not reviewed.

Abbreviations: TGAI = technical grade active ingredient; TEP=typical end use product; conc.=concentration; WP=wettable powder, EC = emulsifiable concentrate; C.I. = confidence interval; LOD = limit of detection; LOQ = limit of quantitation

[1]All toxicity endpoints are reported in terms of a.i. unless otherwise stated.

Table 8. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for *Lambda*- and *Gamma*-cyhalothrin

Table 8-1. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for *Lambda*-cyhalothrin

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute	Golden orfe *(Leuciscus idus)* *Lambda*-cyhalothrin TGAI (87.7)	96-hr LC_{50}: 0.078 µg ai/L (0.055-0.11 µg ai/L) Sublethal effects: quiescence, sounding, erratic swimming, spiraling, loss of balance, rapid respiration, labored respiration, swimming cessation, light discoloration, surfacing, irregular respiration, and gulping air.	44584001	Supplemental **(**Non-guideline species)
	Bluegill sunfish *(Lepomis macrochirus)* *Lambda*-cyhalothrin TGAI (99% ai)	96 hr LC_{50}: 0.106 µg ai/L (0.085-0.140 µg ai/L) NOAEC : 0.034 µg ai/L Based on mortality	45447216	Supplemental (Mean weight of test fish was below the guideline-required weight range)
	Bluegill sunfish *(Lepomis macrochirus)* *Lambda*-cyhalothrin TGAI (98% ai)	LC_{50} 96 hr : 0.210 µg ai/L (0.16-0.31 µg ai/L) NOAEC : 0.16 µg ai/L Based on mortality	0259807	Acceptable
	Bluegill sunfish *(Lepomis macrochirus)* *Lambda*-cyhalothrin TEP (12.9% ai)	LC_{50} 96 hr : 2.2 µg ai/L (1.9-2.7 µg ai/L) NOAEC : 0.77 µg ai/L Based on mortality	00151598	Acceptable
	Bluegill sunfish *(Lepomis macrochirus)* *Lambda*-cyhalothrin TEP (24% ai)	LC_{50} 96 hr : 1.2 µg ai/L (1.0-1.5 µg ai/L) NOAEC :0.46 µg ai/L Based on mortality	43908812	Acceptable
	Rainbow Trout	*Lambda*-Cyhalothrin	49646301a	Acceptable

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	(*Oncorhynchus mykiss*) *Lambda*-Cyhalothrin: Piperonyl Butoxide 1:5 ratio mixture (98.1% wt/wt (*Lambda*-Cyhalothrin)	LC_{50}: 0.286 µg ai/L (0.238 – 0.343 µg ai/L) *Lambda*-Cyhalothrin:PBO 1:5 mixture LC_{50}: 2.01 µg ai/L (1.65 – 2.44 µg ai/L) Endpoint(s) Affected: mortality and sub-lethal effects including: fish lying on the bottom of the test vessel and fish exhibiting a partial loss of equilibrium		
	Rainbow Trout *(Oncorhynchus mykiss)* *Lambda*-cyhalothrin TGAI (98% ai)	LC_{50} 96 hr : 0.240 µg ai/L (0.20-0.29 µg ai/L) NOAEC : 0.11 µg ai/L Endpoints based on: Mortality	00151597	Acceptable
	Rainbow Trout *(Salmo gairdneri)* *Lambda*-cyhalothrin TEP (12.9% ai)	LC_{50} 96 hr : 3.4 µg ai/L (3.0-4.0 µg ai/L) NOAEC : N/A Endpoints based on: Mortality	00151600	Acceptable
	Rainbow Trout *(Oncorhynchus mykiss)* *Lambda*-cyhalothrin TEP (24% ai)	LC_{50} 96 hr : 2.7 µg ai/L (2.3-3.1 µg ai/L) NOAEC :1.3 µg ai/L Endpoints based on: Mortality	04308813	Acceptable
	Rainbow Trout (*Oncorhynchus mykiss*) Lambda-Cyhalothrin: Piperonyl Butoxide 1:25 ratio mixture	*Lambda*-Cyhalothrin LC_{50}: 0.186 µg ai/ (0.160 – 0.217 µg ai/L) *Lambda*-Cyhalothrin:PBO 1:25 mixture LC_{50}: 6.72 µg ai/L (5.87 – 7.70 µg ai/L) Endpoint(s) Affected: mortality and sub-lethal effects including: fish lying on the bottom of the test vessel, partial loss of equilibrium, complete loss of equilibrium, and lethargy	49646301b	Acceptable
	Fathead Minnow (*Pimephales promelas*)	LC_{50}: 0.70 µg ai/L (0.53-0.93 µg ai/L)	49274202	Supplemental-Quantitative

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Lambda-cyhalothrin TGAI (87.7) 1:1 mixture of the R and S isomers	Endpoint(s) Affected: mortality and sub-lethal effects		(Percent recoveries of the chemical were low 38-68% of nominal concentrations)
Chronic	Fathead minnow *(Pimephales promelas)* *Lambda*-cyhalothrin TGAI (96.7% ai)	60 day - NOAEC = 0.031 µg a.i./L 60 day - LOAEC = 0.062 µg a.i./L Endpoints based on: F1 survival at 28 days, F0 length at 56 days, male length and weigh at 300 days, and F1 weight and length at 31 days	41519001	Supplemental (Low-level contamination in the solvent and negative controls, use of lower number of eggs than guideline recommendations, and other guideline deviations.)
Freshwater invertebrates				
Acute	Amphipod *(Hyalella azteca)* *Lambda*-cyhalothrin TGAI (93.2% ai)	96-hr EC_{50} = 0.0003 µg a.i./L (0.00024-0.00037 µg/L) NOAEC= 0.00012 µg a.i./L Endpoints Affected: Survival and sublethal effects Sublethal effects: Lethargy, erratic swimming, immobility	49234301	Acceptable
	Water Flea *Daphnia magna* *Lambda*-cyhalothrin TGAI (99% ai)	EC_{50} 48 hr :0.051 µg ai/L (0.034-0.10 µg ai/L) NOAEC <0.0055 µg ai/L	45447220	Acceptable
	Water Flea *Daphnia magna* *Lambda*-cyhalothrin TGAI (96.5% ai)	EC_{50} 48 hr :0.23 µg ai/L (0.18-0.29 µg ai/L) NOAEC : 0.04 µg ai/L	00151599	Acceptable
	Water Flea *Daphnia magna* *Lambda*-cyhalothrin TEP (5.5% ai)	EC_{50} 48 hr : 0.04 µg ai/L (0.03-0.06 µg ai/L) NOAEC: Not established	00151599	Acceptable
	Water Flea *Daphnia magna*	EC_{50} 48 hr : 0.065 µg ai/L (0.04-0.11 µg ai/L) NOAEC: Not established	00151599	Acceptable

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Lambda-cyhalothrin TEP (12.9%ai)			
	Water Flea *Daphnia magna* *Lambda*-cyhalothrin TEP (24% ai)	EC_{50} 48 hr : 0.18 µg ai/L (0.14-0.23 µg ai/L) NOAEC : 0.03 µg ai/L (immobility)	43908811	Acceptable
	Gammarus pulex *Lambda*-cyhalothrin TGAI (94% ai)	EC_{50} 96 hr : 0.007 µg ai/L (0.005-0.009 µg ai/L) NOAEC : 0.0005 µg ai/L (mortality)	00152730	Supplemental (Non-guideline test species)
Chronic	Water Flea *(Daphnia magna)* *Lambda*-cyhalothrin TGAI (92.8% ai)	NOAEC: 0.004 µg ai/L LOAEC:0.005 µg ai/L Number of young/female	00152733	Supplemental (Less than the requisite number of test vessels for each treatment)
	Water Flea *(Daphnia magna) (96.6% ai)* *Lambda*-cyhalothrin TGAI (96.6% ai)	21-d NOAEC = 0.0020 µg/L 21-d LOAEC = 0.0035 µg/L Based on significant effects on survival, reproduction and growth	41217501	Supplemental (Only the healthiest organisms in the source population were chosen for the test and there were only two replicates at each treatment level. Exposure concentrations also varied substantially within a treatment (approximately 3x), such that maximum and minimum values overlapped among treatments.)
Freshwater benthic invertebrates				
10-day Subchronic	Amphipod *(Hyalella azteca)* *Lambda*-cyhalothrin TGAI (90.7% ai)	Based on Estimated Pore Water Concentrations: NOAEC: 0.00022 µg ai/L LOAEC: 0.00031 µg ai/L Based on Sediment Concentrations: NOAEC: 0.31 µg ai/kg-dw LOAEC: 0.44 µg ai/kg-dw Endpoints based on survival.	48593612	Supplemental (Growth was the most sensitive endpoint; however, the study failed to determine a definitive NOAEC because effects were seen at all test concentrations.) No sublethal effects reported. Pore water estimated by normalizing sediment concentrations by TOC fraction (0.024) and then dividing by the Koc = 59677.28 L/kg-OC
	Amphipod *(Hyalella azteca)*	Based on Sediment Concentrations:	49368103	Acceptable

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Lambda-cyhalothrin TGAI (93.2% ai)	LC_{50}: 10.7 µg ai/kg (9.62 to 11.9 µg ai/kg) NOAEC: <6.8 µg ai/kg LOAEC: 6.8 µg ai/kg Based on Estimated Pore Water Concentrations: LC_{50}: 0.004 µg ai/L NOAEC: <0.003 µg ai/L LOAEC: 0.003 µg ai/L OC-Normalized Sediment Concentrations: LC_{50}: 0.30 µg ai/g OC (0.27 to 0.33 µg ai/g OC) NOAEC: <0.19 µg ai/g OC LOAEC: 0.19 µg ai/g OC Endpoints based on survival.		The pore water values are estimated using: pore water estimate = the bulk sediment value/Kd. The Kd value being used in the pyrethroid assessments is 2678 L/kg for cyhalothrins.
	Midge *(Chironomus tentans)* *Lambda*-cyhalothrin TGAI (90.7 % ai)	Based on Estimated Pore Water Concs: NOAEC: 0.025 µg ai/L LOAEC: 0.050 µg ai/L Based on Sediment Concs: NOAEC: 31 µg ai/kg-dw LOAEC: 63 µg ai/kg-dw Endpoints based on survival	48593613	Acceptable No sublethal effects reported. Pore water estimated by normalizing sediment concentrations by TOC fraction (0.021) and then dividing by the Koc = 59677.28 L/kg-OC
Estuarine/marine fish				
Acute	Sheepshead minnow *(Cyprinodon variegatus)* *Lambda*-cyhalothrin TGAI (96.5% ai)	0.807 µg a.i./L (0.672 - 0.967 µg a.i./L) Sub-lethal effects included quiescence, loss of balance, weakness, hyper-excitability, and rapid respiration	00153506	Acceptable (Very highly toxic)
Chronic	Sheepshead minnow (*Cyprinodon variegatus*) *Lambda*-cyhalothrin TGAI (96.6% ai)	NOAEC =0.25µg a.i./L LOAEC =0.38 µg a.i./L Endpoints based on weight.	00152732	Supplemental (Lack of raw data and Recovery in measured concentrations ranged from 20-64% of nominal)
Estuarine/marine invertebrates				

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Acute	Mysid Shrimp *(Americamysis bahia)* *Lambda*-cyhalothrin TGAI (97% ai)	96-h LC_{50} = 0.00491 µg ai/L (0.00413-0.0058 µg ai/L)	00152729	Acceptable (Very highly toxic)
	Pacific Oyster Larvae (*Crassostrea gigas)* *Lambda*-cyhalothrin TGAI (96.5 % ai)	48 hr LC_{50}> 0.58 mg ai/L NOAEC=0.58 mg ai/L	00152728	Supplemental (Toxicity effects were not reported for all 5 treatment levels)
Chronic	Mysid Shrimp *(Americamysis bahia)* *Lambda*-cyhalothrin TGAI	28-day NOAEC = 0.0002 µg a.i./L 28-day LOAEC = 0.0005 µg a.i./L Endpoints based on reductions in the number of young per reproductive day and number of young per treatment.	MRID Not available: Accession# 073989	Acceptable
Aquatic plants				
Vascular	Duckweed (*Lemna gibba*) *Lambda*-cyhalothrin TGAI (98.1% ai)	IC_{50}: >5.4 µg/L NOAEC: 5.4 µg/L No endpoints affected	49274205	Acceptable
Non-vascular	Green Algae (*Selenastrum capricornutum*) *Lambda* - cyhalothrin TGAI (96.5% ai)	EC_{50}:>310 µg/L NOAEC : ≥310 µg/L	00152731	Supplemental

Table 8-2. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for *Gamma*-cyhalothrin

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute	Bluegill sunfish *(Lepomis macrochirus)*	96-hr LC_{50}: 0.051 µg a.i./L (0.039-0.066 µg a.i./L) NOAEC : <0.013 µg a.i./L (mortality and sublethal)	45447216	Supplemental

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Gamma-cyhalothrin TGAI (100% ai)			
	Bluegill sunfish *(Lepomis macrochirus)* *Gamma*-cyhalothrin TGAI (100% ai)	96-hr LC_{50} = 0.029 µg a.i./L (95% C.I.: 0.021- 0.039 µg ai/L) NOAEC: 20.2 µg a.i./L NOAEC based on: Mortality	45447215	Supplemental (20% mortality in negative control on the last day of the study and use of fish with mean weight less than the 0.5 to 5g guideline recommendation.)
	Rainbow Trout *(Oncorhynchus mykiss)* *Gamma*-cyhalothrin TGAI (100% ai)	LC_{50} 96 hr: 0.19 µg a.i./L (0.16-0.22 µg a.i./L) NOAEC : 0.031 µg a.i./L NOAEC based on sublethal effects	45447217	Supplemental
	Rainbow Trout *(Salmo gairdneri)* *Gamma*-cyhalothrin TGAI (100% ai)	LC_{50} 96 hr: 0.072 µg a.i./L (0.057-0.091 µg a.i./L) NOAEC: <0.0093 µg a.i./L (NOAEC based on mortality and sublethal effects)	45447214	Supplemental (Variability in measured concentrations, effects observed below lowest test concentration)
	Rainbow Trout *(Oncorhynchus mykiss)* *Gamma*-cyhalothrin TEP (14.7% ai)	LC_{50} 96 hr: 1.10 µg a.i./L (0.86-1.89 µg a.i./L) NOAEC: 0.28 µg a.i./L (NOAEC based on sublethal effects)	45447218	Core
Freshwater invertebrates				
Acute	Amphipod *(Hyalella azteca))* *Gamma*-cyhalothrin TGAI (97.9 % ai)	96-hr EC_{50} = 0.00008 µg ai/L (0.000046- 0.000103 µg ai/L) NOAEC (visually determined): < 0.00008 µg ai/L	49463701	Supplemental/Quantitative (All test concentrations produced at least 50% mortality).
	Water Flea *Daphnia magna* *Gamma*-cyhalothrin TGAI (100% ai)	EC_{50} 48 hr : 0.045 µg ai/L (0.020-0.079 µg ai/L) NOAEC: <0.015 µg ai/L	45447220	Acceptable
	Water Flea *Daphnia magna* *Gamma*-cyhalothrin TGAI (100% ai)	48 hr-EC_{50}: 0.095 µg ai/L (0.078-0.114 µg ai/L) NOAEC: <0.0263 µg ai/L	45447219	Supplemental (Uncertainty related to the lowest test concentrations)
	Water Flea *Daphnia magna*	EC_{50} 48 hr : 0.154 µg ai/L (0.099-0.310 µg ai/L) NOAEC: <0.011 µg ai/L	45447221	Supplemental

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
	Gamma-cyhalothrin TEP (14.7% ai)			(Uncertainty related to the lowest test concentrations)
	Amphipod (*Gammarus pseudolimnaeus*) *Gamma*-cyhalothrin TGAI (99.2% ai)	LC_{50}: 0.00048 µg ai/L (neonate), 0.00385 µg ai/L (juvenile), 0.00812 µg ai/L (adult) NOAEC: 0.00038 µg ai/L (neonate), 0.0017 µg ai/L (juvenile), 0.00020 µg ai/L (adult)	46065601	Supplemental (Inadequate analytical confirmation of test concentrations)
Chronic	Water Flea *(Daphnia magna)* *Gamma*-cyhalothrin TGAI	NOAEC: 1.93 ng ai/L LOAEC: 5.01 ng ai/L Based on time to brood (no of young/surviving females)	49708801	In Review
Freshwater benthic invertebrates				
42-day Life Cycle	Amphipod *(Hyalella azteca)* *Gamma*-cyhalothrin TGAI	TWA Sediment NOAEC: 0.45 µg ai/kg-dw LOAEC: 1.6 µg ai/kg-dw TWA Pore water (estimated) NOAEC: 0.00015 µg ai/L LOAEC: 0.00054 µg ai/L Endpoints based on reproduction (cumulative egg production). Other affected endpoints: Male:Female and survival	49469801	In Review Pore water estimated by normalizing sediment concentrations by TOC fraction (0.05) and then dividing by the Koc = 59677.28 L/kg-OC
Estuarine/marine benthic invertebrates				
10-day Subchronic	Amphipod (L*eptocheirus plumulosus)* *Gamma*-cyhalothrin TGAI (97.9% ai)	<u>Based on bulk sediment:</u> LC_{50}: 3.35 µg ai/kg-dw (2.93-3.77 µg ai/kg) NOAEC: <2.40 µg ai/kg-dw LOAEC: 2.40 µg ai/kg-dw <u>Based on mean measured pore water:</u> NOAEC: <0.0013 µg a.i./L (0.0312-0.0360 µg ai/L) LOAEC: 0.0013 µg a.i./L	49734102	Acceptable Pore water estimated by normalizing sediment concentrations by TOC fraction (0.032) and then dividing by the Koc = 59677.28 L/kg-OC

Acute/ Chronic	Species (Test substance)*	Toxicity Value Used in Risk Assessment	Citation or MRID #	Study Classification/ Comment
		Based on OC-Normalized Sediment LC50: 0.104 µg ai/g OC (0.0914-0.117 µg ai/g OC) NOAEC: <0.075 µg ai/g OC LOAEC: 0.075 µg ai/g OC Endpoints based on survival		
Aquatic plants				
Vascular	Duckweed (*Lemna gibba*) *Gamma*-cyhalothrin TGAI (97.9% ai)	IC_{50}: >0.508 µg/L NOAEC: 0.508 µg/L No endpoints affected	49734101	Acceptable
	Duckweed (*Lemna gibba*) *Gamma*-cyhalothrin TGAI (97.9% ai)	IC_{50}: Not Determined NOAEC: 0.4 µg ai/L No endpoints affected	49438001	Supplemental- Qualitative (Presence of precipitate meant exposure concentrations were uncertain)
Non-vascular	Green Algae *(Selenastrum capricornutum)* *Gamma*-cyhalothrin TGAI (100% ai)	96 hr EC_{50}:>2850 NOAEC : <1340 Endpoint Affected: Cell Density	45447406	Supplemental (Cell density was reduced more than 20% at the lowest test concentration and reduction at highest test concentration was below 50%; as a result, definitive endpoints could not be calculated)
	Green Algae *(Selenastrum capricornutum)* *Gamma*-cyhalothrin TEP (14.7% ai)	Cell density 72 hr EC_{50}: 15000 µg ai/L NOAEC: 5480 µg ai/L Growth rate 72 hr EC_{50}:41300 µg ai/L NOAEC: 5480 µg ai/L Area under curve 72 hr EC_{50}:16100 µg ai/L NOAEC: N.R.	45447407	Supplemental (Study was conducted for 72 hours)

Table 9. Comprehensive Aquatic Toxicity Profile, Based on Registrant-Submitted Studies for Fenpropathrin

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Freshwater fish (surrogate for aquatic-phase amphibians)				
Acute (Fenpropathrin)	Bluegill sunfish *Lepomis macrochirus* (91.4%)	LC_{50} = 2.2 (C.I.: 1.3 – 3.6)	00127791	Acceptable (Very highly toxic)
Acute (Fenpropathrin)	Channel Catfish, *Ictalurus punctatus* (91.4%)	LC_{50}: 5.5 (C.I.: 4.5-6.8)	Acc.# 249939 (1981)	Acceptable (Very highly toxic)
Acute (2.4 EC: TEP containing Fenpropathrin)	Channel Catfish, *Ictalurus punctatus* (30%)	LC_{50}: 22 µg a.i./L (C.I.: 13-36 µg a.i./L)	Acc.# 250159 (1981)	Acceptable (Very highly toxic)
Acute (2.4 EC: TEP containing Fenpropathrin)	Rainbow trout, *Salmo gairdneri* (30%)	LC_{50}: 10 µg a.i./L (C.I.: 7.8-13 µg a.i./L)	Acc.# 250159 (1981)	Acceptable (Very highly toxic)
Acute (2.4 EC: TEP containing Fenpropathrin)	Bluegill sunfish, *Lepomis macrochirus* (30%)	LC_{50}: 7.7 µg a.i./L (C.I.: 4.6-13 µg a.i./L)	Acc. # 250159 (1981)	Acceptable (Very highly toxic)
Acute (Fenpropathrin)	Bluegill sunfish, *Lepomis macrochirus* (91.4%)	LC_{50}: 2.2 µg a.i./L (C.I.: 1.3-3.6 µg a.i./L)	Acc.#: 249939 (1981)	Acceptable (Very highly toxic)
Acute (Fenpropathrin)	Rainbow trout, *Salmo gairdneri* (89%)	LC_{50}: 2.3 µg a.i./L (C.I.: 1.7-3.1 µg a.i./L)	Acc.#: 249939 (1981)	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Fathead minnow, *Pimephales promelas* (96.5%)	MATC: <0.013 µg a.i./L; NOAEC=1.3 µg a.i./L (growth)	41525901 42360001 (1990)	Supplemental
Chronic (Fenpropathrin)	Fathead Minnow (*Pimephales promelas*) (93.7%)	NOAEC = 0.06 LOAEC = 0.091	41525901	Supplemental due to incomplete submission of raw test data.
Freshwater invertebrates				
Acute (Fenpropathrin)	Water Flea *Daphnia magna* (91.4%)	LC_{50} = 0.53 (C.I.: 0.46 – 0.63)	00127795	Acceptable (Very highly toxic)
Acute (4'-OH-Fenpropathrin)	Water Flea *Daphnia magna* (99.4%)	LC_{50}: = 27.3 (C.I.: 23.1 – 32.5)	49604601	Acceptable (Very highly toxic)
Acute (TMPA[2])	Water Flea *Daphnia magna* (99.7%)	LC_{50}: > 72,000 (C.I.: NA)	49604602	Acceptable (Slightly toxic)

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Acute (Danitol 2.4 EC: TEP containing 31.5% Fenpropathrin)	Water Flea, *Daphnia magna* (30%)	LC_{50}: 2.9 µg/L (C.I.: 2.3-3.6 µg/L)	Acc.#: 250159 (1981)	Acceptable (Very highly toxic)
Acute (Fenpropathrin)	Water Flea, *Daphnia magna* (91.4%)	LC_{50}: 0.53 µg a.i./L (C.I.: 0.46-0.53 µg a.i./L)	Acc.#: 249939 (1981)	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Water Flea, *Daphnia magna* (98%)	MATC: 0.22-0.35 µg/L	Acc. #: 259678 (1985)	Acceptable
Chronic (Fenpropathrin)	Water Flea *Daphnia magna* (98.0%)	NOAEC = 0.064 LOAEC = 0.35	00153801	Acceptable
Freshwater benthic invertebrates				
Acute (Fenpropathrin)	Amphipod *Hyalella azteca* (91.7%)	LC_{50}: 3.05 ng ai/L (C.I.: 2.38 – 3.38 ng ai/L)	49209502	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Amphipod *Hyalella azteca* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **42-d NOAEC**: 4.0 ng ai/L **42-d LOAEC**: 10.1 ng ai/L Based on OC-normalized sediment concs: **42-d NOAEC**: 0.83 µg ai/g_{oc} **42-d LOAEC**: 2.1 µg ai/g_{oc}	49243301	Acceptable. The NOAEC/LOAEC are based on Day 28 survival.
Chronic (Fenpropathrin)	Midge *Chironomus dilutus* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **59-d NOAEC**: 5.78 ng ai/L **59-d LOAEC**: 14.94 ng ai/L Based on OC-normalized sediment concs: **59-d NOAEC**: 0.32 µg ai/g_{oc} **59-d LOAEC**: 1.2 µg ai/g_{oc}	49316005	Acceptable. The NOAEC/LOAEC are based on Day 59 overall emergence rate.

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Sub-chronic (Fenpropathrin)	Amphipod *Hyalella azteca* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **10-d NOAEC**: <1.5 ng ai/L **10-d LOAEC**: 1.5 ng ai/L Based on OC-normalized sediment concs: **10-d NOAEC**: <0.31 µg ai/g_{oc} **10-d LOAEC**: 0.31 µg ai/g_{oc}	49368102	Supplemental-qualitative. A non-definitive "less than" (<) value for amphipod length was reported. This information is needed to characterize the effects of fenpropathrin on other freshwater amphipods. Pore water concentrations were not reported in the study. However, the estimated fenpropathrin in the pore water could still be estimated using the OC-normalized sediment concentrations.
Estuarine/marine fish				
Acute (Fenpropathrin)	Sheepshead Minnow *Cyprinodon variegatus* (91.4%)	LC_{50} = 3.1 (C.I.: 2.4 – 4.0)	00127793	Acceptable (Very highly toxic)
Acute (Danitol 2.4 EC: TEP containing 31.5% Fenpropathrin)	Sheepshead minnow, *Cyprinodon variegatus* (31.5%)	LC_{50}: 15 µg/L (C.I.: 18-23 µg/L)	40974406 (1987)	Acceptable (Very highly toxic)
Acute (Fenpropathrin)	Sheepshead minnow, *Cyprinodon variegatus* (91.4%)	LC_{50}: 3.1 µg/L (C.I.: 2.4-4.0 µg/L)	Acc.#: 249939 (1981)	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Sheepshead minnow *Cyprinidon variegatus* (91.7%)	NOAEC = 0.81 LOAEC = 2.0	48536801	Supplemental due to high analytical variation (>20%) for all treatment levels. NOAEC based on Normal fry at hatch and post-hatch survival
Estuarine/marine invertebrates				
Acute (Fenpropathrin)	Mysid shrimp *Americamysis bahia* (90.0%)	LC_{50} 0.021 (C.I.: 0.018 – 0.025)	40974404	Acceptable (Very highly toxic)
Acute (Fenpropathrin)	Fiddler crab, *Uca pugilator* (91.4%)	LC_{50}: 5.2 µg a.i./L (C.I.: 3.7-7.1 µg a.i./L)	Acc.#: 249939 (1981)	Acceptable (Very highly toxic)
Acute (Danitol 2.4 EC: TEP containing 31.5% Fenpropathrin)	Mysid shrimp, *Mysidopsis bahia* (31.5%)	LC_{50}: 0.33 µg/L (C.I.: 0.29-0.39 µg/L)	40974405 (1987)	Acceptable (Very highly toxic)

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Acute (Fenpropathrin)	Mysid shrimp, *Mysidopsis bahia* (90%)	LC_{50}: 21 ng/L (C.I.: 18-25 ng/L)	40974404 (1987)	Acceptable (Very highly toxic)
Acute (Danitol 2.4 EC: TEP containing 31.5% Fenpropathrin)	Mysid shrimp, *Mysidopsis bahia* (31.5%)	LC_{50}: 0.33 µg/L (C.I.: 0.29-0.39 µg/L)	40974405 (1987)	Acceptable (Very highly toxic)
Chronic (Fenpropathrin)	Mysid shrimp, *Mysidopsis bahia* (98.6%)	MATC: 12-24 ng/L	40974407 (1988)	Acceptable
Chronic (Fenpropathrin)	Mysid shrimp *Americamysis bahia* (98.6%)	NOAEC = 0.012 LOAEC = 0.024	40974407	Acceptable. NOAEC based on reduced survival and reproductive success.
Estuarine/marine benthic invertebrates				
Sub-chronic (Fenpropathrin)	Amphipod *Leptocheirus plumulosus* (91.7%)	Based on Estimated Freely Dissolved Pore Water Concs: **10-d NOAEC**: 15.42 ng ai/L **10-d LOAEC**: 32.76 ng ai/L Based on OC-normalized sediment concs: **10-d NOAEC**: 3.2 µg ai/g_{oc} **10-d LOAEC**: 6.8 µg ai/g_{oc}	48536802	Acceptable. The NOAEC/LOAEC are based on mortality.
Aquatic plants and algae				
Vascular (Fenpropathrin)	Duckweed *Lemna gibba* (91.7%)	**IC_{50}>1.0 mg a.i./L NOAEC=1.0 mg a.i./L**	49055601	Acceptable. No effects were reported.
Nonvascular (Fenpropathrin)	Green algae *Pseudokirchneriella subcapitata* (91.7%)	**IC_{50}>0.85 mg a.i./L NOAEC=0.85 mg a.i./L**	48983501	Acceptable. No effects were reported.
Nonvascular (Fenpropathrin)	Blue-green alga *Anabaena flos-aquae* (91.7%)	**IC_{50}>1.0 mg a.i./L NOAEC=1.0 mg a.i./L**	449055603	Acceptable. No effects were reported.
Nonvascular (Fenpropathrin)	Freshwater diatom *Navicula pelliculosa* (91.7%)	**IC_{50}=1.33 mg a.i./L (yield) NOAEC=0.14 mg a.i./L Area under the curve (AUC)**	49076502	Acceptable. Endpoints effected: yield, growth rate, AUC

Acute/ Chronic (Test substance)	Species (% a.i.)*	Toxicity Value Used in Risk Assessment (µg a.i./L)[1]	Citation or MRID # (Author, Date)	Study Classification/ Comment
Nonvascular (Fenpropathrin)	Marine diatom *Skeletonema costatum* (91.7)	**IC_{50}=0.063 mg a.i./L NOAEC=0.024 mg a.i./L**	49055602	Acceptable. Endpoints effected: Area under the curve (AUC)

*All test materials are TGAI unless otherwise noted.
[1] Values based on the most sensitive toxicity estimates which are used for RQ calculations.
[2] TMPA=2,2,3,3-tetramethylcyclopropanecarboxylic acid

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 10 2015

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

MEMORANDUM

SUBJECT: Pyrethroid and Pyrethrin Usage Data to Support the Down-the-Drain Assessment, DP # 426900

FROM: Nikhil Mallampalli, Entomologist
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TO: Garland Waleko, Chemical Review Manager
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Product Review Panel Date: May 20, 2015

SUMMARY

In response to a request for available pyrethroid and pyrethrin indoor usage data to support the Pyrethroid Down-the-Drain (DtD) risk assessment, BEAD is providing estimates based on proprietary market survey databases. The most recent (2011) data relevant to indoor residential pyrethroid and pyrethrin uses come from surveys of four market sectors: pest management professionals (PMPs) - also known as pest control operators (PCOs), consumer use for households and house plants, consumer use for pets, and consumer use of repellents. These data have been adjusted by BEAD to include only those estimates of amounts used indoors that are

expected to result in a down-the-drain exposure. These adjustments are described further on in this memorandum. BEAD concludes that overall, approximately 225,000 pounds *a.i.* of pyrethroids and pyrethrin (combined) are estimated to be used indoors annually in the U.S., in ways that have some likelihood of resulting in DtD exposure. BEAD considers this a very high-end estimate; high-end values for individual active ingredients are listed in Table 1 (below).

PYRETHROID and PYRETHRIN USAGE BY MARKET SECTOR

BEAD used private market research data to determine the estimated amounts of pyrethroids used indoor in the U.S. by Pest Control Operators (PCOs) and consumers. The table below provides a summary of the available data for each sector. Note that in each sector, only a single year's survey is used; this is because these surveys are not conducted every year for every sector. These data are the most recent available to BEAD at this time. Following the table is a description of each market sector and the methods used by BEAD to calculate the estimate.

Table 1. DtD Pyrethroid/Pyrethrin Usage: Indoor Residential Use by Market Sector

Active Ingredient (a.i.)	Amount (1,000 lb a.i.)		
	PCO	Consumer Household/Houseplant/Pets	Total (high-end estimate only)
Bifenthrin	14-32	0.06-0.1	**32**
Cypermethrin	13-29	2-5	**34**
Permethrin	4-10	3-7	**17**
Deltamethrin	1-3	0.2-0.5	**3.5**
d-Trans Allethrin	nr	0.06-0.1	**0.1**
Imiprothrin	nr	1-3	**3**
Lambda Cyhalothrin	1-3	0.06-0.1	**3**
Cyfluthrin	1-2	nr	**2**
Prallethrin	nr	0.05-0.1	**0.1**
Pyrethrin	nr	89*	**89**
S-Bioallethrin	nr	1-2	**2**
Sumethrin	nr	0.01-0.03	**0.03**
Tetramethrin	nr	0.5-1	**1**
Tralomethrin	nr	0.02-0.05	**0.05**
Other *a.i.*s (#)	4-8	13-28	**36**
Total (high-end estimate only)	**87**	**137**	**225**

Source: Proprietary Data, 2011
Nr = not reported
*Consumer use on pets
(#) Includes prallethrin, pyrethrin, esfenvalerate, and d-trans allethrin, among other unspecified pyrethroids.
Notes: (i) The range of figures in each row represents use estimated based on sales by PCOs for bedbugs (approximately 6 %) or cockroaches (approximately 12 %). Therefore, the "high end estimates" are based on the sales for cockroach control. For additional discussion, please see the discussion of "adjustment factors" below.
(ii) Totals are rounded up to the nearest whole figure.

Use by Pest Control Operators

Survey results indicate that the majority of pyrethroid/pyrethrin use (71%) by PCOs is directed at residential use. The largest pest market segment is classified as "general insect control," which includes ants, cockroaches, fleas and bed bugs primarily. Sales of products for general insect control (minus exterior pests) constitute 55% of total sales of insecticides. The leading indoor application methods used by PCOs for general insect control are crack and crevice applications followed by concentrate sprays inside. For this DtD assessment, crack and crevice pose a lower potential for substantive release to water destined for publicly owned treatment works (POTWs). However, in the survey data available to BEAD, the percentage of sales or pounds used by PCOs is not broken down in terms of application method. It is described in terms of target pest category (flies, cockroaches, bedbugs, etc.). These details were used by BEAD to adjust overall usage figures, as follows.

Adjustment factors for PCO use of pyrethroids/pyrethrin

BEAD's high-end estimate for the DtD assessment (Table 1) was obtained by first determining the percentage of residential treatments by PCOs. According to proprietary data, 71% of PCO sales is derived from products used in residential settings. To provide a reasonable refinement of this figure, BEAD took into account the percentage of sales for general pest control (55%) and the reported percentage of sales for the control of pests likely to result in DtD residues. BEAD believes that these pests include flies, cockroaches, and bed bugs, since these pests frequently occur near drains, or occur on materials, such as bedclothes, that could result in more frequent washing off of pesticide treatments (see, for example, Crenshaw and Peairs 2009, Layton 2013). Available proprietary data shows that sales of products to control these pests range from 6-13.5%. These figures were used to determine the range of estimates of pyrethroid use by PCOs in residential settings. Sales for bedbugs fall within this range.

Use by Consumers in Households, on Houseplants, and on Pets.

For household/house plant insecticides, in 2011 pyrethroids accounted for the majority of consumer products that include 1% or less of the active ingredient by weight. Frequently targeted pests of household insecticide sales are cockroaches, mosquitoes, ants, fleas, and flies in and around the home. Frequently targeted pest of houseplant insecticides are red spider mites, scales, aphids, white flies, mealybugs, and "other [unspecified] pests". The formulations used to control these pests are aerosol products predominantly, followed by baits, liquid concentrates, and ready-to-use sprays.

For consumer use on pets, pyrethrin represents 18% of the active ingredients used in pet products, primarily in shampoos, powders and sprays. In 2011, available data show that 111,000 pounds of pyrethrin were used in pet products. For pet insecticides, liquid products (shampoos, dips, and topical spot-ons/vet medications) represent 78% of the market, followed by tablets for veterinary use (15%) and collars (5%) and other (2%).

Adjustment factors for consumer household use of pyrethroids/pyrethrin

Regarding data for consumer use in households and house plants, BEAD believes that baits and foggers pose a lower potential for substantive release of residues to POTWs. Therefore, sales for these application methods was excluded from the estimates shown in Table 1. The remaining product formulations constitute 64% of sales of household/house plant insecticides. Detailed survey figures for pyrethroid sales in this market sector are not available for specific target pests. However, since target pests for consumers include flies, bedbugs, and cockroaches, BEAD used the figures reported for the PCO sector in the same way to further adjust the estimates for consumer household use, as reported in Table 1.

For the "consumer pet" market sector, BEAD assumed that tablets and collars have lower potential for substantive release to POTWs. Therefore, the percentage of sales reported for these formulations was excluded from the figure reported for this sector in Table 1. Thus, to calculate the amount of pyrethrin used, BEAD reduced the total pounds *a.i.* of pyrethrin by applying a factor of 80% to the pyrethrin amount reportedly used by consumers. The final estimate of pyrethrin use on consumer pets is 89,000 lbs *a.i.* as shown in Table 1.

BEAD also notes that "other active ingredients" used in pet products represent 37% of the "consumer pet" market sector. However, the exact amounts of the pyrethroids were not disclosed for this figure. Therefore, BEAD is unable to provide more specific data on pyrethroid use in the consumer pet market for the down-the-drain assessment, beyond the usage data for pyrethrin described above.

Consumer Repellents

For consumer repellents, proprietary data indicate that DEET continues to be the predominant active ingredient used in 2011, followed by picaridin. The category of "other repellents" used in the consumer repellent market totaled 1.9 million pounds *a.i.* Permethrin, which was one component of "other repellents," was reported to be used when applied to clothing, but the estimated amount used is not disclosed in the proprietary data. Therefore, in the absence of more specific data, BEAD does not have an estimate of pyrethroid usage in the consumer repellent market, and so this type of use is not included in Table 1.

CONCLUSIONS

BEAD has reviewed the most recent available proprietary data to provide best available estimates of indoor pyrethroid use in the PCO and consumer markets to support the DtD pyrethroid assessment. In reporting these estimates, BEAD considered only the uses (in terms of application site, application method, and/or target pest, depending on the market sector) with higher potential for substantive release of pyrethroids into domestic wastewater. Following these adjustments, BEAD estimates that approximately 225,000 pounds of pyrethroids and pyrethrin are used annually indoors. BEAD believes that this is a very high-end estimate, since it assumes

that all indoor treatments targeting flies, bedbugs, and cockroaches are equally likely to result in DtD exposure every time an application is made.

REFERENCES CITED

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Attachment VI. Pyrethroid and Pyrethrins Aquatic Incident Database Review

A review of the OPP Incident Data System which now incorporates the Ecological Incident Information System (EIIS) database for ecological incidents was completed on 2016. This database consists of exposure incident reports submitted to the EPA from 1994 to present. A summary of aquatic ecological incidents involving Pyrethroids are listed in the tables below. These tables are divided into individual chemical incidents involving aquatic organisms only.

Incidents listed in EIIS are categorized by the likelihood that a particular pesticide is associated with that particular incident. These classifications include highly probable, probable, possible, unlikely or unrelated. "Highly probable" incidents usually require carcass residues or clear circumstances regarding the exposure. "Probable" incidents include those where residue information was not available or circumstances were less clear than those for "highly probable." "Possible" incidents occur when multiple chemicals may have been involved and the contribution of an individual chemical is not conclusive. An "unlikely" incident classification is given when a given chemical is considered nontoxic to the type of organism involved or the chemical was analyzed and not detected in samples. The "unrelated" category is used for incidents confirmed not to involve pesticides.

The number of reports listed in the EIIS database is believed to be only a small fraction of the total incidents involving non-target organism mortality and damage caused by pesticides. For instance, aquatic reports generally deal with highly visible fish kills whereas mortality involving invertebrate organisms generally is not discovered. In some cases pesticide contamination incidents may occur in moving water where dissipation of the pesticide occurs more quickly than in static water bodies and affected organisms are dispersed from the initial point of contact, making determination of cause more difficult.

Reporting by states is only voluntary, and individuals discovering incidents may not be informed on the procedure of reporting these occurrences. Additionally, a large portion of the recent database entries are generated from registrant-submitted incident reports. Registrants are legally required to provide detailed reports of only "major" ecological incidents involving pesticides, while "minor" incidents are reported aggregately. Because of these logistical difficulties, the IDS is most likely a minimal representation of all pesticide-related ecological incidents.

Summary of Incident Review

The IDS and EIIS databases contained 7 incidents for Bifenthrin, 29 incidents for Permethrin, 17 incidents for Cypermethrin, 10 incidents for Cyhalothrin (Lambda and Gamma), 11 incidents for Esfenvalerate, 6 for Cyfluthrin, 2 for Deltamethrin, 2 for Pyrethrins and only one for Fenpropathrin. The total for all pyrethroid actives searched was 84 aquatic incidents, but there were some duplicate incidents due to detection of multiple chemical residues. It should be noted that some of these incidents involved detection of multiple pyrethroids and are therefore may be repeated for each chemical that was detected. For instance I012265-006 involved a large potential watershed contamination incident that effected a large area where multiple pyrethroids and other actives were used. The differences in reported incident numbers for individual pyrethroids may be due to several factors including length of time the chemicals have been registered, the amount of national usage, individual label restrictions for mitigating exposure potential and the numbers of crops or other uses for which they are

registered. Chemicals with higher numbers of uses might be expected to offer more opportunity for incidents to occur.

Incident Certainty and Legality: Thirty two of the reported incidents were determined to be from legally registered uses of the pesticides. Fourteen of the incidents were assessed to have been caused by misuse of the pesticides which resulted in accidental exposure and mortality to non-target organism. These might be caused by unexpected spray drift or runoff from a registered use. Intentional misuse is less common (4 reported), but these generally result from illegal discharge into local waterways or complete disregard for label instructions regarding application procedures. Twenty four of the incident reports list the legality as undetermined. This classification is generally used when the source or usage of the contaminant is not confirmed, and may in some cases occur in a watershed where multiple use sites might contribute to the incident, such as an urban watershed or an area where there are numerous farms using multiple pesticides.

Incident certainty numbers are generally based on analyses of residue levels in organism tissues or in water and sediment samples obtained from the incident location. Where multiple actives are detected the determination of certainty may be based on the aquatic toxicity characteristics of the chemical in relation to the other chemicals detected. Certainty numbers range from 1-4 with 4 being highly probable and 1 being considered unlikely to have been caused by the active even though it may have been detected. In some incidents there is a more direct link to the pesticide in that the incident was observed immediately after use, the use site is in close proximity to the incident location, or the pesticide was the only active used in the immediate area where the incident occurred. Twenty one of the incidents listed in the tables below list the active as highly probable to have been the causative agent. Thirty of the incidents list the active as the probable cause of the incident. Twenty three of the incidents list the active as a possible cause of the incident and in many cases include detections of multiple actives. There may also be some uncertainty regarding the actual use site which contributed to the incident. In some cases residue analysis may not be reported for these incidents.

Table 1. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Bifenthrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I001838 -001	Cotton	Sept.28, 1994	TN	N.R.	1	RU	Catfish	25	Mortality	Dead fish were observed in a pond several hours after a torrential rain storm that moved soil from a recently treated cotton field some 100 plus feet from the pond. Water samples from the pond contained both Guthion and bifenthrin. The fish found dead were not bottom feeders and the kill occurred very soon after the runoff.
I016338 -006	Building	May 2005	NY	Duchess	4	RU	Rainbow trout, Bullhead catfish, Fathead minnows	500-1000	Mortality	New York, Pawling in Duchess County. 2005. Two registrants submitted reports of the same fish kill incident. BASF's report is identified as I016304-002, and that of FMC as I016338-002. Both reported 500 - 1000 rainbow trout, bullhead catfish and fathead minnows killed in a pond/stream system 30-40 feet from treated buildings. Numerous buildings on a property were power sprayed with a mixture of bifenthrin and permethrin in a total of 200 gallons of water with 100 gallons being used. Permethrin also used on trees in the estate area to control borers.
I017659 -001	Turf	1994	CA	Imperial	4	RU	Koi, Catfish	400	Mortality	California, 2006. Three pounds of Telstar CA Granular Insecticide (Bifenthrin) was applied to lawn/turf area of approximately 20,000 sq. ft. Applicator was careful to avoid treating in the direction of adjacent pond, but a potential for runoff did exist. Approximately 400 total mortalities including Koi and Catfish.
I028127 -001	Urban	2015	CA	Ventura	3	UN	Carp, Silversides, Topsmelt, Striped mullet, Staghorn Sculpin, Mosquito fish and Sailfin	thousands	Mortality	California, 2015. Port Hueneme in Ventura County. Fish kill in the J Street Drain, an urban drain that terminates in Ormond Lagoon, was observed. It was estimated by US Fish and Wildlife Service staff that thousands of dead fish were in the drain, including carp, silversides, topsmelt, striped mullet, staghorn sculpin, mosquito fish and sailfin mollies. Bifenthrin detected in mullet and sculpin gills (0.31-2.69 ppb) and livers(3.44 -15.7 ppb)

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
							mollies.			
I001280 -019	Corn	July 22, 1994	NE	N.R.	3	RU	Catfish	Small number	Mortality	Runoff to pond 130 feet from application site- some catfish killed-corn use with Capture 2 EC
I003351 -028	N.R.	Sept. 1994	CA	Imperial	3	UN	Catfish	25	Mortality	A fish kill occurred in Imperial County, probably as the result of bifenthrin poisoning. Twenty five catfish were involved. For further information consult Brian Finlayson, Chief, Pesticide Investigations Unit.
I004439 -076	N.R.	1996	NC	N.R.	3	RU	N.R.	N.R.	Mortality	Fish died in a pond adjacent to a field sprayed with Biflex. Apparently the windy conditions during the spraying operation were responsible for the contamination of the pond.

(1) Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
(2) Date: = start date of incident report.
(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
(5) Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
(6) Effect Code: M = mortality; P.D. = plant damage.

Table 2. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Permethrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
B000175-001	Corn	April 1, 1992	KN	Grayson	2	RU	N.R.		Mortality	1-2" fish killed-species not reported. Fishkill may have begun about 04/01/92. Three pesticides (Paraquat, Permethrin, and Atrazine) were implicated in this incident which followed 1-2 inch rainfall after application to corn.
I000124-014	Building	Mar. 31,1992	IL	N.R.	3	MA	Bluegill		Mortality	Assumed treatment of dwelling with 0.5% Permethrin was picked up by house sump pump and emptied into a fish pond allegedly causing mortality to the Bluegill. There have been no additional fish kills. No investigative data in relation to this event was included.
I000598-022	Corn	July 5, 1992	NE	Merrick	3	MA	Bluegills and Black bullhead catfish	350 150	Mortality	Nebraska-Merrick County near Chapman. 350 Bluegills and 150 Black bullhead catfish in a farm pond across the road from a 500 acre corn field. Potential drift exposure. Pounce 1.5G dry granular was aerially applied to the field.
I001028-010	Residence	August 1993	N.R.	N.R.	3	RU	Fish (sp)	N.R.	Mortality	Home and outside deck use with runoff to adjacent canal. Fish reported killed, but number not specified.
I001849-002	Building	April 6, 1994	LA	E.B.R.	4	RU	Fish (sp)	300	Mortality	Building treatment. 300 fish-species not identified- were killed from runoff to a pond near treated building.
I001849-003	Corn	April 12,1994	LA	St. Landry	4	RU	Fish (sp)	1300+	Mortality	Louisiana, Little Bayou Darbonne.1994. Terbufos (Counter) and Permethrin (Pounce) had been applied preplant to about 3,769 acres of corn. After the application, between the dates of March 24 and April 20, several heavy rain storms caused the fields to be under water and the subsequent runoff into the bayou lake killed over 1300 fish.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I003402-005	Building	1995	VA	Tazewell	4	RU	Crayfish Fish (sp)	Thousands	Mortality	Virginia, near Tazewell. 1995. A fish kill occurred in a stream running through area Nov. 14, 1995. The cause of the event was the application of permethrin (Dragnet FT) to a residence for the control of termites, after which a heavy rain washed some of the permethrin into the creek. Dead crayfish were found a mile to 1.5 miles downstream from the application site. No charges were filed since the pesticide was applied in accordance with regulations.
I003582-010 I0003582-042		March 5, 1996	PA	N.R.	3	UN	Fish (sp)	N.R.	Mortality	Pennsylvania. 1996. The only information provided was that a small stream became contaminated during the application of Dragnet. Pesticide ran down hill to stream. There were dead fish as the result, and the PA Dept. of Natural Resources investigated the incident.
I003653-001	Home use		PA	Mont-gomery	4	RU	Carp, Bass, and Catfish	N.R.	Mortality	March, 1996. Carp, Bass, and Catfish killed in lake near a home treatment site.
I003826-030	Corn Soybean	1994	NC	Sampson	2	RU	Fish (sp)	N.R.	Mortality	North Carolina. 1994. An owner of a 2.50 acre commercial fish pond filed a complaint with the North Carolina Department of Agriculture reporting a fish kill in her pond. She suspected that the drift of pesticides that had been applied aerially to the nearby corn and soybean
I004374-003	Home use	1995	MO	St. Louis	4	MA	Catfish and Sunfish	Thousands	Mortality	A large fish kill resulted from the use of permethrin in a residence; one factor seemed to be that the pesticide operator had rinsed equipment in such a way that it drained into the pond that was affected. It is possible also that rain contributed to the exposure. Thousands of catfish and sunfish killed in pond adjacent to home.
I004439-038 (MA)	Turf	1996	MA	N.R.	4	MA	Fish (sp)	N.R.	Mortality	While treating a lawn area with Astro, a fish pond in the back yard was contaminated and resulted in a fish kill.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I004439-039 and 121	Turf	1996	TN NJ	N.R.	3	RU	Fish (sp)	N.R.	Mortality	Dead fish are now appearing in a pond that was treated two weeks earlier with Dragnet. It is uncertain whether Dragnet was responsible for the fish kill.
I004439-119	Turf	1996	VA	N.R.	3	UN	Fish (sp)	N.R.	Mortality	The outside of a home had been treated with Dragnet, 210 feet from a pond. Four days later there were dead fish in the pond.
I004439-121	Turf	1996	NJ	N.R.	2	UN	Fish (sp)	N.R.	Mortality	A lawn around a back yard was sprayed with liquid Astro plus fertilizer. At some later, time unspecified, the fish began to die.
I005761-001	Cattle	1997	IA	N.R.	4	UN	Fish (sp)	N.R.	Mortality	1997. A cattleman sprayed 120 head with Ectiban (permethrin) and the cattle were kept away from a pond for several hours. When they did enter the pond, an undetermined number of fish died as the result.
I006022-001	Mosquito control	1997	MD	Talbot	3	UN	Bluegill, Striped bass, Crayfish, and Frogs	N.R.	Mortality	Maryland. 1997. Several newspaper articles reported on a kill at a fish farm that was suspected of being caused by mosquito control spraying with permethrin. On June 16, a truck from the Maryland Department of Agriculture, Mosquito Control Section sprayed permethrin nearby (10 feet?). Unspecified number of Bluegill, Striped bass, Crayfish, and Frogs were reported killed.
I006261-001	Home use-termite control	April 1997	VA	Washing -ton	3	MA	Rainbow trout Crayfish	50 200	Mortality	A possible fish kill was reported after termiticide application at a residence in Abingdon (Greendale area). Dead fish were found in a creek 160 feet.downstream from the residence. Circumstantial evidence of damage was revealed from dead and dying crayfish. The French drain around the foundation of the house routed moisture through a discharge pipe directly into the adjacent creek, 30 ft. West of the house.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I007226-001	Mosquito control	1998	MS	Washing -ton	3	RU	Bass and Sunfish	15 2	Mortality	Mississippi. AgrEvo Environmental Health reported this incident to EPA to comply with FIFRA Section 6(a)(2). Permanone 31-66 (permethrin) was applied within the city limits of Greenville, MS for vector control. A total 15 bass and two brim were found dead in a lake.
I007984-003	Mosquito control	1997	MD	Talbot	2	MA	Striped bass	600	Mortality	Maryland. Talbot County. June 16, 1997. An employee of the Mosquito Control Section of the MD Dept. of Agriculture applied permethrin to a residential property on the Eastern Shore. Nearby was a striped bass aquaculture operation and, 24 hours later, 600 fish, were found dead in pond 74 feet from application site.
I008293-001	Tomato	1998	FL	Hills-borough	2	RU	Velvet swordfish	4000	Mortality	1998. Tomato growing area. 4000 Velvet Swords (tropical fish) killed in pond 100 yards from treatment site.
I009136-001	Home use-termite control	1998 April 13.	VA	Lee	4	RU	Crayfish	N.R.	Mortality	The homesite near sinkholes allegedly created a path down a long slope to an underground creek conducting the product 1/3 of a mile where it emptied alongside Kentucky Ave. This was where dead crayfish were found. Crawl spaces at the house were dry despite heavy rainfall, although all creeks were severely swollen.
I014312-007	Turf	2003	KS	N.R.	2	RU	Goldfish	50-60	Mortality	Kansas near Newton. June 16, 2003. Lawn use of Eliminator Ant, Flea and Tick Killer Granules may have runoff to pond where 40-60 ornamental goldfish were found dead. Product was applied within 1 foot of pond edge. Rainfall occurred after application and fish continued dying over a 5 day period.
I014689-015	Home lawn use	2003	IN	Crawford	3	MU	Catfish and Bluegills	72 and 8	Mortality	Indiana near Milltown. December 9, 2003. United Industries Corp. reported an incident in which runoff from the application of Real-kill Multi-purpose concentrate (permethrin) may have killed 72 catfish and 8 bluegills in a farm pound. This product is intended for use around the home only for lawn and garden insect pest. The pond is 400 feet away for the treatment site.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I016338-006	Building	2005	NY	Duchess	4	RU	Fathead minnow, Bullhead catfish, Rainbow trout	hundreds	Mortality	Pawling, NY-Duchess County. 2005. See Bifenthrin for description- both implicated. Hundreds of fish found dead. Analyses of the water showed it to contain between 0.098 and 3.40 ppb Bifenthrin and 99.8 ppb Permethrin. Rainbow trout fillets contained 34.4 ppb Bifenthrin and 406 ppb Permethrin.
I022283-001	Fish farm	2010	Scot -land	Shetland	2	MU	Salmon	6000	Mortality	Scotland in Burrastow near Walls. 2010. Fish farm located on the west coast of Shetland may face prosecution after approximately 6000 salmon were accidentally killed by an overdose of an unauthorized and highly toxic pesticide. The pesticide found in samples contained permethrin, a synthetic pyrethroid which is highly toxic to fish and marine life.
I022718-001	Industrial-wood treatment	2010	UK	N.R.	4	MU	Sunfish (Bream) and Perch, Chubs, Roach, Rudds	Hundreds	Mortality	United Kingdom, in Somerset. February, 2010. An Environment Agency officer visited the Glastonbury Canal to investigate reports of dead and dying fish down river from wood treatment site. The agency saw hundreds of dead fish including roach, bream, rudd, chub, and perch. Other dying fish were showing signs of distress and behaving erratically including jumping out of the water, swimming in circles and on their sides. Distressed fish were observed as far as Burtle-6 miles from the source of the spill. Analysis of dead fish revealed the presence of the pesticides Permethrin, Tebuconazole, and Propiconazole.
I028877-00001	Crayfish ponds	Oct. 2015	TN	N.R.	N.R.	MA	Crayfish	N.R.-probably thousands	Mortality	October 2015 a misapplication of EPA registration number 432-1150 (active ingredients piperonyl butoxide, permethrin; manufacturing concentrate) saw immediate death of four commercial crawfish farmer's ponds. The 4 Crawfish ponds were accidently sprayed during an aerial application. The flight plans were for the applicators to pass next to, but not above the ponds themselves. The State Lead Pesticide Agency came out on the 5th of October 2015 and took samples from the ponds and dead crawfish. The pesticide was found in the water.

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I028968-00001	Urban	2016	AU	N.R.	N.R.	N.R.	Eels Fish (sp)	100	Mortality	Australia. Darebin Creek. Twenty eels and fish, later changed to 100, were found dead along 3 Km of the creek and a pesticide is being blamed for the deaths. The Australian EPA's Regional Services said the deaths were likely caused by the stormwater runoff of permethrin. Analysis of eel organs identified the presence of permethrin, which is commonly used in domestic and industrial pesticide products.

[1] Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
[2] Date: = start date of incident report.
[3] State: values in parenthesis represent countries of origin when states are not reported or applicable.
[4] Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
[5] Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
[6] Effect Code: M = mortality; P.D. = plant damage.

Table 3. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Cypermethrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I000011-001		1992	NJ	Union	2	RU	N.R.	N.R.	Mortality	1992. Mortality occurred in a pond 150-200 feet from use site.
I001031-001	Home use	April 1994.	KY	Henderson	4	UN	Bluegill, Carp, Largemouth bass, and Catfish	30 12 1 1	Mortality	April 1994. Residential use on home exterior. 30 Bluegill, 12 Carp, 1 Largemouth bass, and 1 Catfish killed in pond 50 feet from application site. *Mortality numbers different in EIIS report.
I006971-001	N.R.	Feb 6, 1996	TN	Hamilton	4	UN	Bass, Bluegill Shad other fish sp		Mortality	Tennessee, Hamilton County. February 6, 1996. Zeneca reported that the state Dept. of Agriculture was contacted about fish kill in several small ponds fed by a small stream. State investigators estimated 2,200 dead fish (i.e., bass, bluegill, and shad) were impacted along with various other unspecified species. Demon TC was used nearby.
I007107-003	N.R.	Feb, 1997	CA	Placer	4	UN	Gambusia	1000	Mortality	California, Placer County. February, 1997. This incident is one of the incidents stated on a consolidated report submitted by the Pesticide Investigation Unit, California Dept. of Fish and Game for the year 1997. One thousand Gambusia (minnows) were reported killed..
I009966-002	Building	June 1998	TN	Hamilton	3	MA	Bass, Crappie, Shad Carp, Bluegill Catfish, Minnows	33 8 157 125 1820 4 91	Mortality	June 1998. Building use near a pond. Accidental exposure led to mortality of 33 Bass, 8 Crappie, 157 Shad, 125 Carp, 1820 Bluegill, 4 catfish, and 91 minnows in the pond.
I010444-004	Urban runoff	2000	MD	Mont-gomery	3	MA	Fish sp	10000	Mortality	Maryland, Montgomery County 2000. Near Rock Creek. Runoff from residential street after applicator cleaned equipment in the street, resulting in a kill of

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
										10000 fish in the creek from Walter Reed hospital to Potomac River resulted. Concentration of 50 ppb was measured by MD Dept. of Agriculture.
I011346-001	Kennel	April, 1998.	UK	N.A.	4	MA	Crayfish	thousands	Mortality	United Kingdom. April, 1998. According to a report from the Environment Agency - UK, thousands of crayfish had been killed in the Sherston Avon at Pinkney, upstream of Malmesbury, Wiltshire. An investigation led to the Badminton sewage treatment works and, ultimately, to a kennel where a sheep dip called Crovert (containing cypermethrin) had been used to treat hounds for mange. After treatment, the Crovert was washed off and entered the river through the effluent of the sewage treatment plant.
I012265-006	Ag area	July 20, 1996	Canada	PEI	2	UN	Salmon Trout (sp)	40000 +	Mortality	Prince Edward Island, Canada. July 20, 1996, Approximately 40,000 salmon and a large number of trout were killed beginning at Profit's Pond, A survey of streams across the province on July 22 and 23 did not identify any other fish kills. Though Cypermethrin was used in the area along with 8 other actives, only Chlorothalonil was detected at 4 ppb. From EIIS report- not in IDS
I013857-011	Direct into stream	February 26, 2003.	UK	N.A.	3	MI	Fish (sp)	100,000	Mortality	United Kingdom, Sleaford near Lincolnshire. February 26, 2003. Misuse. 100,000 fish killed by direct application (disposal) into stream/river near an industrial site. 13 miles of Slea River affected.
I015094-001	Urban	April 2004	OH	Mont-gomery	2	MI	Fish (sp)	5000	Mortality	Ohio, Montgomery County. April 2004. 5000 fish killed in a creek nearby. EIIS FMC 6(a)(2) incident report stated that a contractor applied Prevail (cypermethrin) on a horizontal soil surface where a concert slab was to be poured. Dead fish were found in a stream 1/2 to 1 mile from the construction site. No analysis were given.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I017029-001-update	Urban street-runoff	May 17, 2000	MD	Montgomery	4	MA	Fish (sp)	Large number	Mortality	This is an update of a previous incident (I010444-004? that occurred in Takoma Park, MD. "Prevail" spilled from one of the company's pesticide application trucks onto a driveway while an employee was attempting to repair-
I017984-001	Pet use	October 1998.	UK	N.A.	2	MA	White clawed Crayfish	10000	Mortality	United Kingdom. October 1998. Accidental exposure. Pet owner pleaded guilty to allowing hounds treated with cypermethrin, which is used to treat mange, to enter the River Avon. 10,000 crayfish in a stream flowing through the site. May be repeat of I011346-001
I018158-017	Home termite treatment	Nov. 2006	LA	Vermillion	3	UN	Koi	N.R.	Mortality	Louisiana, Asheville in Vermillion County. November, 2006. Residential use. Koi allegedly died from a drift exposure caused by a Pest Control technician performing a routine quarterly perimeter treatment using the labeled rate of Probuild TC (a.i. cypermethrin). Koi fish pond was located at the backyard of the treatment area.
I021456-001 IDS only	Ag use	Aug. 28, 2008	IA	Dallas	2	UN	Bluegills Largemouth bass	Dozens	Mortality	Iowa, Dallas County, August 28, 2008. Drift from agricultural use site into a nearby 2 acre pond. Dozens of Bluegills and Largemouth bass killed (6-10” in size). Rainfall on 8/27/08. Samples collected tested positive for Lambda cyhalothrin, Esfenvalerate, and zeta-cypermethrin (all <0.2 ppb (LOQ)), Chlorpyrifos (0.069 ppb), and atrazine (0.14 ppb)
I021616-001	N.R.	Nov. 2009	Can a-da	Grand Manan area	4	MA	Lobsters	Three separate kills	Mortality	Canada, Seal Cove area of Grand Manan. November 2009. Three major kills of Lobsters from a misuse. Environment Canada scientists found the pesticide cypermethrin in dead lobsters during November and December according to news sources. Cypermethrin is illegal to use in marine environments in Canada. The source of the contamination was not resolved.

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I028127-001 IDS only	Urban runoff	July 20, 2015.	CA	Ventura	2	UN	Crappie, Striped mullet, Silverside minnows, and Mosquito fish	N.R.	Mortality	July 20, 2015. Unspecified numbers of Crappie, Striped mullet, Silverside minnows, and mosquito fish killed. Cypermethrin, Bifenthrin and Cyfluthrin detected in samples.
I028714-00001		January 2, 2016	KS	N.R.	N.R.	N.R.	Crappies, Bass, and Bluegill	N.R.	Mortality	January 2, 2016- summary details not entered yet. Crappies, Bass, and Bluegill killed -Use site not reported-250 feet from pond. May be part of an aggregate report as a human incident is also listed for I028714

[1] Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
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[4] Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
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[6] Effect Code: M = mortality; P.D. = plant damage.

Table 4. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Lambda/Gamma Cyhalothrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I000921-011	Cotton	Dec 8, 1991	GA	Lowndes	3	RU	Fish (sp)	N.R.	Mortality	Cotton 1991.
I000922-001	Cotton	July 30, 1991	GA	Laurens	2	RU	Catfish, Bass (Largemouth and others), and Bream (Sunfish)	Hundreds	Mortality	1991. Cotton use hundreds of Catfish, Bass (Largemouth and others), and Bream (Sunfish) killed - runoff from application site 20-50 Yards from pond
I003826-029	Cotton	1994	NC	Cumberl and	2	RU	Bass And Other sp	200	Mortality	North Carolina. 1994. An owner of a fish pond in Roseboro, NC, complained that an application of Karate to a nearby cotton field caused the death of 200 fish (mostly Bass). The NC Department of Agriculture sampled the bond but their analysis for lambda-cyhalothrin was negative and it could not confirm.
I007176-001	Corn	May 18, 1998	LA	N.R.	3	RU	Crayfish	N.R.	Mortality	Crayfish killed in Ponds and canals from corn use on 90-100 acres adjacent to the ponds.
I007462-001	Zoo	March 6 1998	MS	Kansas City		MA	Fish	16	Mortality	Zeneca reported this incident to EPA to comply with FIFRA Section 6(a)(2). DVM of Swope Park Zoo, Kansas City, Missouri reported the death of sixteen fresh water fish in the zoo 8000 gallon fish tank after the application of Demand CS(Cyhalothrin or Lamb
I007650-001	Pond	May 5, 1998	LA	Acadia		MI	Crayfish	N.R.	Mortality	Crayfish killed adjacent to pond-numbers not reported

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I012265-006	Ag area	July 20, 1996	Canada	PEI	2	UN	Salmon Trout sp.	40,000 +	Mortality	This is repeated in Cypermethrin incidents. Prince Edward Island, Canada. July 20, 1996, Approximately 40,000 salmon and a large number of trout were killed beginning at Profit's Pond, A survey of streams across the province on July 22 and 23 did not identify any other fish kills. Though Cypermethrin was used in the area along with 8 other actives, only Chlorothalonil was detected at 4 ppb.
I015186-003	Cotton	May 21, 2004	TX	Wilson	4	RU	Crawfish	Thousands-assumed	Mortality	2004. Twin County COOP reported that an aerial application of Karate (lambda-cyhalothrin) to an adjacent cotton field affected 37 acre crawfish aquaculture pond. Not determined if from drift or inversion of Karate into the pond. The active ingredient is highly toxic to crustacea.
I021456-001	Ag Use area	Aug. 28 2008	IA	Dallas	2	UN	Bluegills Largemouth bass	dozens	Mortality	This incident was also reported for Cypermethrin and Esfenvalerate. Multiple Actives detected in 2 acre pond.
Gamma Cyhalo-thrin										
I026688-001	Ag Site near airport	July 7, 2014	IL	Hancock		MA	Frogs and Fish	Hundreds	Mortality	This incident in Hancock County, IL involved the death of hundreds of frogs and a couple of dead fish located in some ponds nearby where a crop dusting plane was taking off. The plane was not able to gain enough altitude and hit a dirt pile at the end of runway.

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[4] Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
[5] Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
[6] Effect Code: M = mortality; P.D. = plant damage.

Table 5. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Esfenvelerate

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I000109-009	Sugar-cane	Aug 7, 1991	LA	Iberville	2	UN	Gars, Buffalo fish, and Drum fish	N.R.	Mortality	August 1991. Gars, Buffalo fish, and Drum fish were reported killed in streams adjacent to Sugarcane fields.
I000247-004	Sugar-cane	Aug 8 1992	LA	LaFourche	2	RU	Bream, Catfish, Bass and Gar	N.R.	Mortality	Louisiana, Iberville County. July, 1991. Assumed aerial pesticide application onto nearby sugarcane-field, accompanied by consistent inclement weather (i.e. heavy rainfall), led to runoff at biotoxic levels and allegedly resulted in fish kills in three waterways associated with the Whitewater Canal. Unspecified numbers of Bream, Catfish, Bass and Gar were reported to have been killed.
I002166-001	Tree farm	May, 1995	NC	Wautauga	2	MA	Brook trout	Hundreds	Mortality	North Carolina, Wautauga County. May, 1995. It was reported that a spill occurred when, on a tree farm, a insecticide-laden tank was being towed uphill. Subsequently several hundred small brook trout were found dead in a nearby stream. Soil residue analyses were made between the spill site and stream.
I002200-001	Potato area	August 1994.	ME	Arrostock	3	RU	Brook trout	10,000	Mortality	Maine, Aroostook County. August 1994. This event occurred on the Maine/New Brunswick border where high acreages of potatoes are grown. Three pesticides had been used in the area. The discovery revealed 10,000 dead brook trout in a nearby pond which is fed by a brook. Water samples showed Maneb, Esfenvalerate and Chlorothalonil present in fish tissues.
I003596-001	N.R.	Aug 8, 1994	ME		2	RU	Trout (sp)	Thousands	Mortality	This appears to be the same incident as I002200-001

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I003659-001	Tomato	January, 1996.	VA	Accomack	3	UN	Juvenile Clams	Thousands	Mortality	Virginia, Accomack County. January, 1996. A shellfish farmer accustomed to raising clams, using water from the Gargatha Creek which flows nearby, has had to import water from Chincoteague Bay 10 miles away. Gargatha Creek has been badly contaminated, evidently, with pesticides as the result of a new procedure for growing tomatoes commercially.
I003781-002	Tomato	June 27, 1996.	KY	N.R.	3	UN	Fish	N.R.	Mortality	Kentucky, Ledbetter. June 27, 1996. Private citizen called DuPont to say that a neighbor who grows tomatoes had used Asana XL on his tomatoes, and a subsequent rainfall washed the Asana into her pond, killing the fish. Subsequently DuPont received several other calls from the same individual.
I006173-001	Cowpeas	October, 1997.	TX	N.R.	3	RU	Fish (sp)	N.R.	Mortality	Texas. October, 1997. A citizen reported that Asana@ XL(Esfenvalerate) was applied at rate of 0.02 lb a.i/acre, along with Thiodan (Endosulfan) at rate of 1 qt/acre, to treat cowpeas for curculio. In addition a 4-11-11 fertilizer had recently been applied to the field.
I007984-010	Ag area	1995	NC	Ashe	3	MA	Brook trout	N.R.	Mortality	A spray rig with 400 gallons of Asana and Lindane solution overturned on a large farm and the mixture seeped into a boggy area and drained into a nearby stream. The spill was contained and remediation included removing the soil and placing it in a plastic lined bed. The contaminated water was irrigated onto a Fraser Fir field. Charcoal was placed at the point of runoff to bind up any future chemical seepage.
I013170-001	Ag area	June 2002.	CA	Monterey		UN	Fish	2000	Mortality	California, Monterey County. June 2002. A fish kill occurred in Tembladera Slough and the Old Salinas River channel, and more than 2,000 fish were observed over 3-4 miles of stream channel. The first report of the fish kill was on June 27, 2002, but the condition of some of the fish indicated

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
										they had died earlier. Asana (esfenvalerate) and Supracide (methidathion) had been applied in the area.
I021456-001	Ag area	August 28, 2008	IA	Dallas	2	UN	Bluegill and Largemouth Bass	Dozens	Mortality	Iowa, Dallas County, August 28, 2008. This incident was also reported for Cypermethrin and Cyhalothrin. Drift from agricultural use site into a nearby 2 acre pond. Dozens of Bluegills and Largemouth bass killed (6-10" in size). Rainfall on 8/27/08. Samples collected tested positive for Lambda cyhalothrin, Esfenvalerate, and zeta-cypermethrin (all <0.2 ppb (LOQ)), Chlorpyrifos (0.069 ppb), and atrazine (0.14 ppb)

(1) Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
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Table 6. Summary of Ecological Aquatic Incident Reports in the Ecological Incident Information System for Deltamethrin (PC Code 097805)

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
AQUATIC INCIDENTS										
I015407 -001	Turf-golf course	2004	OH	Allen	3	MA	Bullhead catfish	350	Mortality	Ohio, Allen County. 2004. 350 Bullhead catfish killed in a pond adjacent to a golf course where Deltagard GC 5 SC was used. Runoff due to misuse is suspected. Imidacloprid (Merit 75WP) also used on the course.
I022217 -023	Turf- residen- tial	August 2010.	PA	Lancaster	2	RU	Fish (sp)	N.R.	Mortality	Pennsylvania, Lancaster County. August 2010. Possible exposure due to runoff from residential turf of Delta Dust product led to fish mortality in adjacent pond.

(1) Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
(2) Date: = start date of incident report.
(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
(5) Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
(6) Effect Code: M = mortality; P.D. = plant damage.

Table 7. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Fenpropathrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I004215-006	Cotton	July 23, 1996	CA	Imperial	4	RU	Carp Threadfin shad Channel catfish Flathead catfish	N.R.	Mortality	Canal was contaminated near application site. Necropsies of 4 catfish were performed.

(1) Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
(2) Date: = start date of incident report.
(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
(5) Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
(6) Effect Code: M = mortality; P.D. = plant damage.

Table 8. Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Pyrethrins

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I001297-011		Feb 9, 1994	TX	N.R.		MI	Fish(sp)	6	Mortality	A game preserve employee misused Adams Flea and Tick Dust II (active ingredients pyrethrins, PBO, carbarl, and silica gel) by applying it to an ant hill. Heavy rain washed product into nearby pond thus killing 5-6 fish
I021276-024	Urban	Aug.17, 2003				RU	Koi(Cyprinus)	13	Mortality	Mortality occurred from use for mosquito control which drifted into a pond containing ornamental Koi.

(1) Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
(2) Date: = start date of incident report.
(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
(5) Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
(6) Effect Code: M = mortality; P.D. = plant damage.

Table 9 Summary of Aquatic Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Cyfluthrin (none for Beta)

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
AQUATIC INCIDENTS										
I003621-001	Field	5/29/96	N.R.	N.R.	3	MU	Bluegill sunfish	650	Mortality	Aztec 2.1% granular was applied in a manner at variance with the label requirements. Subsequently a heavy rain fell and washed an appreciable amount into a stream where hundreds of fish were killed
I004564-001	Building	Oct. 1996	CA	Town of Irvine	4	RU	Koi	5	Mortality	A fish kill occurred in two ornamental ponds in Irvine, CA, sometime after October 25, 1996. Tempo was the product used near ponds. The incident was reported to the Bayer Co. on November 14, 1996.
I009427-006	Cotton	7/9/99	LA	Madison	2	RU	Crayfish	Hundreds	Mortality	Bayer Agricultural Division reported that a complaint was made, alleging that an aerial application of Cyfluthrin and Baythroid caused the death of an unknown number of crayfish in ponds totalling 200 acres in area. The Louisiana Dept. of Ag. took water samples 8 hours after the application and found neither compound (LOD for cyfluthrin = 1.4 ppb; LOD for curacron = 1.48 ppb). The incident took place in Tallulah, LA. A cotton field, 100 yards from the ponds, was the subject of the spraying. The Bayer Co. suggested that the crawfish might have died from a lack of oxygen since the spraying occurred in hot weather. The complainant indicated there is a cascade type of drainage from one pond into another, and if one became contaminated then all would be contaminated.
I003351-021	N.R.	4/21/94	CA	Placer	3	UN	Crayfish and Snails	Hundreds	Mortality	No real summary, but Cyfluthrin thought to be the causative agent.

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I013927-001	N.R.	2/19/03	CA	Imperial	3	UN	Flathead catfish Grass carp Largemouth bass	320 60 20	Mortality	A fish kill took place in the Lavender Canal east of Highway 111, Imperial County on February 19, 2003. There had been a Notice of Intent for aerial application of a tank mix containing cyfluthrin and chlorpyrifos for the agricultural field adjacent to the site of the kill. Water and fish samples were taken for analyses. Chlorpyrifos was in both water samples (at 0.08 and 11.7 ppb), and cyfluthrin was in only one water sample at 0.33 ppb. Analyses of fish gills ranged from 220- to 390-ppb cyfluthrin, and 660- to 2,100-ppb for chlorpyrifos.
I028127-001 Repeated in Cyperme-thrin and Bifenthrin	Urban runoff	7/20/15	CA	Ventura	3	UN	Silverside Mosquitofish Striped mullet Crappie	Thousands	Mortality	There were storms on the weekend of 18-19 July 2015 in Ventura County, CA that lead to numerous fish kill on 20 July 2015.in the J Street drain, an unban drain that terminates in the Ormond Lagoon, was observed. It was estimated by US Fish and Wildlife Service staff that thousands of dead fish were in the drain, including crap, silversides, topsmelt, striped mullets, staghorn, sculpin, mosquito fish, and sailfin mollies. July 20, 2015. Unspecified numbers of Crappie, Striped mullet, Silverside minnows, and mosquito fish killed. Cypermethrin, Bifenthrin and Cyfluthrin detected in samples.

(1) Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System (IDS). (Download date: September 2015).
(2) Date: = start date of incident report.
(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
(5) Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
(6) Effect Code: M = mortality; P.D. = plant damage.

Attachment VII. Pyrethroid and Pyrethrins Pollinator Incident Database Review

A review of the OPP Incident Data System which now incorporates the Ecological Incident Information System (EIIS) database for ecological incidents was completed on 2016. This database consists of exposure all types incident reports submitted to the EPA from 1994 to present. A summary of pollinator ecological incidents involving Pyrethroids are listed in the tables below. These individual tables are divided into incidents involving pollinator insects sorted from the IDS system by active ingredient. Some individual incidents may be duplicated if more than one pyrethroid active was detected or used in the areas surrounding the incident location.

Incidents listed in EIIS are categorized by the likelihood that a particular pesticide is associated with that particular incident. These classifications include highly probable, probable, possible, unlikely or unrelated. "Highly probable" incidents usually require tissue residue analysis or clear circumstances regarding the exposure. "Probable" incidents include those where residue information was not available or circumstances were less clear than those for "highly probable." "Possible" incidents occur when multiple chemicals may have been involved and the contribution of an individual chemical is not conclusive. An "unlikely" incident classification is given when a given chemical is considered nontoxic to the type of organism involved or the chemical was analyzed and not detected in samples. The "unrelated" category is used for incidents confirmed not to involve pesticides.

The number of reports listed in the EIIS database is believed to be only a fraction of the total incidents involving organismal mortality and damage caused by pesticides. For instance, honeybee and other pollinator insect incidents are generally tied to loss of commercial or private hives. Mortality in the wild would not normally be observed or reported, particularly when solitary species are involved. Honeybees may also forage over relatively large areas and thus, certainty of the source of exposure may not be readily apparent. Many of the pollinator incidents are reported by beekeepers and involve direct or indirect exposure to private or commercial hives from nearby application sites.

Reporting by states is only voluntary, and individuals discovering incidents may not be informed on the procedure of reporting these occurrences. Additionally, much of the database is generated from registrant-submitted incident reports. Registrants are legally required to provide detailed reports of only "major" ecological incidents involving pesticides, while "minor" incidents are reported aggregately. Because of these logistical difficulties, EIIS is most likely a minimal representation of all pesticide-related ecological incidents.

Summary of Pollinator Insect Incidents for Eight Synthetic Pyrethroids and Pyrethrins

The IDS and EIIS databases contained 11 incidents for Bifenthrin, 12 incidents for Permethrin, 5 incidents for beta and zeta Cypermethrin, 12 incidents for Cyhalothrin (Lambda and Gamma), 9 incidents for Cyfluthrin (including Beta-cyfluthrin), 2 incidents for Esfenvalerate, 1 incident for Fenpropathrin, 1 incident for Pyrethrins and no pollinator incident reports for Deltamethrin. It should be noted that some of these incidents involved detection of multiple chemicals and are therefore repeated for more than one chemical. The differences in reported incident numbers for individual pyrethroids may be due to several factors including length of time the chemicals have been registered, the amount of national

usage, individual label restrictions for mitigating exposure potential and the numbers of crops or other uses for which they are registered. Chemicals with higher numbers of uses might be expected to offer more opportunity for incidents to occur.

Incident Certainty and Legality: Eleven of the reported incidents were determined to be from legally registered uses of the pesticides. Three of the incidents were assessed to have been caused by misuse of the pesticides which resulted in accidental exposure and mortality to non-target pollinator insects. These might be caused by unexpected spray drift from a registered use. Intentional misuse is less common (4 incidents), but these generally result from complete disregard for label instructions regarding application procedures. Thirty four of the incident reports list the legality as undetermined. This classification generally indicates that the source or usage of the contaminant is not confirmed, and may in some cases occur where multiple use sites might contribute to the incident, such as an urban use site or an area where bees may forage on numerous farms and crops near the hives. These farms may also be using multiple pesticides.

Incident certainty numbers are generally based on analyses of residue levels in organism tissues or in environmental samples obtained from the incident location. Where multiple actives are detected the determination of certainty may be based on the aquatic toxicity characteristics of the chemical in relation to the other chemicals detected. Certainty numbers range from 1-4 with 4 being highly probable and 1 being considered unlikely to have been caused by the active even though it may have been detected. In some incidents there is a more direct link to the pesticide in that the incident was observed immediately after use, the close proximity of the use site to the incident location, or the pesticide was the only active used in the immediate area where the incident occurred. Five of the incidents listed in the tables below list the active as highly probable to have been the causative agent. Thirteen of the incidents list the active as the probable cause of the incident. The majority of the incidents (20) list the active as a possible cause of the incident. In many cases, incidents listed as possible, include detections of multiple actives or there is some uncertainty regarding the actual use site which contributed to the incident. In some cases residue analysis may not be reported for these incidents. Thirteen of the incidents were listed as unlikely for that particular active. These generally showed that other actives were more likely to have been the causative agents or that no detections of the active were found in samples analyzed from the incident locations.

Table 1. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Bifenthrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magni -tude	Effect (6)	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I000080-009	Alfalfa for seed	1/5/92	N.R.	N.R.	3	MA	Leafcutter bees	N.R.	Mortality	Insecticidal application of Capture in the vicinity of seed alfalfa allegedly entrapped and caused mortality to an unspecified number of leafcutter bees
I014202-017	Forest	9/13/01	MN	N.R.	1	RU	Honey bee	N.R.	Mortality	On Sept. 13, 2001, a bee keeper reported alleged bee kills due to Sevin insecticide applications made to nearby hybrid poplar fields. The bee yard is located approximately 3/4 to 1-3/4 miles from the fields. The two fields were aerially sprayed with Sevin (carbaryl) on Aug. 10, 2001. Additionally, it was determined that a corn field 1/4 miles from the bee yard was aerially sprayed with Capture (Bifenthrin) on Aug. 4, 2001. Samples of bee mortalities were taken for analyses. Test show that Carbaryl and Bifenthrin were both below level of detection. However, Coumaphos was detected at 3.58 mg/kg.
I020835-001	Alfalfa	June, 2007	UT	Box Elder	2	UN	Honey bee	61 hives	Mortality	Utah Department of Agriculture and Food reported an incident that involve bee mortality to 61 hives at nearby Christensen Bee Yard, Box Elder county, Utah. Aerial spray of pesticide the pesticides Thionex (endosulfan) and Capture (bifenthrin) occurred on seed alfalfa fields 1-2 mile from the bees. Several farmers in the area also had been spraying Furadan (carbofuran). Because so much spraying of different insecticides occurred in the area, it was not possible to determine which application caused this incident.
I023061-001		6/2/11	NV	Las Vegas	3	RU	Bees	Hundreds	Mortality	On June 22, 2011 in Clark County NV a resident reported to the U.S. EPA, that she found hundreds of dead bees scattered across her patio, steps, walkways and throughout the parking areas that surround her apartment. The pesticide applicator had sprayed 200 gallons of Masterline Bifenthrin (EPA Reg. # 1021-1810) during a routine pesticide application around an apartment building. The pesticide applicator stated he did not see any bees at the time of the application. The apartment owner also mentioned there

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magni -tude	Effect (6)	Summary Description
										were no birds on the premises this particular year.
I024221-001	Cotton	6/16/12	AZ	Yuma	3	RU	Honey bee	N.R.	Mortality	Half of a beekeeper's worker bees experienced mortality after an aerial application of Belay Insecticide (a.i. clothianidin), brigade (a.i. bifenthrin) and the adjuvant Exit to a nearby cotton field. Bees were actively foraging in the field at the time of application. The beekeeper observed dead bees five days after the application. Hives were not checked prior to this time. Dead bees were in the vicinity of hives, but not in considerable numbers. The beekeeper feels most bees died in the cotton field.
I024936-001	N.D.	October 2012	CA	Montecito area	2	UN	Honey bee	Several hives	Mortality	Numerous bee kill incidents from one small area of Montecito, CA occurred during October of 2012. One beekeeper reported that his bees were acting as if they were intoxicated before they died. The active ingredients bifenthrin (0.01) ppm), coumaphos (0.04 ppm), and fluvalinate (0.216 ppm) were detected brood/wax.
I025162-001	Almonds	3/5/13	CA	Madera	1	UN	Honey bee	thousands	Mortality	On March 05, 2013 in Madera County, CA, it was alleged an application of diluted Pristine (a.i. **pyraclostrobin and boscalid**) to an almond orchard killed numerous foraging bees. Workers for the beekeeper observed the spraying and bees dying at the entrances of the hives and on the orchard floor. Fifteen per cent of the bees per colony, mainly foragers, were killed. There were 12,000 colonies affected. Test results from the California DPR detected the pesticides: bifenthrin, chlorothalonil, cypermethrin, fenvalerate, pyraclostrobin, propiconazole, permethrin, pendimethalin, oxyflourfen, methoxyfenozide, iprodione, hexythiazox, fluvalinate, diuron, diflubenzuron, chlorantraniliprole, saflufenacil, pyriproxyfen, carbendazim and boscalid.
I027663-001	Home garden	4/27/15	OH	Fulton	1	RU	Butterflies (sp)	4	Mortality	Resident picked up over 1000 plants and had them planted in the garden on April 18th. Purchased butterflies arrived in chrysalis form on April 24th. Two Nectar feeding butterflies emerged two days later, and were placed in the garden on Sunday April 26th. By April 27th it was noticed one of the nectar feeding butterflies was comatose and not able to fly. The next day that butterfly was found dead in the same spot.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magni -tude	Effect (6)	Summary Description
										Another nectar feeding butterfly was found deceased in the garden April 28th. Resident took video and pictures observing the remaining nectar feeding butterflies. Less than 2 nectar feeding butterflies remained in the garden. By April 30th, only one of the emerged nectar feeding butterflies that had eaten any of the nectar survived. No other deaths reported by fruit eating butterflies. Resident contacted nursery April 30th and requested the entire list of pesticides they had applied to their plants. The list of seven products included Criterion 75 WSP, Conserve SC, Orthene -97, Tame , Avid .15, Talstar-Bifenthrin and Overture 35 WP.
I025673-001	Resi-dential	9/14/13	CO	Arapa-hoe	4	UN	Honey bee	2 hives	Mortality	On September 14th Arapahoe County, CO, a neighbor's pest control company applied Ortho Max Pro (a.i. bifenthrin) to trees overhanging her property. Caller reported the company was spraying excessively and that her garden was up against the fence the pesticide fell down into it. Two bee hives about 15 feet from the fence eventually suffered total mortality. No unusual behavior in the bees prior to the incident. Caller reported she noticed the bees acting sick a couple of hours after the application.
I025685-001	Soybean	8/9/12	IA	Wood-bury	1	UN	Honey bee	Low number	Mortality	Allegedly an aerial application of the insecticides Warhawk (i.e. chlorpyrifos) and Sniper (a.i. bifenthrin) to a soybean field drifted onto some beehives. The beekeeper noted that several dead bees were around the hives. The lab samples detected no residues from the active ingredients in Warhawk and Sniper.
I026685-001	Home use-	7/18/14	CO	Adams	2	UN	Honey bee	hundreds	Mortality	NPIC provided a report involving the death of "hundreds" of bees on 07/18/2014. A pest control company applied an avitrol (a.i. 4-aminopyridine) to control pigeons on her property, as requested. Subsequently the owner noticed a number of bees dropping from the air. A beehive was attached to a column outside her house and they were identified as honey bees . Pest company had also applied products(Reg 2724-786 1 (Piperonyl butoxide (PBO), Tetramethrin, Etofenprox), and Reg 279-3206 (Bifenthrin) to "control wasps". Owner did not request that service.

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(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
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(6) Effect Code: M = mortality; P.D. = plant damage.

Table 2. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Permethrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I003826-028	Soybean	8/30/94	NC	Sampson	4	MA	Honeybees	Several Hives	Mortality	A bee keeper complained to the NC Department of Agriculture about the bee kill in his hives suspected from aerial application of Ambush (containing Permethrin) to the nearby soybean field. The NC Department of Agriculture investigated this complaint. Several other bee keepers in the area also reported the similar kills in their bee hives. A certified aerial applicator treated the 400 acres the soybean field. Samples of dead bees, bee hive, and vegetation were obtained and tested. The results showed the presence of Permethrin. The NCDA believe that the aerial applicator violated provisions of the North Carolina pesticide regulations by depositing a pesticide by aircraft within 300 feet of agribusiness, 25 feet of a public road and within 100 feet of any residence. Thus, by agreement the applicator paid a fine of $1800.00 to the NCDA.
I011527-002	Urban	8/23/00	MN	Sibley	3	RU	Butterflies-multiple species including Monarchs	1000-10000	Mortality	Applicator reported an extensive butterfly kill in Gaylord, MN on August 23, 2000. This constitutes I011527-001. The principal fact was that there was a spraying of the town of Gaylord, MN with Biomist 30+30MLV that resulted in the deaths of many Monarch butterflies. Considerably more information regarding the same incident was contained in I011861-001. In this narrative it was shown that, several hours after the truck performed its spraying, residents observed hundreds of butterflies falling like leaves from the trees. The next morning, many other residents noticed the dead butterflies (mostly Monarchs) and estimates varied from less than 1000 to 10,000. Many dead butterflies disappeared that morning when a street sweeper made a pass through the neighborhood. The Minnesota Department of Agriculture analyzed the product and formulation oil samples and this

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
										indicated that there was a potential formulation problem. Analyses of butterfly samples showed concentrations of permethrin ranging from 20-37 ppm. The mortalities were also high because of the unanticipated, and concentrated presence, of Monarch butterflies at that time.
I012515-005		5/9/01	MS		2	UN	Honeybees in Apiary	N.R.	Mortality	Applicator reported an incident in its aggregate report of July-October, 2001. Biomist 312+30 ULV application resulted in claim of apiary damage. The Agency and MS Dept of Agriculture & Commerce, Bureau of Plant Industry, are aware of this claim. No information is available re: method of application or suspected misuse. Amendment has been submitted to the Agency to include bee hazard language on the label." From this, it can be inferred that there was a bee kill in MS related to this product.
I016728-010	Urban-mosquito control	7/1/05		Pinellas	3	RU	Butterflies-adults and larvae	12-24		Pinellas County Mosquito Control received a report of mortality of one to two dozen commercially raised butterflies following community-wide spraying. Adult and caterpillar mortality occurred in a colony maintained by a local butterfly hobbyist. This mortality was attributed to mosquito control spraying with Biomist 31+66 ULV with active ingredients permethrin and piperonyl butoxide
I020998-040	Apiary	6/20/03	WA	Benton	4	MI	Honeybees	Numerous hives	Mortality	The Office of Environmental Health and Safety, Washington State Department of Agriculture Annual report 2003 indicates a case that involve bee mortality caused by insecticide Permethrin. Beekeepers suspected that hives were deliberately sprayed to kill bees.
I023359-001	Urban use-along bike path	10/15/11	UT	Wash-ington	2	UN	Honeybees	120 colonies	Mortality	On October 15, 2011 a Washington County, UT beekeeper observed dead bees at the entrances of his hives. By October 22, , no queens were apparent in the colonies, no eggs had been laid and there were no field bees in any of the 102 colonies. According the beekeeper the county applied Kontrol (a.i. permethrin and piperonyl butoxide.) alongside a bike path where his bees forage

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I024183-001	Forest area	6/20/12	AU	N.A.	4	MI	Honeybees	1200 beehives		On June 20, 2012 in Batemans Bay, Australia a common household insecticide with the active ingredient permethrin was in an act of industrial sabotage to poison 1,200 beehives resulting in a mass mortality of bees. Police are still investigating the mass slaughter of the bees. 10 different sites were affected.
I025162-001	Almond orchard	5/3/13	CA	Madera	1	UN	Honeybees	12,000 colonies	Mortality	On March 05, 2013 in Madera County, CA, it was alleged an application of diluted Pristine (a.i. pyraclostrobin and boscalid) to an almond orchard killed numerous foraging bees. Workers for the beekeeper observed the spraying and bees dying at the entrances of the hives and on the orchard floor. Fifteen per cent of the bees per colony, mainly foragers, were killed. There were 12,000 colonies affected. Test results from the California Department of Pesticide Regulation detected the pesticides: bifenthrin, chlorothalonil, cypermethrin, fenvalerate, pyraclostrobin, propiconazole, permethrin, pendimethalin, oxyfluorfen, methoxyfenozide, iprodione, hexythiazox, fluvalinate, diuron, diflubenzuron, chlorantraniliprole, saflufenacil, pyriproxyfen, carbendazim and boscalid.
I025359-001	Urban-mosquito control	Fall 2012	IL	Lake	2	UN	Honeybees	10-20 hives	Gradual Loss of hives	A caller reported to NPIC that a Pest Control Company was hired by the fall of 2012 city to spray for mosquitoes. The caller reported last fall they sprayed Biomist 3+15 ULV (Piperonyl butoxide (PBO) and permethrin) with a truck at night within 10 feet of 20 beehives and 100 feet of 23 beehives. Caller reported going into winter there were only 2 hives left. Caller reported during hot nights the bees are outside to cool down, but reported he doesn't know if that was the case during the application. Caller reported he doesn't know how his bees got exposed but he is sure the application hurt them.

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I027332-005	Urban-mosquito control	2014	IA	Polk	1	UN	Honeybees	N.R.	Exposed	Alleged mosquito fogging near bee hives after 6:00 pm, but before sundown in Polk County, IA . Honey bees were ruled to have no adverse effects at time of reporting. The pesticide was mixture of cis and trans permethrin.
I027332-006	N.R.	2012	IA	Warren	1	UN	Honeybees	N.R.	Exposed	In Warren County, Iowa, honey bees were allegedly exposed to permethrin Biomist 4 + 4 ULV (a.i. permethrin). No adverse effects at filing of the state report. No lab testing performed.
I028166-001	N.R.	7/13/15	TN	Sevier	4	UN	Honeybees	2 hives	Mortality	On 14 September 2015, a beekeeper called stating his two bee hives had been poisoned the previous day between 4:00 PM and this morning. TDA was requested to investigate. Analysis of the sample sent to the TDA showed that permethrin was present. This is an ongoing investigation which has not been closed and Pesticide and Apiary Section are both involved in this case. Another beekeeper reported that bees were poisoned too.

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[2] Date: = start date of incident report.
[3] State: values in parenthesis represent countries of origin when states are not reported or applicable.
[4] Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
[5] Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
[6] Effect Code: M = mortality; P.D. = plant damage.

Table 3. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Beta and Zeta Cypermethrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I014202-007 Zeta Cypermethrin	Alfalfa	8/8/02	MN	N.R.	2	RU	Honeybees	8 hives-Queen-less	Mortality – loss of Queens	A bee keeper reported that queen-less hives were observed on Aug 8, 2002. Yard had contained 32 hives, but had declined to 26 hives. All 26 hives were opened and inspected. 8 of the hives were queen-less or failing. No diseases were found, but Varroa mite was positive for one hive. An erratic or spotty brood pattern was common. Pesticide exposure was suspected. An alfalfa field 2.75 miles from the yard was sprayed with zeta-cypermethrin (Fury) 23 days prior to the observation in the bee yard. Samples of pollen were taken and analyzed with no detection of zeta-cypermethrin, carbaryl, 1-naphthol and carbofuran. Coumaphos was detected. It is used in Check Mite Strips used to control Varroa mites. The insecticide used on the alfalfa field was identified as Mustang and the EPA Reg. # 279-3126. Mustang is a pyrethrin pesticide cancelled in 1983. The product Fury contains zeta-cypermethrin.
I014202-008 Zeta Cypermethrin	Alfalfa	9/4/02	MN	N.R.	1	RU	Honey bees	Several hives-numbers N.R.	Mortality	A bee keeper reported on Sept 4, 2002 that there were dead bees in his bee yard. It was also stated that on Aug. 27, 2002, the bee keeper removed honey and that the hives were fine. The inspector opened and examined 20 of the twenty hives. Colonies appeared to be disease free, except for two hives with normal chalkbrood. Two hybrid poplar fields, 3,25 and 8 miles from the bee yard, were identified. There were no insecticide treatments to these fields in 2002. An alfalfa field had been treated with zeta-cypermethrin about 50 days before symptoms were reported. Bee tissue and pollen samples were obtained. Analyses of the samples did not detect any carbaryl, 1-naphthol or

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
										carbofuran. Coumaphos was detected in both the bee tissue and pollen samples. Level were not given. Test for Varroa mites was negative.
I025162-001 Repeated in Permethrin-cypermethrin detected	Almond orchard	5/3/13	CA	Madera	1	UN	Honeybees	12,000 colonies	Mortality	On March 05, 2013 in Madera County, CA, it was alleged an application of diluted Pristine (a.i. pyraclostrobin and boscalid) to an almond orchard killed numerous foraging bees. Workers for the beekeeper observed the spraying and bees dying at the entrances of the hives and on the orchard floor. Fifteen per cent of the bees per colony, mainly foragers, were killed. There were 12,000 colonies affected. Test results from the California Department of Pesticide Regulation detected the pesticides: bifenthrin, chlorothalonil, cypermethrin, fenvalerate, pyraclostrobin, propiconazole, permethrin, pendimethalin, oxyfluorfen, methoxyfenozide, iprodione, hexythiazox, fluvalinate, diuron, diflubenzuron, chlorantraniliprole, saflufenacil, pyriproxyfen, carbendazim and boscalid.
I027332-013	Hay field	8/1/14	IA	Powesheik	2	MA	Honeybees	N.R.	Exposed	A round application Mustang Mix Insecticide (a.i. cypermethrin) onto a hay field allegedly drifted onto fruits and vegetables, No adverse effects to bees were reported at the time of report.
I029062-00001 ZETA Repeated for Cyhalothrin as well	Alfalfa	7/1/16	CA	Fresno	1	RU	Honeybees	120 hives	Mortality	A bee incident was reported by a beekeeper in Fresno County, California. Mortality in two colonies, which were under contract for pollination of seed alfalfa, was reported on 28 June 2016. It was reported 40 queens and 120 hives, were affected. Swabs and dead bee samples were submitted to California's Department of Food and Agriculture Sacramento Residue Laboratory. The results indicated that many pesticides labeled as toxic to bees had been applied within one mile radius surrounding of the bee colonies.

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(2) Date: = start date of incident report.
(3) State: values in parenthesis represent countries of origin when states are not reported or applicable.
(4) Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
(5) Legality Code: MA = misuse accidental, MI = misuse intentional, RU = registered use, UN = unknown
(6) Effect Code: M = mortality; P.D. = plant damage.

Table 4. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Lambda Cyhalothrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I021053-001	Sunflower	8/16/09	CO	Boulder	2	MI	Honeybees	N.R.- hives assumed	Mortality	A beekeeper claimed that the product Warrior (lambda-cyhalothrin micro encapsulated) was sprayed on 100 acres of blooming sunflowers, resulting bee mortality. The farmer and applicator were told that application of the product would be violation of Federal law. Spraying was done at 6:00 AM.
I022774-008	Canola-during flower	6/16/10	CA	Ontario	3	MI	Honeybees	4-7 million	Mortality	On June 6, 2010 in Hanover Ontario CA an application of Matador 120EC Emulsifiable Concentrate Insecticide was applied to a flowering canola field killing 4 to 7 million foraging honeybees. The report states that the application of Matador (a.i. Lambda-Cyhalothrin) was made in the middle of the day to the field. This application timing is contrary to the use directions stated on the product label.
I023107-019	Cotton and Pistachio orchards	7/26/11	CA	Kings	2	UN	Honeybees	92 colonies	Mortality and sublethal	An apiary owner notified the Kings County Agricultural Commissioner's Office of a bee loss on July 26, 2011. One pesticide application was reported in the vicinity of the affected apiary involved Dimate- 4E and Grizzly- Z (a.i. lambda cyhalothrin). Both pesticides were applied by an aerial applicator to a cotton field. Another application in the area involved ground applications of Warrior- II (a.i. lambda cyhalothrin) and Intrepid (a.i. methoxyfenozide) to a pistachio orchard. Bee and swab samples were collected and sent to the California Department of Food and Agriculture Center for Analytical Chemistry. 92 colonies were affected, 12 colonies were completely dead on September 26. Dimethoate detected at 0.007, 0.024, and 0.017 ppm. Cyhalothrin- not detected.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I023225-004	Canola	4/17/11	Slovenia	Mura region	2	UN	Honey bees and other Apis species	2500 hives	Mortality and sublethal	A bee decline occurred in parts of Slovenia during the spring of 2011. Inspections were conducted between April 17 and May 10, 2011 by the Agricultural Inspection Service in Radican located in the Mura Region of Slovenia. More than 2,500 hives were afflicted or nearly 10% of the all the beekeepers in the Mura District. At maize sowing time the weather in the Mura Region was extremely dry. Coumaphos in concentration as high as 0.42 ppm and o-phenylphenol were detected in bee tissue. Samples of oilseed rape showed detected traces of pendimethalin (H) and clothianidin in the stem of one sample. Methiocarb, thiacloprid (2.3 ppm) and lambda-cyhalothrin were detected in another sample of oilseed rape.
I024118-001	Near Wheat field and orchard	6/12/12	NY	Niagra	2	UN	Honeybees	22+ colonies	Mortality and sublethal	On June 2, 2012 in Niagara County, NY a bee owner reported that a large amount of bees were either dead or dying at the entrances of 22 colonies of 1,200 colonies. These bees exhibit a shaking behavior on the exterior of the colony. The colonies are located on the margins of an orchard and within 40 ft. of a wheat field. Wheat fields in the area have been treated with Warrior (a.i. lambda cyhalothrin) for army worm. The NY State Apiary Inspection officials took samples from the affected colonies and forwarded them to Pennsylvania State University for pesticide residue analyses. Samples also forwarded to the USDA Beltsville Bee Research Laboratory for disease analyses. Results are not reported.
I024129-001	Wheat field nearby	6/6/12	NY	N.R.	3	UN	Honeybees	thousands	Mortality-mostly to drones	On June 6, 2012 in NY a beekeeper found thousands of drones laying on the ground in front of colonies. Roughly 96% of the dead bees in front of the colony were drones. The bee owner noticed that the dead drones appear to have ejaculated (as evidenced by exterior endophallus). A wheat field in the vicinity of the colonies were recently treated with Warrior (a.i. lambda cyhalothrin) to control army worms.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I024149-001	Apple orchard. Corn and Soybean fields in the area	6/4/12	NY	Chen-ango	2	UN	Honeybees	1 colony	Mortality	On June 4, 2012 a beekeeper in Chenango County, NY noticed Russian bees dying outside their colonies. At the time of the kill the bees were most likely foraging on thorn apple. However, corn and soybean were also being grown in the vicinity. Dead bees were oil-colored and their proboscis extended. Beekeeper stated that the insecticide Cavalry (a.i. lambda cyhalothrin) was applied near another bee yard maintained on his farm.
I024173-001	Orchards	6/21/12	NY	Endigo	0	UN	Honeybees	260 colonies	Mortality	On June 21, 2012 in NY a beekeeper indicated that the 260 colonies in his bee yard had piles of dead bees in front and 12 colonies died outright. A large number of bees at the entrance to the colonies were male drones. Wheat fields surrounding the affected bee yard had not been treated. The orchards within 0.25miles of his yard had been treated with a sprayer. The beekeeper believes the formulated product Endigo (a.i. thiamethoxam and lambda cyhalothrin) was applied. Based on the level of pesticides detected in the bee bread and the amount of bee bread that adult bees could consume in a day, the USDA determined it not likely that pesticide exposure was the cause of this incident.
I024875-001	Ag areas	7/01/13	UT	N.R.	3	UN	Honeybees	3972 hives	Repro-ductive failure	Between the last week May and third week in July a beekeeper in Utah alleges that all 3,972 of his hives placed in agricultural area were affected by direct exposure to pesticides. The bees stopped foraging and failed the queens the rest of the summer and fall. The bee tissue tested positive for estimated concentrations of carbofuran (37 ppb), carbofuran 3-OH (190 ppb), THPI 63, lambda cyhalothrin (27 ppb) and thymol (15,000 ppb). The bee hive tested positive for concentrations of boscalid (6 ppb), carbofuran (2 ppb), carbofuran 3-OH 4 (ppb), coumaphos (15 ppb), fluvalinate (67 ppb), malathion (4 ppb), piperonyl butoxide (5 ppb), propiconazole (61 ppb) and thymol (5,000 ppb).

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I025665-001	Soybean fields	8/20/13	Canada	Ontario	3	UN	Honeybees	Hives- no number provided	Mortality	It was report an increased mortality was observed in an unknown number of bee hives at two apiaries in Ontario, Canada that were located adjacent to soybean fields that were treated with Endigo Insecticide (a.i. thiamethoxam and lambda-cyhalothrin). It was reported that the applications were made in the late afternoon of August 19 and during the day on August20. It was reported that the first observations of increased bee mortality were made on August 20 and 21 by one of the farm owners.
I026963-002	Sweet Corn and residential areas	N.R.	MA	Bristol	3	UN	Honeybees	Thousands	Mortality	Article about the documenting of bee kills from Awansea, Massachusetts to Barrington, Rhode Island. This beekeeper is convinced pesticides applied to keep sweet corn more cosmetically appealing are to blame for the death of countless bees. There have been 218 different chemicals found in tests performed on bees and a number of homes are putting out pesticides above label-rate. It's not just the farmers. Plymouth county has also had bee kills.
I029062-00001	Seed alfalfa,	7/1/16	CA	Fresno	2	UN	Honeybees	120 hives and 40 queens-thousands	Mortality	A bee incident was reported by a beekeeper in Fresno County, California. Two colonies, which was under contract for pollination of seed alfalfa, mortality were reported on 28 June 2016. It was reported 40 queens and 120 hives were affected. Swabs and dead bee samples were submitted to California's Department of Food and Agriculture Sacramento Residue Laboratory. The results indicated that many pesticides labeled as toxic to bees had been applied within one mile radius surrounding of the bee colonies.

[1] Source: USEPA Ecological Incident Information System (EIIS) and Incident Data System(IDS). (Download date: September 2015).
[2] Date: = start date of incident report.
[3] State: values in parenthesis represent countries of origin when states are not reported or applicable.
[4] Certainty Code: 1 = unlikely; 2 = possible, 3 = probable, 4 = highly probable
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Table 5. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Esfenvalerate

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I024676-014	Sugarbeet	10/26/12	CA	Imperial	2	UN	Honey bees	132 colonies	Mortality	On 10/26/2012 in Imperial County, CA a beekeeper found 132 colonies of his bees dead. The beekeeper supsects the bees were killed by a nearby aerial application of Govern 4E (a.i. chlorpyrifos) and Asana XL (a.i. esvenvalerate) to a sugarbeet field. Samples were sent to CDFA.
I026517-001	Almond orchard	3/24/14	CA	Merced	2	UN	Honey bees	2000 hives	Mortality	There were 2000 honey bee hives for pollinating almonds effected in Merced County, CA. The bees started dying 24 March 2014 and ended 19 April 2014. Coumaphos (at 2.9 ppb), cyprodinil (at 6.6 ppb) diflubenzuron (at 184 ppb) esfenvalerate (at trace amounts) fenbuconazole (at 1060 ppb) fluvalinate (at trace amounts) methoxlfenozide (at 1280 ppb) and pyripoxyfen (at 391 ppb) were detected in dead bees. These same analyses were submitted under I026518-001.

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Table 6. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Fenpropathrin

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I027112-001	Orange Grove	10/31/14	FL	Indian River	2	UN	Honey bee	100 hives	Mortality	On 10/31/2014 a bee keeper noted a die-off in his bee yard adversely affecting 100 bee hives. The orange orchard adjacent to his bee yard may have been sprayed with Mustang (a.i. pyraclostrobin, metconazole) and Danitol (a.i. fenpropathrin). The beekeeper reported that the colonies that most affected from the application of pesticides to an adjacent citrus orchard were continuing to fail and exhibit poor queen performance. No lab testing results were provided.

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Table 7. Summary of Pollinator Ecological Incident Reports in the Incident Information Systems (IDS and EIIS) for Pyrethrins

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I026996-001	Urban residence Mosquito control	8/19/14	CA	Contra Costa	3	UN	Honey bee	Beehives - several	Mortality	After sundown there was a bee hive die off in an area 0.5 miles outside of the spray zone. Fogging from application of Pyrocide Fogging Formula 7067 adulticide to a yard for ULV mosquitos was believe to cause the deaths. The active ingredients of the pesticide was Pyrethrins and Piperonyl Butoxide was applied to a yard on 19 August 2014. The fogging concentrate was 5% PY and 25% PBO-Oil based 0.75 oz/acre. Two (with a potential third) complaints from local bee keepers that many of their bees had also died.

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[6] Effect Code: M = mortality; P.D. = plant damage.

Table 8. Pollinator Ecological Incident Reports in the Incident Information Systems for Cyfluthrin and Beta Cyfluthrin

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
NON-TARGET POLLINATOR INSECT INCIDENTS										
I027797-001	Ag area	5/14/15	PA	Dauphine	0	UN	Honey bee	11 hives	Mortality	On May 14, 2015 1/4 of 11 hives were found dead in Dauphin County, PA. The lab results were negative for pesticides. Labels were supplied to inspectors for product applied to a small on property orchard. Products were Aza-Direct IPA Reg. # 71908-1-10163 (ai is Azadirachtin). And Baythroid EPA Reg. # 264-840 (ai beta-Cyfluthrin).
I026288-002	Resi-dential	April 2013	CA	Santa Barbara	2	RU	Honey bee	12 hives	Mortality	In Santa Barbara County, California, 12 hives were located within 300 yards of an area treated by CDFA for control of the Asian Citrus Psyllid in April of 2013. The colonies were sampled by a Bee Informed Technical team sponsored by Project Apis m (PAM), but not tested for pesticide levels. According to the beekeeper, the state has an emergency exemption to apply pesticides to citrus trees during full bloom against label recommendations not to apply the compound while bees are foraging or trees are in bloom. The beekeeper expressed concern regarding the proposed use of Merit 2F (iimidacloprd), CoreTect (a.i. imidacloprid) and Tempo (a.i. cyfluthrin) to control the Asian psyllid. Only one colony has survived out of the 12. An additional 7 colonies located in this treatment area have died out as well and several SBBA members in or nearby have reported that their colonies have not fared well, or have died out. SBBA desires to have several of these hives tested, but cannot afford to do so.
I026011-001	Cotton.	6/24/13	AZ	Yuma	1	UN	Honey bee	30 hives	Mortality	On June 24, 2013 a pesticide application to cotton and alfalfa containing the active ingredients cyfluthrin and clethodim allegedly killed 30 hives in Yuma County, AZ.
026012-001	N.R.	7/15/13	CA	Riverside	1	UN	Honey bee	48 hives	Incapa-citation	On July 15, 2013 a pesticide application to cotton containing the active ingredients cyfluthrin and clethodim allegedly incapacitated 48 hives in Riverside County, CA.

Incident ID	Use Site	Date (1)	State (2)	County (3)	Cert. Code (4)	Legal. Code (5)	Species	Magnitude	Effect (6)	Summary Description
I025496-001	Corn	N.R.	Ohio	Putnam	2	UN	Honey bee	3 hives	Mortality	Ohio Beekeepers Association reported that in Putman County, OH, beekeeper allegedly had three hives killed due to an application of the product. Tombstone (a.i. cyfluthrin). It only took 11/2 hours for the bees to die. Very little information was contained is report.
I026789-001 Beta	Soybean	1/8/14	IL	Woodford	2	RU	Honey bee	600	Mortality	A grower in the El Paso, IL area reported the issue to a BCS sales representative and described the issue where the grower had two separate applications in the same vicinity between 11:00 a.m. and Noon on Friday, August 1st. The beekeeper contacted the grower between 1:30 and 2:00 p.m. indicating he observed at least 300 bees dead and dying in front of one of his 4 hives at his home apiary location. By the time Bayer personnel arrived on site at 5:00 p.m. the additional three hives appeared to have 100 or so dead I dying bees in front of them from an aerial application based in the Colfax, IL area in which applied Stratego YLD +Zinc +Adjuvant on corn approximately 300ft to the north of the affected apiary. The lab test name two degradas (olefin and 5-hydroxy) of imidacloprid as the likely cause of bee morality.
I028003-001 Beta	N.R.	8/20/15	VA	South-hampton	3	UN	Honey bee	30 hives	Mortality	On 17 August 2015 a farmer sprayed 71 acres of cotton in bloom for stink bugs with Baythroid XL (EPA Reg. No 264-840, ai beta Cyfluthrin) in Southampton. County, VA Thirty hives across the street were affected with dead bees. This was a misuse of Baythroid XL which should not be applied on blooming plants..
I029062-0001 Beta -also repeat for Lambda Cyhalothrin	Alfalfa	7/11/16	CA	Fresno	1	UN	Honey bee	120 hives 40 Queens	Mortality	A bee incident was reported by a beekeeper in Fresno County, California. Two colonies, which was under contract for pollination of seed alfalfa, mortality were reported on 28 June 2016. It was reported 40 queens and 120 hives. Swabs and dead bee samples were submitted to California's Department of Food and Agriculture Sacramento Residue Laboratory. The results indicated that pesticides labeled as toxic to bees had been applied within one mile radius surrounding of the bee colonies.

Incident ID	Use Site	Date [1]	State [2]	County [3]	Cert. Code [4]	Legal. Code [5]	Species	Magnitude	Effect [6]	Summary Description
I025512-001 Beta	Soybean	8/1/13	MO	Benton	3	UN	Honey bee	11 hives	Mortality	Beekeeper reported on 08/01/13 thousands of dead and dying honeybees in and around his 11hives. The beekeeper recalled seeing a spray rig in the adjacenty soybeans field and talked to the neighbor. His neighbor had a local applicator apply the product Leverage 360 (a.i. beta-cyfluthrin and imidacloprid). The soybeans were in full bloom and the bees had been taking advantage of them because there were few other flowers blooming.

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