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OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

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MEMORANDUM

Subject: Preliminary Ecological Risk Assessment for the Registration Review of Emamectin Benzoate

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This memorandum transmits the preliminary ecological risk assessment for the registration review of emamectin benzoate (PC Code 122806), an insecticide registered for use on many agricultural crops and ornamental plants, including foliar and tree injection uses. This risk assessment provides the Division's assessment of the environmental fate, terrestrial and aquatic exposure, and ecological effects associated with all registered uses of emamectin benzoate.

The results of this preliminary risk assessment indicate that a number of uses of emamectin benzoate have the potential for direct adverse effects to several non-target taxa, with acute and chronic LOCs exceeded for aquatic invertebrates (water column and benthic dwelling) and chronic LOC exceedances for mammals. Based on a dataset limited to acute adult honey bee toxicity tests, effects are expected for terrestrial invertebrates and a full assessment of effects on pollinators will be conducted when data are available to form the weight of evidence at the individual and colony level. Adverse effects are not anticipated for fish (surrogate for aquatic phase amphibians), and aquatic or terrestrial plants. There are LOC exceedances for small birds (surrogate for reptiles and terrestrial-phase amphibians). **Tables I-III** summarize the potential adverse direct effects from registered uses of emamectin benzoate. The analysis is performed based on both upper- and lower-bound half-life assumptions. Additional characterization is provided based on typical use patterns (1-2 apps/year) from BEAD, and for the aquatics, a best case single year application (2 applications total in the 30-year simulation).

Table I. Summary of Risk Quotients for Aquatic Organisms from Foliar Applications

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	LOC EXCEEDANCE		Additional Information/ Lines of Evidence
			Non-listed	Listed (Direct effect)	
Freshwater fish	Acute	0.001-0.014	No	No	
	Chronic	0.034-0.362	No	No	
Estuarine/ marine fish	Acute	<0.001-0.002	No	No	
	Chronic	0.015-0.162	No	No	
Freshwater (FW) invertebrates	Acute	0.3-3	Yes	Yes	LOC exceeded for all uses except tobacco and baits considering accumulation via upper bound (EFED policy) half-life assumptions. Exceedances for lower bound half-lives for some uses and no exceedances under the typical use pattern and also a best case single year application.
	Chronic	3-27	Yes	Yes	LOC exceeded for all uses (upper and lower bound half-lives); effects to growth and reproduction; RQs above LOC with typical use pattern and also a best case single year application.
Estuarine/ marine (E/M) invertebrates	Acute	6-61	Yes	Yes	LOC exceeded for all uses (for upper and lower bound half-lives), LOC exceedance with typical use pattern and also a best case single year. Steep dose response-LC_{100} also exceeded.
	Chronic	26-275	Yes	Yes	LOC exceeded for all uses (for upper and lower bound half-lives); effects to growth and reproduction; RQs above LOC based on typical use pattern and also a best case single year application.
Benthic Invertebrates	Subchronic	0.04-1.0(Pore water) 0.1-1.7(sediment)	Yes	Yes	Marginal LOC exceedance for the Brassica-Leafy use (upperbound half-life only)
	Chronic	17-181 (Pore water) 67-700 (Sediment)	Yes	Yes	LOC exceeded for all uses (for upper and lower bound half-lives); RQs above LOC based on typical use pattern and also a best case single year application.
Aquatic plants	Acute	N/A (non-definitive; greater than values)	No	No	Low likelihood of adverse effects based on highest test concentration proxy and accumulation scenario.
Level of Concern (LOC) Definitions: Terrestrial Animals: **Acute=0.5**; Acute (listed) terrestrial animals = 0.1; **Chronic=1.0** Aquatic Animals: **Acute=0.5;** Acute (listed) aquatic=0.05; **Chronic=1.0;** Plants: **1.0**					

Table II. Summary of Risk Quotients for Terrestrial Organisms from Foliar Applications

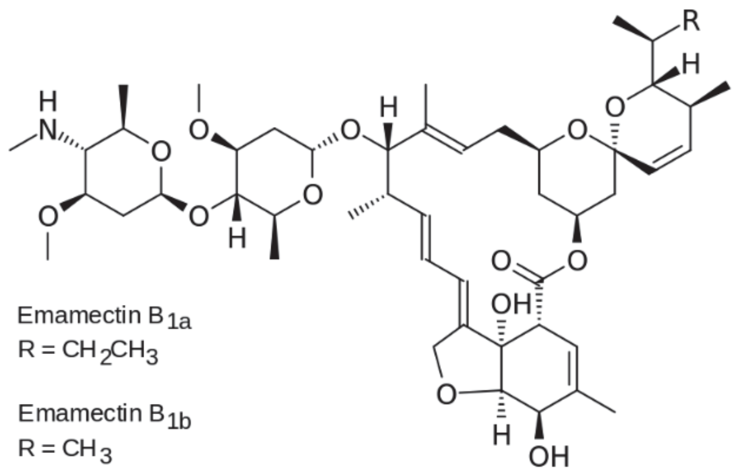
Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	LOC EXCEEDANCE		Additional Information/ Lines of Evidence
			Non-listed	Listed (Direct effect)	
Mammals	Acute	TREX foliar Spray: <0.01-0.6 Piscivores-KABAM: 0.07-0.2 (max) 0.013-0.04 (lower bound)	Yes	Yes	Foliar: Minor exceedance for the 15g mammal foraging on short grass. Considering typical usage of 1-2 applications, the likelihood of effects is minimal. KABAM-No LOC exceedances
	Chronic	TREX foliar Spray 0.07-11.4 Piscivores-KABAM: 1.-4.3 (max) 0.2-0.8 (lower bound)	Yes	Yes	Foliar: LOC exceedance based on upper bound and mean EECs. Multiple studies exceeding the NOAEC and LOAEC; extends off-field. Based on reproduction and neurotoxicity effects. When considering the typical number of applications, there are LOC exceedances (with a single application RQs range up to 2.6). KABAM-LOC exceedances for maximum use/upperbound EECs only.
Birds	Acute	TREX foliar Spray <0.01-0.75 Piscivores-KABAM 0.004-0.3 (Max)	Yes	Yes	Foliar: LOC exceedances for lethal and sublethal (long lasting neurotoxicity). Considering typical usage of 1-2 applications, the likelihood of adverse effects is minimal. No LOC exceedances based on KABAM.
	Chronic	Foliar:0.02-0.39 Piscivores-KABAM 0.05-0.19 (Max)	No	No	
Terrestrial invertebrates	Acute Adult	1.4-76.5	Yes	Yes	RQs range from 1.4 for the queen to 76.5 for the nectar foraging worker. Some crops/uses have potential for on-field exposure based on bee attractiveness. Many methods/droplet combinations result in a buffer in excess of 100 feet to no longer exceed the LOC. Uncertainties: Tier 1 toxicity studies and crop residue studies are not available. The likelihood of adverse effects to adults (chronic) and larvae (acute and chronic) is uncertain.
	Chronic Adult	No Data-Uncertain			
	Acute Larval				
	Chronic Larval				
Terrestrial plants	N/A	<0.1	No	No	

<u>**Level of Concern (LOC) Definitions**</u>
Terrestrial Animals: **Acute=0.5**; Acute (listed) terrestrial animals = 0.1; **Chronic=1.0; Terrestrial invertebrates=0.4**
Aquatic Animals: **Acute=0.5;** Acute (listed) aquatic=0.05; **Chronic=1.0**
Plants: **1.0**

Table III. Summary of Risk Quotients for Terrestrial Organisms from Tree Injection Uses

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	LOC Exceedance		Additional Information/ Lines of Evidence
			Non-listed	Listed (Direct effect)	
Mammals	Acute	0.1-0.7 (Avg.) 0.3-2.2 (Max)	Yes	Yes	LOC exceedance based on bing cherry leaf residues from sampling interval closest to injection. Uncertainty in exposure potential to upper bound residues, no LOC exceedances using ash tree residues and marginal exceedance based on average values. Use of leaves as surrogate for tree parts such as fruit, buds, flowers etc.
	Chronic	5-10 (Avg.) 15-33 (Max)	Yes	Yes	LOC exceedances based on estimates for mammals foraging on the high-end residues exclusively and leaf residues used as surrogate for other tree parts (seeds, fruit, etc.). Exposure is considered highly uncertain and the likelihood of adverse effects is relatively low.
Birds	Acute	0.2-0.5 (Avg.) 0.7-1.7 (Max)	Yes	Yes	Same as Mammals acute (above)
	Chronic	Not calculated	No	No	Low likelihood of adverse effects. No effects at 40 mg/ a.i./kg diet which is slightly below the maximum leaf EEC (45 ppm) for bing cherry.
Terrestrial invertebrates	Acute Adult	**Prior to leaf drop**: 0-0.121 (RQs based on measured pollen and nectar residues) **Post leaf drop:** 0.6-18.1 (RQs based on measured pollen adjusted for leaf drop/timing factor-see further discussion of uncertainties)	No/Yes	No/ Yes	RQ exceedance not anticipated for fall applications based on empirical residue values for pollen and nectar. For spring applications (applications made after leaf drop and before/during bloom), there are LOC exceedances based on the estimated values. However, when applications are made after the leaf drop, the most likely exposure considering real world application timing is better represented with the empirical residue data from the submitted study because the application is likely to be after bloom. For other life stages and chronic exposure, adverse effects cannot be precluded based on a lack of toxicity data.
Level of Concern (LOC) Definitions Terrestrial Animals: **Acute=0.5**; Acute (listed) terrestrial animals = 0.1; **Chronic=1.0; Terrestrial invertebrates=0.4**					

Ecological Risk Assessment for the Registration Review of Emamectin Benzoate



[Emamectin CAS Reg. No. 119791-41-2; Emamectin Benzoate CAS 155569-91-8]
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I. EXECUTIVE SUMMARY

Overview

Emamectin benzoate is an avermectin class insecticide targeting nervous system and muscle function in insect pests. Emamectin benzoate consists of two components differing by an R constituent; >90% of the chemical is MAB_{1a} ($R=C_2H_5$) and <10% is MAB_{1b} ($R=CH_3$). It is registered for use on agricultural crops, ornamental plants/ trees, and also has non-agricultural uses. Applications may be made via foliar spray, bait station, and as a tree injection. This risk assessment provides EFED's assessment of the environmental fate, terrestrial and aquatic exposure, and potential for adverse ecological effects associated with all registered uses of emamectin benzoate.

The results of this preliminary risk assessment indicate that a number of uses of emamectin benzoate have the potential for direct adverse effects to several non-target taxa, with acute and chronic LOC exceedances for aquatic invertebrates (water column and benthic dwelling), and chronic LOC exceedances for mammals being the greatest. Based on a dataset limited to acute adult honey bee toxicity tests, potential adverse effects are also identified for terrestrial invertebrates, and a full assessment of pollinator risk will be conducted when data are available to form the weight of evidence at the individual and colony level.

Adverse effects are not anticipated for fish (surrogate for aquatic phase amphibians), and aquatic or terrestrial plants. There are LOC exceedances for small birds (surrogate for reptiles and terrestrial-phase amphibians). The results of this assessment are generally similar for the taxa assessed in past assessments, however, this assessment incorporates new half-life calculations resulting in slower degradation in the aquatic environment and, thus, resulting in higher RQs for aquatic taxa. Additionally, terrestrial invertebrates are formally assessed (to the degree possible with the available data) and the tree injection analysis is refined.

Risk Conclusions

AQUATIC RISK SUMMARY

- There is low likelihood of adverse effects to fish as there were no level of concern (LOC) exceedances using the upper bound EEC*s*.

- There is low likelihood of adverse effects to aquatic plants.

- Emamectin benzoate is very highly toxic to water column and benthic dwelling aquatic invertebrates on a chronic exposure basis. For both freshwater (FW) and estuarine/marine (E/M) invertebrates, there were effects to reproduction and growth at low concentrations. Based on modelling, emamectin benzoate accumulates in the waterbody, but there is some uncertainty with the available data on persistence in the aquatic environment. Thus, this assessment provides upper and lower bound risk quotients (RQs) for taxa with LOC exceedances. The highest RQs were for E/M and benthic dwelling invertebrates. For E/M water column invertebrates, the RQ values range from 26-275 (considering EFED policy aquatic metabolism half-lives) and lower bound RQs (considering shorter half-lives without correction factors) are all above the LOC ranging from 5 to 56. For benthic invertebrates, the RQs range from 17-181 and 67-700 for pore water and sediment based upper bound EECs, respectively. Lower bound RQs exceed the LOC for all uses with RQs ranging from 2-33 and 10-129.

TERRESTRIAL RISK SUMMARY

Foliar Applications

- For birds, there are acute LOC exceedances that are limited to the 20-gram size class feeding on short grass (RQ=0.75), however, there is also a potential for sublethal effects at lower exposures. On a chronic exposure basis, the potential for adverse effects to birds is low. For mammals, the likelihood of effects is low for acute exposures, but there are LOC exceedances on a chronic exposure basis. For chronic risk to mammals, there are several lines of evidence to consider, including exceedances of the LOAEC and NOAEC, multiple studies with similar effects, the severity of effects, exceedances using the mean and upper bound residues, and exploration of a lower bound foliar half-life still leading to LOC exceedances.

- For terrestrial invertebrates, emamectin benzoate is classified as "very highly toxic" to the honey bee (surrogate for terrestrial invertebrates) and based on an array of screening level LOC exceedances (RQs up to 76 for foliar uses), there is a potential for adverse effects identified for terrestrial invertebrates. Additionally, without the full Tier 1 suite of studies, the impacts on larvae (acute and chronic) and adults (chronic) are a major uncertainty, but are anticipated when considering the extent of effects to aquatic invertebrates based on chronic exposure.

- There is low likelihood of adverse effects to terrestrial plants.

Tree Injections

- For birds and mammals, there were acute LOC exceedances, however, based on the narrow exceedances and uncertainties with the estimated exposures, the likelihood of adverse effects is not considered high. For chronic exposure, there were no LOC exceedances for birds, however, there is exceedance identified for mammals (RQs ranged from 5-10 when based on average leaf EEC values and RQs ranged from 15-33 for the maximum leaf EEC). The uncertainty with the available tree injection residue data is due to the timing of the application (in the fall prior to leaf drop). This assessment is using leaf residues from the application timing prior to leaf drop as an upper bound dietary item and surrogate for the other tree parts such as buds, fruit, and seeds because it is uncertain what the residues would be if the injection was made under the more likely timing of spring or summer. Overall, the potential exposure to mammals is highly uncertain and the likelihood of adverse effects from the tree injection use is relatively low.

- For terrestrial invertebrates, application timing is an important consideration for this assessment. For application scenarios in which emamectin benzoate is injected into the tree in the fall (prior to the leaf drop), there are no acute risk LOC exceedances based on the measured pollen and nectar residues from the submitted study. In contrast, the available data are not suitable for post leaf drop applications due to uncertainties related to the residues that could potentially be available for uptake into the new spring growth. Using leaf residue data as a surrogate in the modelled exposure estimates led to LOC exceedances and further refinement/using an adjustment factor resulted in RQs well above the acute risk LOC. Thus, the possibility of effects to pollinators/terrestrial invertebrates cannot be precluded under some timing intervals (based on the available data). When considering an application for the main target pest, the Emerald ash borer, the pre-leaf drop scenario may be more in-line with exposures as the optimal timing for application is considered to be late spring/early summer and post bloom. Altogether, there is low likelihood of adverse effects under the most likely use scenario, but it is noted that timing is critical for interpreting these conclusions.

Environmental Fate Summary

Based on laboratory studies, emamectin benzoate is expected to sorb rapidly and strongly to soil. Batch sorption experiments achieved maximum sorption within two hours, and K_F values for various soils ranged from 219-2037 L/kg. Similarly, soil column leaching studies demonstrate no mobility of emamectin benzoate in soil, and terrestrial field dissipation studies found no emamectin benzoate deeper than the top 6 inches of soil. Emamectin benzoate is not expected to volatilize.

Emamectin benzoate is stable in soil under dark, anaerobic conditions (half-life = 429 days). Multiple laboratory soil metabolism studies demonstrate that emamectin benzoate undergoes aerobic metabolism in soil, with half-lives ranging from 35 to 741 days. The major (MAB_{1a}) and minor (MAB_{1b}) components of emamectin benzoate were shown to produce similar half-lives under aerobic conditions (63.6 and 71.5 days, respectively). Photolysis may also influence the degradation of toxic emamectin benzoate residues in water (half-life = 26.1 d), where applicable. Emamectin benzoate is stable to hydrolysis at an environmentally relevant pH range (5.2-8), with a reported half-life of 19.5 weeks at pH 9. There is no data available for aerobic or anaerobic aquatic metabolism.

Multiple transformation products were identified from both aerobic soil metabolism and soil photolysis studies, but individual products rarely exceeded 10% of the total applied radioactivity at any time. Many of the identified transformation products were found to retain a majority of the parent structure (**Appendix E**). Four degradates in particular are anticipated to have similar toxicity to emamectin benzoate (8,9-Z isomer, AB_{1a}, MFB_{1a}, and FAB_{1a}). Though none is a major transformation product, all are included in a total toxic residues (TTR) approach when the data is available. Several studies also noted the formation of a polar fraction consisting of many, lower-molecular weight components. Unextractable radiocarbon increased over time in all aerobic soil metabolism studies, with low CO_2 output.

Emamectin benzoate is anticipated to reach surface water directly by spray drift, or indirectly sorbed to soil particles during runoff due to its affinity for soil. Once in an aquatic system, emamectin benzoate will have a propensity to bind to sediment or suspended particles, and unbound emamectin benzoate is likely to be photodegraded in shallow, clear water. Under conditions favoring low photolytic degradation, aquatic organisms are expected to be exposed to emamectin benzoate dissolved in the water column. Emamectin benzoate has low potential for bioconcentration (BCF = 69).

Ecological Effects Summary

Aquatic Organisms

Emamectin benzoate is classified as “highly toxic” to freshwater (FW) fish and “moderately toxic” to estuarine/marine (E/M) fish on an acute exposure basis. Emamectin benzoate has higher acute toxicity to aquatic invertebrates, and is classified as “very highly toxic” with EC_{50} values of 1.0 and 0.04 µg a.i./L for the waterflea (*Daphnia magna*) and mysid shrimp (*Americamysis bahia*), respectively. The available data for a mollusk (*Crassostrea virginica*) suggests lower toxicity. On a chronic exposure basis, effects to larval survival and fish growth occurred at 12 µg a.i./L (NOAEC: 6.5 µg a.i./L). Chronic toxicity data for E/M fish are not available. For aquatic invertebrates, in a waterflea life-cycle study, emamectin benzoate affects egg production, young survival, and growth with a NOAEC and LOAEC of 0.088 and 0.16 µg a.i./L, respectively. For E/M species, there was higher toxicity with a NOAEC of 0.0087 µg a.i./L based on reduced growth at concentrations of 0.013 µg a.i./L. Based on a subacute test with the benthic dwelling E/M amphipod (*Leptocheirus plumulosus)* the sediment based NOAEC is reported as 1100 µg a.i./kg and based on pore water concentrations, the NOAEC is 2.3 µg a.i./L. On a chronic exposure basis, the midge (*Chironomus dilutus)* was the most sensitive and in this study there were effects to several endpoints, including weight, emergence, time to death, and number of eggs per egg mass with NOAEC values of 2.7 µg a.i./kg and 0.013 µg a.i./L, for sediment and pore water, respectively. For aquatic plants, there are two studies available and both are non-definitive with EC_{50} values above the highest test concentration.

Terrestrial Organisms

On an acute exposure basis, emamectin benzoate is classified as "highly toxic" to birds based on an acute oral LD_{50} value of 46 mg a.i./kg-bw for the mallard duck. On a chronic exposure basis, the two-generation reproduction study with the mallard reported no effects up to the highest dose tested (40 ppm). For mammals, emamectin benzoate is classified as "highly toxic" to the mouse based on an LD_{50} value of 22 mg a.i./kg-bw. Emamectin benzoate is also toxic on a chronic basis as the two-generation reproduction rat study had a NOAEL of 0.6 mg a.i./kg-bw, based on decreased fecundity and fertility indices and clinical signs (tremors and hind limb extension) in offspring of both generations at doses as low as 1.8 mg/kg/day. For terrestrial invertebrates, emamectin benzoate is very highly toxic to bees on an acute contact basis (96-hr LD_{50}: 0.0035 µg a.i./bee) and foliar residues can remain lethal for 8-24 hours post-application based on the application rate of 0.015 lb a.i./A. New data are also available for a formulated product and the toxicity values are generally similar to the TGAI. For terrestrial plants, there were no effects in the Tier I vegetative vigor test and the seedling emergence data reflected no effects to monocots and an EC_{25}=0.232 lb a.i./A for dicots based on a reduction in dry weight (NOAEC = 0.038 lb a.i./A; tomato).

Uncertainties and Identification of Data Needs

Overall Label Uncertainties due to lack of Annual Rates- Several of the labelled uses do not indicate an annual maximum rate (lbs a.i./A) and are instead specified as the rate per crop cycle. For the brassica, leafy vegetables, and fruiting vegetables, this assessment assumed a 3-crop cycle /year scenario (detailed in **Appendix A**) to provide a representative scenario of high end estimates under a rotation scheme. This scenario was also bounded by a single crop cycle per year. For the other crops that are labeled on a crop cycle basis (cotton, tree nuts and pome fruit, and tobacco), the assumption of one crop cycle per year was used. Clarification on labels to specify rates on an annual basis would reduce the uncertainty in future assessments.

Environmental Fate

Due to the fate properties of emamectin benzoate, particularly the slow metabolism rates (soil half-life range = 35-741 days; estimated aquatic metabolism half-lives) and high sorption (average K_F = 804 L/kg), PWC model outputs suggest accumulation of emamectin benzoate in the pond. The resulting estimated environmental concentration (EEC) is therefore not a true measure of the 1-in-10 year return, since peak values for each year are dependent on the emamectin benzoate concentration from previous years. Therefore, RQs based on the model output are conservative and take into consideration up to 30 years of accumulation. For comparison, RQs were also calculated from EECs factoring in revised aquatic metabolism estimates for each highest use scenario, in order to provide a lower bound estimate for EECs (by not applying a correction factor to soil metabolism data, described below).

To date, no aerobic or anaerobic aquatic metabolism studies have been submitted. As such, there is uncertainty in the persistence of emamectin benzoate in a waterbody. Current EFED guidance is to estimate aerobic aquatic metabolism using the aerobic soil metabolism half-life (301 x 2 = 602 days). Since there is only one soil analyzed for anaerobic soil metabolism, EFED policy would require this half-life to first be multiplied by 3 (429 x 3 = 1287 days) before multiplying by 2 for the application of soil data to an aquatic system (1287 x 2 = 2574 days). Due to the uncertainty around this adjustment, anaerobic aquatic metabolism was considered stable except during characterization, when it was estimated as 429 days. During characterization, the aerobic aquatic metabolism half-life was also estimated at 301 days (equivalent to aerobic soil metabolism).

Unextracted residues were quantified in aerobic soil metabolism studies (maximum residues range from 5.7 to 36.4% applied radiocarbon), but were not included in determinations of model input values. The updated half-life of emamectin benzoate (TTR) without unextracted residues is 301 days (90^{th} percentile confidence bound on the mean of 8 half-lives). It is unclear from the submitted studies whether unextracted residues constitute sorbed parent or metabolites, and if these residues would desorb. One study extracted soil samples with solvents of differing polarity, and did not achieve more extraction of emamectin benzoate than most other studies (26% unextracted residues remaining in 12-month samples). Given the persistent half-life without including unextracted residues, and the inherently upper bound assessment due to accumulation of emamectin benzoate in the pond, the inclusion of unextracted residues would not benefit the assessment. For example, inclusion of unextracted residues in studies that had >10% unextracted residues and without a sufficient extraction procedure (multiple solvents of varying polarity), the aerobic soil metabolism half-life increases to 483 days. This half-life increased the highest use scenario EEC by 20%, which did not affect risk conclusions.

Four degradates of emamectin benzoate have been identified as residues of concern (8,9-Z isomer, AB_{1a}, MFB_{1a}, and FAB_{1a}), to be included in the calculation of half-lives with a total toxic residues (TTR) approach. Many studies, particularly the aerobic soil metabolism studies, only monitored for one or two degradates, which limits the certainty around the calculation of these half-lives. As such, inclusion of TTR changes the aerobic soil metabolism half-life from 297 days to 301 days and aqueous photolysis half-life from 19.8 days to 26.1 days. This does not change the effects outcome.

Ecological Effects

Data Gaps

Since the completion of the Problem Formulation, EPA issued guidance (U.S. EPA, et. al., 2014) on the framework to conduct risk assessments for pollinators (*e.g.*, honey bees). EPA is unable at this time to conduct a full risk assessment for pollinators (*e.g.*, honey bees) exposed to emamectin benzoate because EPA does not have a full suite of toxicity data to assess potential for effects to honey bees. Additional data needed in order to conduct a full risk assessment for pollinators include the following studies:

- Honey bee larvae acute oral study (Non-guideline / OECD TG237, Tier 1)
- Honey bee larvae chronic oral toxicity study (Non-guideline, Tier 1)
- Honey bee adult chronic oral toxicity study (Non-guideline, Tier 1)
- Semi-field testing for pollinators using TEP (Non-guideline / OECD 75, Tier 2)[1]
- Field Trial of Residues in Pollen and Nectar using TEP (Non-guideline)[1]
- Field Testing for Pollinators Using TEP (OCSPP 850.3040, Tier 3)[1]

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[1] Need for higher tier study is dependent on earlier tier study; tunnel study should use TEP; semi-field feeding study should use TGAI or TEP.

Uncertainties

Systemicity-It is unclear if Emamectin benzoate is truly systemic or better defined as locally systemic. Based on information from the registrant, *when applied to foliage, emamectin benzoate demonstrates translaminar movement only, thereby making it locally systemic in the leaf and not translocated throughout the plant. In contrast, when injected into the tree, emamectin is said to behave as if it were systemic.* At this time, the specific uncertainties are the degree that the product passes across leaf/stem/root membranes and is transported to pollen and nectar. Submission of a foliar residue study (pre and during bloom) for a bee attractive crop use would be of high value for future assessments of risk to pollinators.

Tree Injection Timing—In the current submitted study, there are some uncertainties with respect to the timing of the application as it pertains to the residues in certain wildlife food items of interest. For example, some dietary items could be subject to more concentrated exposure if the application timing were to be closer to the development of that plant part (pollen, nectar, fruit, etc.) in the growing cycle. In each case, the respective uncertainties will be discussed in the related **Risk Description** sections (See Tree Injection-Birds and Mammals and Terrestrial Invertebrates). Overall, given the uncertainties related to application timing and the potential impact on the residues, a magnitude of residue study with multiple application timings to better reflect the typical field practice would be of value for assessing pollinators and other organisms that forage on tree parts.

II. PROBLEM FORMULATION

A. Purpose of Assessment

The purpose of this assessment is to evaluate the potential adverse effects of registered uses of emamectin benzoate on non-target animals and plants. This risk assessment incorporates the available exposure and effects data and most current modeling and methodologies.

Some changes from the Problem Formulation phase include, addition of updates to half-life calculations for aerobic soil metabolism based on new guidance and models, and thus also updates the aquatic metabolism estimates. The present assessment includes a relevant half-life calculation for a soil not previously included from MRID 48480102, which shows much slower degradation of emamectin. Therefore, the overall half-life for aerobic soil metabolism has changed to 301 days (90^{th} percentile confidence bound on the mean).

Previous assessments propagated an error in residues of concern included by a total toxic residues (TTR) approach; the residue avermectin B1 monosaccharide (also misidentified as MAB instead of MSB) was previously assessed instead of 4'-deoxy-4'-epi-(N-formyl-N-methyl)amino-avermectin (MFB). This assessment corrects for this error.

Additionally, several toxicity studies have been submitted and are incorporated into the current assessment including the following: acute oral toxicity test (passerine), subchronic and chronic toxicity to benthic invertebrates, acute honey bee toxicity (formulated product), vegetative vigor and seedling emergence tests for terrestrial plants, and also a magnitude of residues from a tree injection study.

B. Nature of the Stressor

Emamectin benzoate is an active ingredient (a.i.) used as an insecticide in numerous agricultural and non-agricultural products. The end use products are formulated emulsifiable/soluble concentrate, liquid, dry flowable and ready to use/stations (0.1-5% a.i. range).

The Agency has identified four degradates of concern based on structural similarity to emamectin benzoate that are formed via aerobic soil metabolism and/or photolysis:

- 4'-deoxy-4'-epi-amino-avermectin B_1; NOA 438376; **8,9-Z MAB isomers**
- 4'-deoxy-4'-epi-amino avermectin B_{1a}; NOA 438309; **AB_{1a}**
- 4'-deoxy-4'-epi-(N-formyl-N-methyl)amino-avermectin; NOA 415692; **MFB_{1a}**
- 4'-deoxy-4'-epi-(N-formyl)amino-avermectin B_{1a}; NOA 415693; **FAB_{1a}**

Toxicity data are not available for these degradates, however, all four degradates are similar in structure to the parent. For ecological assessment, the ECOSAR tool is often used to predict toxicity based on structure. However, given the complexity of the molecule structure, the poor fit when comparing the parent predicted values vs empirical data, and the structural similarity of degradates to the parent, the ECOSAR tool was not considered reliable/useful for this assessment. Thus, this assessment is based on the assumption of equal toxicity to the parent compound which is a similar approach as used for assessing human health(U.S. EPA, 2002).[2] The structures of these transformation products and description of use in the assessment is included in **Appendix E**.

C. Mode of Action

Emamectin benzoate is an avermectin class insecticide developed for the control of lepidopteran insects, although the mode of action extends to a variety of invertebrates. This class of pesticide consists of homologous semi-synthetic macrolides that are derived from the natural fermentation products of *Streptomyces* bacteria. Emamectin benzoate causes insect mortality by interfering with nervous system and muscle function by binding to GABA and glutamate-gated chloride channels (GluCls) in the membranes of invertebrate nerve and muscle cells. The increased permeability to chloride ions, and the resulting hyperpolarization disrupts neurotransmission and leads to irreversible paralysis. It is more effective when ingested, but it also is somewhat effective on contact. When sprayed to foliage, emamectin benzoate penetrates the leaf tissue and forms a reservoir within treated leaves, which provides residual activity against foliage-feeding pests that ingest the substance when feeding. Within the avermectin class, there are also several active ingredients that are used for medical and veterinary uses (*e.g.,* treating for disease related to parasitic roundworms and heartworms in dogs).[3] Additionally, emamectin benzoate is registered in other countries for use in aquaculture to control sea lice in farmed salmon and trout.[4]

D. Pesticide Use and Usage

Emamectin benzoate is used to protect agricultural crops and ornamental plants/trees from insect damage. It is registered for use on various agricultural crops, including vegetables, fruits, nuts, cotton, and ornamentals grown outdoors in commercial nursery production. Emamectin benzoate may be applied to crops as a foliar spray using a ground sprayer, air blast sprayer, or aircraft (depending on the site/location). Multiple applications may be made and the rates are given on annual or crop cycle basis. In addition, there are tree injection uses for control of arthropod pests in deciduous, coniferous, and palm trees. The non-agricultural uses include crack and crevice/void or refillable stations in and around buildings for insect control (*e.g.,* cockroach). Indoor uses include crack and crevice or void treatments in eating establishments, processing plants, commercial/industrial buildings, etc. Outdoor uses are permitted as either crack and crevice/void treatment or via a refillable bait station around buildings, garbage holding areas, around patios and in other areas where cockroaches are harboring or foraging. For residential applications, the label generally suggests using two bait stations per side of a structure for an average sized single family home. These non-agricultural uses do not restrict the number of applications per year as the product is for use "as needed."

There are eight Section 3 end-use product labels for emamectin benzoate and there is one Section 24(c) labels for use in Puerto Rico. Label use information and registrations for emamectin benzoate are summarized in **Table 1.**

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[2]U.S. EPA. 2002. Emamectin. Conclusions of the 12/4/2001 Meeting of HED Metabolism Assessment Review Committee (MARC) Meeting on Livestock Metabolism Studies. January 28, 2002. U.S. Environmental Protection Agency, Office of Pesticide Programs, Health Effects Division. Arlington, VA.

[3] https://www.acs.org/content/acs/en/molecule-of-the-week/archive/a/avermectins-ivermectins.html

[4] http://www.msd-animal-health.no/binaries/Slice-SSP-Usage-Guidelines_tcm84-151877.pdf

Table 1. Summary of the Maximum Labeled Use Patterns for Emamectin Benzoate

Use Site	Reg. #	Form[1]	App. Target	App. Type	App. Equip.	App. Time	A.I. Max Rate / App.[2]	Max # App. / C.C.[3]	A. I. Max Rate / C.C.[2]	Max # App. / Yr.[3]	A. I. Max Rate / Yr.[2]	MRI	Comments	Drift Restrictions to Waterbodies	Poll-inator
Brassica (head and stem) vegetables; cole crops; fruiting vegetables; leafy greens	100-904; 100-903	SC/S; EC	Foliage /Plant	B	Aerial; Ground	All[4]	0.015	NS (6)	0.09	NS	NS	7 d	Aerial apps. not allowed in NY. No more than 2 sequential apps before rotating pesticide mode of action (MOA).	Buffer- Aerial=150 ft Ground=25 ft WS=2-10 mph	Yes
Field corn [for seed-no food/feed contact]	PR160002-SLN Exp. Date: 4/11/21	DF	Foliage /Plant	B	Ground	All[4]	0.015	NS	NS	NS (3)	0.045	7 d	Only for use in Puerto Rico	Buffer- Ground=25 ft WS=2-10 mph	No
Cotton	100-903	EC	Foliage /Plant	B	Aerial	All[4]	0.015	NS (4)	0.06	NS	NS	5 d	No more than 2 sequential apps before rotating MOA.	Buffer- Aerial=150 ft Ground=25 ft WS=2-10 mph	Yes
Ornamentals [Outdoor-grown plants in commercial nursery]	100-1411	SC/S	Foliage /Plant	B	Aerial; Airblast; Ground	All[4]	0.015	NS	NS	NS (6)	0.09	7 d	Aerial apps. not allowed in NY No more than 3 apps. before rotating MOA for 2 apps.	Buffer- Aerial=150 ft Ground =25 ft WS=2-10 mph	Yes
Tree nuts; pistachio; pome fruit	100-904	SC/S	Foliage /Plant	B	Airblast sprayer; Ground	All[4]	0.015	NS (3)	0.045	NS	NS	7 d	Specific REI: Do not allow workers to perform the following until 48 h after application: poling, pruning, and thinning	Buffer- Ground=25 WS=2-10 mph	Yes
Research crops [not for consumption/ for seed]	PR160002-SLN Exp. Date: 4/11/21	DF	Foliage /Plant	B	Ground	All[4]	0.015	NS	NS	NS (3)	0.045	7 d	Only for use in Puerto Rico	Buffer- Ground=25 WS=2-10 mph	No

Use Site	Reg. #	Form[1]	App. Target	App. Type	App. Equip.	App. Time	A.I. Max Rate / App.[2]	Max # App. / C.C.[3]	A. I. Max Rate / C.C.[2]	Max # App. / Yr.[3]	A. I. Max Rate / Yr.[2]	MRI	Comments	Drift Restrictions to Waterbodies	Poll-inator
Tobacco	100-903	EC	Foliage /Plant	B	Ground	All[4]	0.015	NS (3)	0.045	NS	NS	5 d	No more than two apps before rotating MOA.	Buffer-Ground=25 WS=2-10 mph	Yes
Trees [non-food]	100-130; 69117-12; 74578-10; 83100-35	EC RTU SC/L	Bark	Inject	Hand inject equip.	All[4]	0.10 lb /tree	NS	NS	NS	NS	NS	*Tree rates ranged from 0.0382-0.101 lb/tree; Some labels say not to apply when dormant	NS	Yes
Various[5]	100-1290	Bait/ solid gel	Surface	Crack and crev., void (for bait gel) Bait station -spot	Hand inject equip. or station	All[4]	0.021 [0.002 gram a.i. per sq yard]	NS	NS	NS	NS	NS	Applied as gel bait injected into crack or crevice or in station.[6]	NS	No

[1] **KEY**: Form SC/S=soluble concentrate; DF=dry flowable; EC=emulsifiable concentrate; RTU=ready to use; SC/L=soluble concentrate/liquid; App Type B=Broadcast; MOA=mode of action; Drift Reduction WS=Wind speed; Pollinator Yes= Do not apply while bees are actively foraging; MRI = minimum retreatment interval; REI= Re-entry interval

[2] All Rates in pounds a.i./A unless otherwise specified

[3] Bracketed number of applications means the value was calculated

[4] All site stages possible (*e.g.*, timing determined solely by pest pressure)

[5] Animal/Pet Areas/Quarters; Commercial; Municipal/School Bldg/Areas; Food Processing Plants/Mills/Premise; Medical/Hospital/Health/Sanitary Premises; Restaurants/Eating Establishments/Grocery/Market; Refuse/Trash/Solid Waste/ Waste Areas; Storage/Transp. Vehicles

[6] For heavy infestations, 2-4 bait points/sq. yd. of treatment area are recommended. Each bait point should be approx. 0.25 to 0.50 grams of product (in A.I.: 0.5 gram product *0.1% a.i. * 4 bait points per sq. yd=0.002 gram a.i. per sq yard). Applications are “as needed.”

Usage
According the Screening Level Usage Analysis conducted by the Biological and Economic Analysis Division (BEAD), emamectin benzoate is applied to a variety of crops and the crops with the highest percentage of acres treated (≥15% on average) include brussels sprouts, celery, and tomatoes (**Table 2**).

Table 2. Screening Level Estimates of Agricultural Uses of Emamectin Benzoate (122806)[5]

Reporting Time: 2005-2015		Average Lbs. A.I. Applied per Year	Percent Crop Treated	
Crop			Average	Maximum
1	Almonds	<500	<2.5	10
2	Apples	<500	10	20
3	Broccoli	<500	5	20
4	Brussels Sprouts*	<500	20	40
5	Cabbage	<500	10	25
6	Cauliflower	<500	5	20
7	Celery	<500	20	40
8	Chicory*	<500	5	10
9	Cotton	<500	<1	<2.5
10	Lettuce	<500	10	20
11	Pears	<500	5	20
12	Peppers	<500	5	15
13	Pistachios	<500	<2.5	<2.5
14	Spinach	<500	5	10
15	Tobacco	<500	<2.5	<2.5
16	Tomatoes	1,000	15	20
17	Walnuts	<500	<2.5	<2.5

All numbers rounded. These results reflect amalgamated data developed by the Agency and are releasable to the public.
* Based on CA DPR data only (80% or more of U.S. acres grown are in California).

E. Previous Ecological Risk Assessments and Evaluations

A number of new use risk assessments have been conducted for emamectin benzoate since the new chemical review completed in 2000 (D226628): cole crops, leafy vegetables, cotton, and tobacco

[5]Sources:
USDA-NASS (United States Department of Agriculture's National Agricultural Statistics Service)
Market Research Data (MRD); California DPR (Department of Pesticide Regulation)

(2002),[6] pome fruit (2005),[7] tree nuts and pistachios (2008),[8] a tree Injection use (2009),[9] and several Section 18 reviews.[10] The primary conclusions identified in the assessments through 2009 indicate potential risks to aquatic and terrestrial invertebrates and mammals. The principal risks that have been identified previously include risk to E/M and FW invertebrates and small herbivorous and insectivorous mammals at levels of concern (LOC) to the EPA. Potential adverse effects to E/M fish and insects have also been noted in these assessments. Chronic risk to mammals was identified in 2002 (DP279840 and 279841) and 2005 (DP309154), and quantified in 2008 (DP 345948). Finally, the results of the screening level analysis for the tree injection use was effects anticipated for birds, mammals, and terrestrial invertebrates.

The most recent assessment (DP 392494, DP 396197; 2012) was for cucurbit vegetables and ornamentals with application rates up to the current seasonal/annual maximum of 0.094 lbs a.i./year (via 0.015 lbs a.i./A applied 6 times at 7-day intervals). **Table 3** provides a summary of the RQs identified in this assessment to give a general overview of the exceedances by taxa.

Table 3. Summary of the Most Recent Ecological Risk Assessment Conducted by EFED

Taxa	Exposure Duration	Exceedance (Yes/No)	RQ Range if exceedance
Freshwater fish and Estuarine/marine (E/M) fish	Acute	No	--
	Chronic	No	--
Freshwater invertebrates	Acute	Yes	0.05 to 0.21
	Chronic	No	--
Estuarine/marine (E/M) invertebrates	Acute	Yes	0.44 to **5.3**
	Chronic	Yes	1.17 to **6.8**
Mammals	Acute	Yes	0.12-**0.58**
	Chronic	Yes	1.31-**11.4**
Birds	Acute	Yes	0.11-**0.75**
	Chronic	No	--
Terrestrial invertebrates	Acute/ Chronic	N/A	Not formally assessed; Concern High
Aquatic plants	NA	No	--
Terrestrial plants	NA	N/A	Not assessed

[6] DP barcode 279840 and 279841 (cole crops, leafy vegetables, cotton, and tobacco)
[7] DP barcode 309154, Pome fruits
[8] DP Barcode 345948 Tree nuts and pistachios
[9] DP barcode 351736 Tree Injection
[10] DP barcodes include D223875, D223876, D239671, D239672; D255357, D279840, and D279841

The 2012 assessment incorporated new aerobic soil metabolism studies (MRID 48480101, 48480102, 48480103) to calculate updated half-lives for aerobic soil metabolism (mean: 79 days) and aerobic aquatic metabolism (estimate: 158 days).

F. Conceptual Model and Risk Hypothesis

Conceptual Model

Based on the use pattern and environmental fate characteristics of this pesticide, the major transport pathways for emamectin benzoate are via spray drift, runoff, and direct deposition. Spray drift, and subsequent exposure, is greater when applied aerially, and lower when applied with a ground boom. Due to emamectin benzoate's vapor pressure (3.0×10^{-8} torr), it is unlikely that emamectin benzoate will volatilize. Likewise, its Henry's Law Constant (3.8×10^{-10} atm m^3 /mol) suggests it is not likely to volatilize from moist soil and water surfaces either. As a result, volatilization is not considered a potential route of exposure.

Exposure from the listed residues of concern (8,9-Z isomer, AB_{1a}, MFB_{1a}, FAB_{1a}) is expected via runoff following metabolism in soil, surface water where photolysis is possible, and by foliar surface dissipation or plant metabolism.

The primary exposure pathways of emamectin benzoate are via direct spray, spray drift, runoff, and consumption of treated wildlife food items. All of these routes of exposure are relevant for foliar spray applications. In addition, there is the possibility of wildlife *(e.g.,* birds, mammals, terrestrial invertebrates) being exposed from the tree injection use via consumption of contaminated tree parts. The non-agricultural gel/bait applications are made using bait stations or as crack and crevice applications with injection equipment and are considered *de Minimus* for exposure and are not assessed.

Additionally, during the Problem Formulation phase, the Screening Imbibition Program (SIP v.1.0, Released June 15, 2010)[11] was used to calculate an upper bound estimate of exposure using emamectin benzoate's solubility (93 mg/L) and the most sensitive acute and chronic avian and mammalian toxicity endpoints. Drinking water exposure alone was determined to be a potential pathway of concern for both avian and mammalian species on an acute and chronic basis. However, given that this model does not take into consideration that emamectin benzoate has high soil binding affinity, the exposure determined by this model to avian and mammalian species is highly conservative and refinements to the screen suggest that exposure to terrestrial animals via drinking water is not an exposure pathway of concern.

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[11] Detailed information about the SIP v.1.0, as well as the tool, can be found on the EPA's website at http://www.epa.gov/pesticides/science/models_pg.htm#terrestrial

Risk Hypothesis

A risk hypothesis describes the predicted relationship among the stressor, exposure, and assessment endpoint response along with the rationale for their selection. For emamectin benzoate, the following ecological risk hypothesis is being employed for this national-level ecological risk assessment:

> Emamectin benzoate*, when used in accordance with current labels, may result in contamination of ecosystems and adverse effects upon the survival, growth, and reproduction of non-target terrestrial and aquatic organisms.*

G. Measures to Evaluate Risk Hypothesis

EFED used standard models and methodology to evaluate potential exposures of emamectin benzoate to aquatic and terrestrial organisms. The Pesticide in Water Calculator (PWC version 1.52)[12] graphical user interface was used to run PRZM-VVWM (v. 1.52) (see Section III A) to produce aquatic estimated environmental concentrations (EECs). For ecological risk, the aquatic EECs were determined for parent and the degradates of concern using a total toxic residue approach. Exposure to terrestrial animals were estimated using the most current version of the Terrestrial Residue Exposure (T-REX) model (version 1.5.2) model and the BeeREX model (version 1.0). Exposure to terrestrial plants were estimated using the TerrPlant model (version 1.2.2). These models are described at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment

Aquatic and terrestrial exposure were modeled assuming the maximum single application rates and the maximum number of applications in a given year. Estimates were made for uses or groups of uses that have unique use rate patterns, such as maximum application rate, number of applications, and application intervals, as given in **Table 1**. For uses of emamectin benzoate other than the tree injections, exposure was assessed for ground applications and, as permitted per the labels, aerial applications. Ground application was assumed to be made with an airblast sprayer for tree crops and ornamentals, and by boom sprayer for other agricultural crops. Spray drift fractions for the generation of aquatic EECs were calculated using AgDRIFT (Version 2.1.1) and based on buffers defined on the label for each application type. Exposure estimates for aquatic animals and terrestrial plants were based on exposure for runoff and spray drift. Exposure estimates for terrestrial animals were based on the dietary dose obtained from consuming food items directly sprayed with emamectin benzoate. Terrestrial invertebrates are assessed using the BeeRex model and the tree injection exposure is being refined using the available magnitude of residues data for pollen and nectar. Given the high log K_{ow} (5-5.7) for emamectin benzoate, there is potential for bioaccumulation in fish and other aquatic organisms, thus, estimated exposures for piscivorous birds and mammals are assessed using the KABAM model, however, based on the low bioconcentration factor in fish (whole fish BCF= 69; MRID 43493005), further refinement steps were also taken to factor in the metabolism using the metabolism rate constant (Km).

[12]The Pesticide in Water Calculator (PWC) is an updated version of the tool previously known as the Surface Water Concentration Calculator (SWCC). The tool's name was changed to better reflect that the PWC can now simulate both surface water and groundwater. In addition, the PWC has an improved volatilization routine and more batch run capabilities. PWC version 1.52 is the latest version approved for regulatory use. It comprises a graphical user interface, a field model (PRZM version 5.02) and a waterbody model (VVWM version 1.02).

Refined Terrestrial Organism Drinking Water Screen

In this assessment, as a follow-up to the SIP model screen, a screen of the soil binding impact was assessed using an approach for estimating drinking water via puddle exposure. In this approach, pesticide concentrations in overlying water are estimated using a simple instantaneous partitioning approach (**Equation 1 below**) that is based on the Tier I rice model (USEPA, 2007b), with modifications.

Equation 1. $$C_w = \left(\frac{A_{rate}*11.2}{d_w+d_{soil}(\theta_{soil}+\rho_b*K_{oc}*f_{oc(soil)})}\right)$$

Equation 2. $$\theta_{soil} = 1 - \frac{\rho_b}{\rho_p}$$

In this equation, the pesticide concentration in the overlying water is dependent upon the pesticide application rate (A_{rate}), mean organic carbon-water partitioning coefficient of the pesticide (K_{oc}; L/kg), and the puddle depth and soil properties. A factor of 11.2 is used to convert the units of the application rate, which are lb a.i./A, to the metric units needed to generate a concentration value expressed in µg a.i./mL. Water depth (d_w) is assumed to be 1.3 cm (0.5 in). *The soil depth (d_{soil}) is set to 2.6 cm (1 inch). Default parameter values for soil properties, including bulk density (ρ_b) and fraction of organic carbon ($f_{oc(soil)}$), are based on EFED scenarios for the Pesticide Root Zone Model (PRZM). The default values of 1.5 kg/L for ρ_b and 0.015 for $f_{oc(soil)}$ represents a range of agricultural soils. Porosity (ϑ_{soil}) and bulk density are related (**Equation 2**), where ρ_p is the density of soil particles (kg/L). A typical value of 2.65 (Smettem 2006) is used for soil particle density.*

Based on Equation 1[13], the estimated drinking water concentration from puddle exposure is 1.08 X 10^{-5} mg a.i./L, thus, **exposure via drinking water is no longer considered an exposure pathway of concern.**

Measures of effect are obtained from a suite of studies conducted with surrogate species. The lowest toxicity endpoints for the most sensitive surrogate test species are used to estimate treatment-related effects on growth, reproduction and/or survival.

III. ENVIRONMENTAL CHEMISTRY, FATE AND TRANSPORT

A. Environmental Fate

Emamectin benzoate is a mixture of two homologues referred to as MAB_{1a} and MAB_{1b}. The two compounds differ by the R constituent (or side chain) at C-25 position by a methylene (CH_2) group as shown in **Figure 1**. MAB_{1a} contains a sec-butyl group while MAB_{1b} has an isopropyl group. The available chemical properties and environmental fate data are primarily on the MAB_{1a} component, and there is some uncertainty on the fate of the MAB_{1b} component. However, both components have very similar structures, therefore, their physicochemical properties, fate, and toxicity profiles are assumed to be similar.

[13] Equation 1: (0.015 lb a.i./A * 11.2)/1.3 cm+2.6 cm (0.433 kg/L+1.5 kg/L*265687 L/Kgoc*0.015 kg/L) = 1.08 X 10^{-5} mg a.i./L
Equation 2: 1 – 1.5 kg/L/2.65 kg/L= 0.567, thus, 1-0.567=0.433 for θ_{soil}

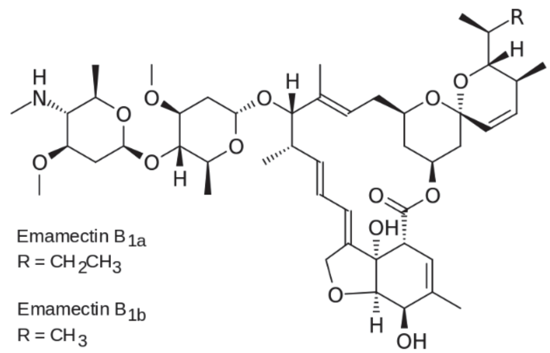

Figure 1. Chemical Structure(s) of Emamectin B_{1a} and B_{1b}

The low vapor pressure and Henry's law constant suggest that volatility of emamectin benzoate from soil and water will be low. Emamectin benzoate exists in three ionic forms, based on its dissociation constants (pK_a) at pH 4.2 and 7.6. Between pH 4.2 and 7.6, more than 50% of the methylamino groups on emamectin molecules are protonated ($R\text{-}NH_2^+$), with a peak in protonated molecules (~90%) around pH 6.7. The neutral, deprotonated methylamino group occurs in greater than 50% of molecules above pH 7.6. Within an environmentally relevant range, however, emamectin is protonated and benzoic acid is not (above pH 4.2). A summary of chemical properties for emamectin benzoate can be found in **Table 6** below.

Table 4. Fate Properties of Emamectin Benzoate

Property	Value	Reference
Molecular Weight	964.23 g/mol	New Chemical Review (D226628, 2000)
CAS Number	Emamectin: 148477-71-8 (formerly 123997-28-4); Emamectin benzoate: 155569-91-8 (formerly 137512-74-4, 179607-18-2)	New Chemical Review (D226628, 2000) http://www.alanwood.net/pesticides/derivatives/emamectin%20benzoate.html
Water Solubility (21 °C) Average MAB_{1a} and MAB_{1b}	101 mg/L (pH 5) 93 mg/L (pH 7) No peaks at pH 9 (unstable)	Product Chemistry; MRID 44883704
Vapor Pressure (25 °C)	3×10^{-8} Torr	New Chemical Review (D226628, 2000)
Henry's Law Constant (25 °C)	3.8×10^{-10} atm m^3/mol	Product Chemistry; MRID 44883705
pK_a	4.2 (benzoic acid) 7.6 (methylamino)	MRID 47002103
Log K_{ow} (pH 10.6)	5.7	MRID 44883703
Bioconcentration factor (BCF)	69 (whole fish)	MRID 43493005

The Agency has identified four degradates of concern based on structural similarity to emamectin benzoate that are formed via aerobic soil metabolism and/or photolysis:

- 4'-deoxy-4'-epi-amino-avermectin B_1; NOA 438376; **8,9-Z MAB isomer**

- 4'-deoxy-4'-epi-amino avermectin B_{1a}; NOA 438309; **AB_{1a}**
- 4'-deoxy-4'-epi-(N-formyl-N-methyl)amino-avermectin; NOA 415692; **MFB_{1a}**
- 4'-deoxy-4'-epi-(N-formyl)amino-avermectin B_{1a}; NOA 415693; **FAB_{1a}**

These transformation products are included in the risk assessment and are assumed to be of equal toxicity to the parent compound (U.S. EPA, 2002).[14] The structures of these transformation products and description of use in the assessment is included in **Appendix E**. The total toxic residues (TTR) approach is used for determining the environmental fate data parameters for modeling using the *Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides*, Version 2.1, October 22, 2009 and the draft Guidance for Modeling Pesticides Total Toxic Residues May 20, 2009. Half-lives for TTR are calculated by summing the residues of the parent compound and the degradates of concern (in terms of percent of the applied radiation) for each sampling interval, when the data are available. **Given the data available for emamectin benzoate, this TTR approach only affects aerobic soil metabolism half-lives (and subsequently the aerobic aquatic metabolism half-life), the aqueous photolysis half-life, and half-lives from the terrestrial field dissipation study. All other half-lives are for parent emamectin benzoate only.**

Aerobic Soil Metabolism. Emamectin benzoate has been observed to undergo aerobic transformation in soil, with a broad range of half-lives between soils and conditions. Updated half-life calculations are included in **Table 5**, along with information on each soil type for which the half-life was determined. These half-lives include degradates of concern when that data are available. The residues included in each half-life are also listed in **Table 5**. Half-lives for emamectin benzoate in soil range from 35-741 days; the half-life value used in model simulations is 301 days. This is the 90th percentile confidence bound on the mean of all aerobic soil metabolism half-lives, temperature corrected to 25 °C.[15,16]

The transformation rate of emamectin benzoate in soil appears to be influenced by soil moisture content (MRID 48480103). Emamectin benzoate applied to soil samples maintained and extracted under the same conditions was transformed more rapidly in samples with 40% maximum water capacity (MWC) than those at 20% MWC, with half-lives of 82.4 and 148 d, respectively.

The major (MAB_{1a}) and minor (MAB_{1b}) components of emamectin benzoate were shown to behave similarly when applied separately to an Arizona sandy loam soil (MRID 48480101). The half-lives of these components were 63.6 d and 71.5 d, respectively.

Several transformation products were identified following aerobic soil metabolism. However, most products accounted for <10% of the total applied radiocarbon (MRIDs 48480102, 48480103). There is little overlap in products identified between each aerobic soil metabolism study, and many products

[14]U.S. EPA. 2002. Emamectin. Conclusions of the 12/4/2001 Meeting of HED Metabolism Assessment Review Committee (MARC) Meeting on Livestock Metabolism Studies. January 28, 2002. U.S. Environmental Protection Agency, Office of Pesticide Programs, Health Effects Division. Arlington, VA.

[15] U.S. EPA. 2010. Guidance for Making Temperature Adjustments to Metabolism Inputs to EXAMS and PE5. October 11, 2010. U.S. Environmental Protection Agency, Office of Pesticide Programs, Environmental Fate and Effects Division. Arlington, VA.

[16] U.S. EPA. 2009. Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1 October 22, 2009. U.S. Environmental Protection Agency, Office of Pesticide Programs, Environmental Fate and Effects Division. Arlington, VA. https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-selecting-input-parameters-modeling (Accessed June 21, 2017)

remained unidentified. Several studies also reported observing a polar fraction consisting of many components of low molecular weight compared to emamectin benzoate (MRIDs 43404303, 43850116); however, this fraction was not well characterized. Confirmed products observed from aerobic soil metabolism include:

- 4'-deoxy-4'-epi-amino avermectin B_{1a}; NOA 438309; **AB_{1a}**
- 4'-deoxy-4'-epi-(N-formyl-N-methyl)amino-avermectin; NOA 415692; **MFB_{1a}**
- 5-O-demethyl-4"-deoxy-4"-(methylamino)-28-hydroxy-(4"R)-avermectin A_{1a}; NOA 438306; **8αOH-MAB_{1a}**
- 5-O-demethyl-4"-deoxy-4"-(methylamino)-28-oxo-(4"R)-avermectin A_{1a}; NOA 438307; **8αoxo-MAB_{1a}**
- 4'O-de(2,6-dideoxy-3-O-methyl-alpha-L-arabino-hexopyranosyl)-5-O-demethyl-avermectin A_{1a}; NOA 419150; **MSB_{1a}**
- 22,23-didehydro-5-O-demethyl-28-deoxy-6,28-epoxy-13-hydroxy-25(1-methylpropyl)-[6R,13S,25R(S)]-milbemycin B; NOA 419153; **MSB_{1a}-aglycone**
- **N-nitroso-MAB_{1a}**; NOA 459720

These products retain much of the parent structure of emamectin benzoate. The previously identified residues of concern which are included with parent emamectin benzoate in fate modeling (TTR) for aerobic soil metabolism are AB_{1a} and MFB_{1a} where the data is available (**Table 5**; Comments). **FAB_{1a} and the 8,9-Z MAB_{1a} isomer were not reported in these studies.**

The generation of volatiles increases over time in all studies (MRIDs 43404303, 48480101, 48480102, 48480103). Most of the captured volatiles was CO_2, and organic volatiles were consistently negligible or non-detectable when they were monitored. Between studies, the percent of applied radiocarbon present as CO_2 varied but always remained <10% through 120 days. One study (MRID 43404303), which monitored volatiles over a 12-month period, reached 16.3% of radiocarbon as CO_2 by the end of the experiment, with no plateau of CO_2 evolution. This suggests that complete mineralization of emamectin benzoate, while increasing over time, is occurring very slowly.

The amount of unextracted residue in soil increased over time for all studies (MRIDs 43404303, 48480101, 48480102, 48480103). While the percentage of unextracted radiocarbon varied between studies, this can be partially attributed to differences in extraction procedures and efficiencies. However, all samples had <30% unextracted radiocarbon, with the exception of one time-point with an average of 33.6% (MRID 48480102; 18 Acres soil, Day 90). Upon further analysis of the unextracted residues by organic matter fractionation, studies concluded that emamectin benzoate had been transformed substantially (*e.g.*, not representing parent emamectin benzoate) and incorporated into organic matter (MRIDs 43850115, 48480103).

Anaerobic Soil Metabolism. The transformation of emamectin benzoate in a Kentucky sandy loam soil was found to decrease when conditions were changed from aerobic to anaerobic (MRID 43850116). Several broad findings are similar to those in the aerobic soil metabolism studies. Extracted radiocarbon decreases over time, though appears to remain relatively constant once the system becomes anaerobic. Additionally, CO_2 production increases over the course of the study (though final amount is only ≤4% of total radiocarbon). The degradate 8αOH-MAB_{1a} was identified in this study at low percentages of the dosed radiocarbon, as well as the polar fraction observed in aerobic soil metabolism studies (up to 13% radiocarbon as a group). Due to the fact that only three time points were analyzed for anaerobic sample conditions (days 30, 59, 90), it is difficult to make definitive conclusions on the effect of anaerobic conditions on emamectin benzoate in soil. However, it is likely that these transformations occurred during the aerobic initiation phase, and did not result from the anaerobic incubation. The half-life for emamectin benzoate under anaerobic metabolism after anaerobic conditions were introduced is 429 days.

Soil Photolysis. The dark control-corrected single first order half-life for emamectin benzoate in the irradiated samples was 16.5 days (MRID 43404302). Samples were dosed with emamectin benzoate at 64X the maximum allowed field application rate. Within the 30-day study period, the percentage of dosed radiocarbon extracted as parent emamectin benzoate decreased from an average 99.1% to 2.5% for irradiated samples, and from 99.1% to 8.5% in dark controls. Given that there is negligible difference between degradation in the dark control and irradiated samples, soil photolysis is not expected to be a route of dissipation for emamectin benzoate.

Several transformation products were identified in both irradiated and dark control samples, though no product represented more than 5% of the applied radioactivity and are not included in the calculated half-life. These products include MSB_{1a}, FAB_{1a}, MFB_{1a} 8αoxo-MAB_{1a}, 8αOH-MAB_{1a}, AB_{1a}, and 8,9-Z MAB_{1a}.

Leaching and Sorption/Desorption. Emamectin benzoate is found to sorb to soil rapidly and completely (MRID 42851526). The minimum mixing time for emamectin benzoate with a sandy loam in batch samples with 10 mM $CaCl_2$ was 2 hours, after which >99% of emamectin benzoate remained sorbed to soil through the 22-hour experiment. Batch sorption studies were thus conducted with a 5-hour equilibration time using four soil types: sandy loam (pH 6.6, 1.26% OM, 65% sand, 11% clay), sand (pH 6.5, 0.05% OM, 100% sand), clay loam (pH 6.2, 4.52% OM, 31% sand, 40% clay), and silt loam (pH 6.4, 1.79% OM, 19% sand, 16% clay). Samples contained 1 g soil with 5 mL emamectin benzoate solution, with solution concentrations ranging from 2 to 130 µg/L. Over 99% of all applied doses of emamectin benzoate was sorbed. Desorption of the soils with the working solution released a negligible amount of emamectin benzoate, whereas organic extraction (ammonia saturated ethyl acetate followed by methanol with 100 mM ammonium acetate) recovered a substantial portion. The remainder of the radioactivity was recovered by soil combustion. The average K_F for emamectin benzoate is 804 L/kg (CV 91%) for the four soils (average 1/n=0.9). Sorption did not correlate with soil properties such as organic matter content, cation exchange capacity, clay content, or pH. The pH range of the soils in the study is narrow (pH 6.2-6.6), and represents a soil pH at which emamectin is predominantly protonated (until pH 7.6). As such, this pH range likely represents sorption by both hydrophobic partitioning and specific (ionic) interactions, and highly basic soils may shift to predominantly partitioning sorption mechanisms.

Aqueous Photolysis. Photolysis of total toxic emamectin benzoate residues (MAB_{1a} + 8,9-Z isomer) was observed in both buffered water and natural water systems (MRID 43850114). Samples were exposed to natural sunlight (40°N) for 30 days in the autumn. The temperature varied around 25 °C, with temperature extremes ranging from ~8 to 32 °C. The buffered water samples were maintained at pH 7, while the natural water dropped from pH 8.9 to 7.6 by the end of the study. Aqueous samples were extracted with ethyl acetate for characterization of extracted residues. Several transformation products were formed in both systems, including 8αOH-MAB_{1a} and the 8,9-Z MAB_{1a} isomer as identified in other studies. Additionally, a fraction containing many components of much greater polarity than emamectin benzoate was observed but not further characterized. Evidence of other components with similar polarity to emamectin benzoate was observed, though these components were not identified. The only transformation product that was quantified alongside emamectin benzoate for each time point was the 8,9-Z MAB_{1a} isomer. The calculated half-lives for emamectin benzoate and the 8,9-Z MAB_{1a} isomer in buffered and natural waters were 26.1 and 7.07 days. Similarly, another study (MRID 43404301) suggested that emamectin benzoate is more likely subject to indirect photolysis (*e.g.*, through radicals and photosensitizers) than direct photolysis.

Terrestrial Field Dissipation. Emamectin benzoate residue dissipation in the field was investigated at three study sites (CA, AZ, and NY) where various relevant crops are grown (MRIDs 43404304, 43404305, 43404306, 43850118). The soils of each site were classified as sandy loam, and the pH of the top 12 inches varied by site: 6.1 (CA), 7.0 (NY), and 8.1 (AZ). Irrigation at each site was determined based on that site's specific crop cycles, and was regulated such that total water on the field (irrigation and precipitation) was at least 110% of the typical monthly evapotranspiration for those crops. The CA site included tomato rotated with cotton and lettuce, while the AZ and NY sites were primarily lettuce and cabbage, respectively. Six applications of emamectin benzoate were applied to bare soil by broadcast sprayer at a rate of 0.015 lb a.i./acre, with 6-8 days in between applications.

Soils were sampled ~24-26 times throughout emamectin benzoate application and over the following 1.5 years. Most samples were taken from the top 6 in of soil, with multiple sampling dates including analysis of deeper soil cores. All samples were analyzed for emamectin benzoate and the 8,9-Z MAB_{1a} isomer, and values reported are combined for these two residues. However, neither residue was detected in any sample below 6 in. For samples taken from the top soil layer after the final application, the residues have non-linear dissipation. Loss of the residues is rapid in the first few days following application, followed by a gradual decline. Calculated half-lives for CA, AZ, and NY sites are 67.9, 3.4, and 25 days, respectively (**Table 5**).

Hydrolysis. Emamectin benzoate is stable to hydrolysis between pH 5 and 8 (MRID 42743642). The half-life for hydrolysis at pH 9 is 19.5 weeks.

Tree Injection. A single application of emamectin benzoate to white ash and bing cherry trees by trunk injection results in detectable concentrations of emamectin benzoate in leaves within two weeks of injection (MRID 49927401). The highest concentration of emamectin benzoate in leaves was measured after injection and before leaf-fall; the maximum concentration was 9599 µg/kg (likely wet weight) in white ash and 45,194 µg/kg in bing cherry. Concentrations of emamectin benzoate were substantially lower but relatively stable in new leaf growth for the next two years, and concentrations of the 8,9-Z isomer seem to increase over time, particularly for ash trees. Variability in the data precludes calculation of a dissipation half-life. Other residues of concern (AB_{1a}, MFB_{1a}, FAB_{1a}) were not monitored. Residues of emamectin benzoate were detected in cherry flowers (both years), cherry pollen (first year), cherry nectar (second year), cherry fruit, cherry buds (both years), cherry seed, ash flowers (both years), ash pollen (both years), and ash buds (both years). The 8,9-Z isomer was also detected in cherry flowers (first year), cherry buds (first year), and ash flowers (first year). Emamectin benzoate was also consistently detected in soil samples up to 12" depth around the treated trees. The 8,9-Z isomer was infrequently detected in soils.

Accumulation in Fish. Very low bioaccumulation potential is found for bluegill sunfish (MRID 43393005). After 28 days of exposure, the bioconcentration factor (BCF) for edible tissues, nonedible tissues, and whole fish were 31, 98, and 69, respectively. Depuration for 14 days resulted in 92% of radioactivity eliminated from edible tissues, 89% from nonedible tissues, and 90% for the whole fish. The primary residues detected in both tissues of the fish were parent emamectin benzoate and AB_{1a}. Emamectin benzoate accounted for 54% of radiocarbon in edible tissues and 53% in nonedible tissues. AB_{1a} accounted for only 12% of radiocarbon in edible tissues and 9% in nonedible tissues.

Table 5. Environmental Fate Parameters of Total Toxic Emamectin Benzoate Residues

Study/ Guideline	System Characteristics	Kinetic Model Fitted Value and Unit (TTR)		TTR Half-life for Model Input (days)[1]	Equation	Source/ Classification	Comments	Parent-only Half-life if different (days)[1]
		DT_{50} (days)	DT_{90} (days)					
PERSISTENCE IN SOIL								
Aerobic Soil Metabolism 835.4100	25 °C, 1.17% OC, pH 6.6, sandy loam	90.5	2460	**741**	IORE	MRID 43404303 Supplemental	MAB_{1a} only, 12-month study	--
	25 °C, 0.5% OM, pH 8.3, sandy loam	63.6	211	**63.6**	SFO	MRID 48480101 Supplemental	MAB_{1a} only, 100-day study	--
	20 °C, 4.8% OM, pH 5.8	29.9	256	**110** *(77.8)*	DFOP	MRID 48480102 Supplemental	18 Acres soil; MAB_{1a} and AB_{1a}, 120-day study	**106** *(75, DFOP)*
	20 °C, 5.4% OM, pH 7.4, silt loam	22.3	116	**35** *(24.7)*	IORE		Gartenacker soil; MAB_{1a} and AB_{1a}, 120-day study	**34.9** *(24.7, IORE)*
	20 °C, 1.8% OM, pH 8.1	425	1412	**425** *(301)*	SFO		Marsillargues soil; MAB_{1a} and AB_{1a}, 120-day study	**414** *(293, SFO)*
	20 °C, 2.7% OC, pH 7.08 (KCl), silt loam	31.1	219	**82.4** *(58.3)*	DFOP	MRID 48480103 Supplemental	Gartenacker soil; 40% MWC low rate; MAB_{1a} and MFB_{1a}, 119-day study	**79.6** *(56.3, DFOP)*
		109	453	**148** *(105)*	DFOP		Gartenacker soil; 20% MWC low rate; MAB_{1a} and MFB_{1a}, 119-day study	**145** *(103, DFOP)*
		23.8	222	**97** *(68.6)*	DFOP		Gartenacker soil; 40% MWC high rate; MAB_{1a} and MFB_{1a}, 119-day study	**67.9** *(48, IORE)*
Anaerobic Soil Metabolism 835.4200	25°C, 1.37% OC, pH 7, sandy loam	429	1426	**429**[2]	SFO	MRID 43850116	MAB_{1a} only, 60-day study	--
Soil Photolysis 835.2410	Irradiated	16.5	--	**16.5**	SFO	MRID 43404302	Dark control corrected[3]	--
Terrestrial Field Dissipation[4] 835.6100	California	0.214	225	**67.9**	IORE	MRID 43850118	MAB_{1a} and 8,9-Z MAB isomer	--
	Arizona	0.622	8.41	**3.39**	DFOP		MAB_{1a} and 8,9-Z MAB isomer	--
	New York	0.596	50.3	**25**	DFOP		MAB_{1a} and 8,9-Z MAB isomer	--

Study/ Guideline	System Characteristics	Kinetic Model Fitted Value and Unit (TTR)		TTR Half-life for Model Input (days)[1]	Equation	Source/ Classification	Comments	Parent-only Half-life if different (days)[1]
		DT_{50} (days)	DT_{90} (days)					
PERSISTENCE IN WATER								
Aerobic Aquatic Metabolism 835.4300	--	--	--	--	--	No study submitted		--
Anaerobic Aquatic Metabolism 835.4400	--	--	--	--	--	No study submitted		--
Hydrolysis 835.2010	pH 5.2, 6.2, 7.2, and 8	--	--	Stable	--	MRID 42743642	No change in concentration over 6 wk	--
	pH 9	--	--	**19.5 weeks**	SFO		Based on 6 wk study	--
Aqueous Photolysis 835.2240	Buffered water, pH 7	26.1	86.7	**26.1**	SFO	MRID 43850114	MAB_{1a} and 8,9-Z MAB isomer	**19.8** *(SFO)*
	Natural water	7.07	23.5	**7.07**	SFO		MAB_{1a} and 8,9-Z MAB isomer	**5.16** *(SFO)*

[1]Values in parentheses are temperature corrected to 25 °C. If no values are listed in the parent-only column, then the TTR half-life is already only including parent emamectin benzoate (no transformation products).
[2]Calculated based on values when samples were converted to anaerobic (*e.g.*, not cumulative of aerobic and anaerobic cycles)
[3]Irradiated rate constant was subtracted from dark control rate constant and back-converted to half-life
[4] Half-lives calculated for terrestrial field dissipation studies are based on measured concentrations following the last application to the field. Combined residues are reported in MRID 43850118.

B. Model Input Parameters

The EECs in surface water were estimated with the Pesticide Water Calculator (Version 1.52). The model simulation uses 30 years of meteorological data (1961-1990), which allows for estimation of a 1-in-10 year probability of exceedance. PWC simulates pesticide transport from a 10 Ha field to an adjacent 1 Ha pond (2 m depth) via runoff, erosion, and spray drift. Spray drift fractions were calculated in AgDRIFT (Version 2.1.1) using buffers defined in the use table (**Table 1**).

The input parameters for the model were derived from data provided in registrant-submitted studies and based on label uses and current guidelines (**Table 6**). The half-lives for aerobic soil metabolism and aqueous photolysis studies were re-calculated in PestDF in order to more adequately fit the data (*e.g.*, biphasic degradation) and include total toxic residues (listed in **Table 5**). Additionally, models were run using K_F values, given that there is no substantial correlation between soil organic matter content and sorption to support the use of K_{FOC}. **Table 7** lists the modeled PWC scenarios and applications for each registered use of emamectin benzoate, with the exception of the gel baits and tree injection applications. Aquatic exposure to emamectin benzoate or its residues by tree injection is not expected; however, terrestrial exposure will be explored separately. Additionally, due to the nature of the gel bait applications which are registered to be used sparingly outdoors, risk from exposure to emamectin benzoate is considered de minimis for this use, and will not be modeled.

The application scenarios in **Table 7** were selected to capture the exposure potential due to differing application methods and PWC scenarios, while accounting for maximum application rates, minimum re-treatment intervals, label-specified pesticide rotations, and label-specified buffers. The crop cycle scenario is further detailed in **Appendix D**, and includes 16 applications of emamectin benzoate based on the number of applications that could be applied for each crop with an adequate pre-harvest interval. Relative application dates of 20 days from emergence were used since the application date is flexible depending on pest pressures, with the exception of cole crops in the three crop cycle scenario which were assumed to be a transplant (**Appendix D**).

Table 6. PWC Input Parameters for Total Toxic Emamectin Benzoate Residues

Parameter	Value	Source/ Classification	Comments
Soil-water distribution coefficient	K_F = 804 L/kg	MRID 42851526 (average)	
Aerobic Soil Metabolism	301 days[1]	MRID 43404303; 48480101; 48480102; 48480103	90^{th} percentile confidence bound on the mean of 8 values
Aerobic Aquatic Metabolism	602 days	No submitted study	Estimated from aerobic soil metabolism (301x2)
Anaerobic Aquatic Metabolism	0	No submitted study	Estimated from anaerobic soil metabolism (429x2x3=2574 days); considered stable
Hydrolysis	0	MRID 42743642	Stable from pH 5.2-8
Aqueous Photolysis	26.1 days	MRID 43850114	
[1]This value is calculated with a total residues approach. Considering parent-only, the half-life would be 297 days. Inpute parameter guidance can be found at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-selecting-input-parameters-modeling			

Table 7. PWC Model Emamectin Benzoate Application Inputs

Use	Application Type	PWC Scenarios	Application Timing (DSE[1])	Application Rate (lbs a.i./A)
Brassica vegetables; cole crops; leafy greens *(3 crop cycles)*[2]	Aerial[3]	CAlettuceSTD CAColeCropRLF_V2 FLcabbageSTD	0, 7, 21, 28, 42, 117, 124, 138, 145, 159, 166, 202, 209, 223, 230, 244	0.015
	Ground[4]			
Fruiting vegetables; brassica vegetables; cole crops; leafy greens *(1 crop cycle)*	Aerial	CAtomato_WirrigSTD FLpeppersSTD FLtomatoSTD_V2 PAtomatoSTD PAvegetableNMC STXvegetableNMC	20, 27, 41, 48, 62, 69	0.015
	Ground			

Use	Application Type	PWC Scenarios	Application Timing (DSE[1])	Application Rate (lbs a.i./A)
Corn, field; grown for seed only *(Puerto Rico)*	Ground	PRcoffeeSTD FLsweetcornOP	20, 27, 34	0.015
Cotton, unspecified	Aerial	CAcotton_WirrigSTD MScottonSTD NCcottonSTD STXcottonNMC TXcottonOP	20, 25, 35, 40	0.015
Ornamental	Aerial	TNnurserySTD_V2 ORnurserySTD_V2 NJnurserySTD_V2 MInurserySTD_V2 FLnurserySTD_V2 CAnurserySTD_V2 NurseryBSS_V2	20, 27, 34, 55, 62, 69	0.015
	Airblast[5]			
Tree nuts; pistachio; pome fruit	Airblast	CAalmond_WirrigSTD CAfruit_WirrigSTD GAPecansSTD NCappleSTD ORappleSTD ORfilbertsSTD PAappleSTD_V2 OrchardBSS WAorchardsNMC	20, 27, 34	0.015
Research crops, grown for seed only *(Puerto Rico)*	Ground	PRcoffeeSTD	20, 27, 34	0.015
Tobacco	Ground	NCtobaccoSTD	20, 25, 35	0.015

[1]Days since emergence. Includes label-specified pesticide rotation where applicable.
[2]Calculation of application dates for a three-crop cycle is outlined in Appendix D.
[3]Application efficiency=0.95; Spray drift=0.0385 (AgDRIFT: ASAE Fine to Medium, 150 ft buffer, EPA-Defined Pond)
[4]Application efficiency=0.99; Spray drift=0.0267 (AgDRIFT: High Boom, ASAE Very Fine to Fine, 90th percentile, 25 ft buffer, EPA-Defined Pond)
[5]Application efficiency=0.99; Spray drift=0.015 (AgDRIFT: Sparse (Young, Dormant), 25 ft buffer, EPA-Defined Pond)

IV. ECOLOGICAL EFFECTS CHARACTERIZATION

A. Aquatic Organisms

Acute

On an acute exposure basis, emamectin benzoate is classified as "highly toxic" to freshwater (FW) fish (rainbow trout, 96-hr LC_{50}: 174 µg a.i./L; MRID 42851529) and "moderately toxic" to estuarine/marine (E/M) fish (sheepshead minnow, 96-hr LC_{50}: 1430 µg a.i./L; MRID 43393003). In general, all of the submitted fish studies have comparable toxicities. A new study was requested for a warm water species because there were some issues with the previous tests conducted [*e.g.,* in the fathead minnow study suspended particulates were not removed (via filtration or centrifugation) prior to extraction and chemical analysis, and in the bluegill study, the test material concentrations fluctuated excessively]. The newly submitted study for the fathead minnow resulted in an LC_{50}: 640 µg a.i./L (MRID 49227401), confirming that emamectin benzoate is highly toxic to FW fish.

For aquatic invertebrates, emamectin benzoate is classified as "very highly toxic" with EC_{50} values of 1.0 and 0.04 µg a.i./L for the waterflea and mysid, respectively (MRIDs 42743603 and 43393001). The Eastern oyster was less sensitive with an EC_{50} value of 490 µg a.i./L (MRID 43393002).

Chronic

On a chronic exposure basis, a freshwater fish early life-stage test with the fathead minnow suggests that emamectin benzoate affects larvae survival and fish growth at 12 µg a.i./L (NOAEC: 6.5 µg a.i./L; MRID 43850107). A chronic toxicity study for an E/M fish has not been submitted; therefore, the chronic toxicity of emamectin benzoate for E/M fish was estimated using an acute-to-chronic ratio (ACR). This ACR was updated from the previous assessment because data are now available for the same species (*i.e.,* fathead minnow: 96-hr LC_{50} of 640 µg/L/NOAEC of 6.5 µg a.i./L* LC_{50} of 1430 µg a.i./L sheepshead minnow / X, chronic estimate for E/M fish x=14.5 µg/L). Application of this ACR derived for fathead minnows assumes that the ACR is conserved across fish species. If the ACR in E/M fish is higher or lower than the ACR derived for fathead minnows, then toxicity could be under- or over-estimated, respectively.

For aquatic invertebrates, in a waterflea life-cycle study, emamectin benzoate affects egg production, young survival, and growth at concentrations between 0.088 and 0.16 µg a.i./L (NOAEC: 0.088 µg a.i./L; MRID 43393004). Two supplemental E/M invertebrate (mysid shrimp) life-cycle toxicity tests using the TGAI were submitted (MRID 44305601, 45833001). In one study (MRID 45833001) a NOAEC of 0.0087 µg a.i./L was reported based on reduced growth at concentrations of 0.013 µg a.i./L. However, in this study, emamectin benzoate concentrations were considerably lower after Day 14, thus, had the exposure concentrations been maintained at a constant level during the entire 28-day study duration, effects may have occurred at or below the identified NOAEC. In this case, the 28-day mean concentration will be used to calculate risk quotients and the mean emamectin benzoate concentration achieved during the latter part of the study (*i.e.,* 0.0049 µg a.i./L at the mean measured NOAEC of 0.0087 µg a.i./L) is considered a lower bound NOAEC for characterization.

In addition to the water column invertebrates, data are also available for benthic invertebrates. Data are available from a subacute 10-Day Toxicity Test with the estuarine/marine amphipod (*Leptocheirus plumulosus;* MRID 49756901) and based on the sediment concentrations, the NOAEC is reported as 1100 µg a.i./kg and based on pore water concentrations, the NOAEC is 2.3 µg a.i./L. Two studies are available for assessing chronic risk to benthic invertebrates. In a 42-day life cycle toxicity test with the freshwater amphipod (*Hyalella azteca*), there were no effects reported (pore water NOAEC: 0.12 µg a.i./L; Sediment NOAEC: 32 µg a.i./kg; MRID 49599101). The second chronic test was a life cycle test with the midge (*Chironomus dilutus),* and in this study*,* the midge demonstrates a greater sensitivity as there were effects to several endpoints, including weight, emergence, time to death, and number of eggs per egg mass with NOAEC values of 2.7 µg a.i./kg and 0.013 µg a.i./L, for sediment and pore water, respectively (MRID 49599102).

Aquatic plants

Two aquatic plant studies were submitted. One study was submitted for non-vascular plant species [freshwater algae (*Selenastrum capricornutum*), 5-day EC_{50}>3.9 µg a.i./L; MRID 43850108] and one study was submitted for vascular plant species [duckweed (*Lemna gibba*), 14-day EC_{50}>94 µg a.i./L; MRID 43850109]. In these studies, the EC_{50} values are greater than the highest concentration tested, although there was a noted 13% reduction in algal growth at the highest concentration tested in the freshwater algae study. In both studies, the endpoints are based on initial measured test concentrations and there is noted uncertainty due to a lack of filtration/centrifuging prior to analysis. While uncertainties exist about the true exposure throughout the test period, these studies are considered acceptable as long as the EECs are not in excess of the highest test concentrations. **Table 8**. provides a summary of the most sensitive acute and chronic toxicity endpoints for aquatic organisms.

Table 8. Summary of the Most Sensitive Measures of Effects for Aquatic Organisms

Assessment Endpoint	Measures of Effect	Species	Toxicity Value*	Endpoint	Reference
Freshwater fish: Survival and reproduction of individuals and communities	Freshwater fish 96-hr acute LC_{50}	Rainbow trout *(Oncorhynchus mykiss)*	LC_{50}: 174 µg a.i./L NOAEC: 30 µg a.i./L Slope:7	Lethality NOAEC based on: 20% mortality at 49 µg a.i./L	MRID 42851529 Acceptable *Highly toxic*†
	Freshwater fish early life-stage NOAEC	Fathead Minnow (*Pimephales promelas)*	NOAEC: 6.5 µg a.i./L LOAEC: 12 µg a.i./L	NOAEC based on: 74% reduction in larvae survival 9% reduction in total length 27% reduction in wet wt. 26% reduction in dry wt. 21% reduction in biomass	MRID 43850107 Acceptable
Freshwater invertebrates: Survival and reproduction of individuals and communities	Freshwater invertebrate acute 48-h EC_{50} Flow-through	Waterflea[2] *(Daphnia magna)*	EC_{50}: 1.0 µg a.i./L NOAEC: 0.3 µg a.i./L	Immobilization 10% immobilization occurred at 0.47µg a.i./L	MRID 42743603 Acceptable *Very highly toxic*†
	Freshwater invertebrate life cycle NOAEC Flow-through	Waterflea *(Daphnia magna)*	NOAEC: 0.088 µg a.i./L LOAEC: 0.16 µg a.i./L	NOAEC based on: 27% reduction in young per female, 86 % in young survival 48% reduction in dry weight	MRID 43393004 Acceptable

Estuarine and marine fish: Survival and reproduction of individuals and communities	Estuarine and marine acute LC_{50} 96-h	Sheepshead minnow (*Cyprinodon variegatus*)	LC_{50}: 1430 µg a.i./L NOAEC: 860 µg a.i./L Slope: 7.9	Lethality NOAEC based on 60% mortality at the 1430 µg a.i./L	MRID 43393003 Acceptable *Moderately toxic*†
	Estuarine and marine fish early life-stage NOAEC	No data	NOAEC: 14.5 µg a.i./L	No specific endpoint	Acute to Chronic Ratio[1]
Estuarine and marine invertebrates: Survival and reproduction of individuals and communities	Estuarine and marine invertebrate acute EC_{50} 96-h Flow-through	Eastern oyster *(Crassostrea virginica)*	EC_{50}: 490 µg a.i./L Slope: 4.7	--	MRID 43393002 Acceptable *Highly toxic*†
		Mysid *(Americamysis bahia)*	LC_{50}: 0.04 µg a.i./L NOAEC: 0.018 µg a.i./L Slope:8.1	Lethality NOAEC based on 10% mortality at 0.026 µg a.i./L	MRID 43393001 Acceptable *Very highly toxic*†
	Estuarine and marine invertebrate life cycle NOAEC Flow-through	Mysid[4] *(Americamysis bahia)*	NOAEC: 0.0087 µg a.i./L LOAEC: 0.013 µg a.i./L	NOAEC based on 11% reduction in body weight. NOAEC for survival = 0.013 µg/L based on a 81% reduction	MRID 45833001 Supplemental[3]
Benthic Invertebrates	Sub-chronic 10-Day Toxicity Test - Estuarine Amphipod NOAEC Static	*Leptocheirus plumulosus*	TWA Bulk Sediment LC_{50}: 2950 µg a.i./kg NOAEC: 1100 µg a.i./kg LOAEC: 2000 µg a.i./kg OC Normalized Sediment NOAEC: 33 mg a.i./kg OC LOAEC: 61 mg a.i./kg OC Pore Water LC_{50}: 5.76 µg a.i./L NOAEC: 2.3 µg a.i./L LOAEC: 4.0 µg a.i./L	Survival	MRID 49756901 Acceptable

	<u>Chronic</u> Life-Cycle Toxicity Test NOAEC Static-Renewal Conditions	Midge (*Chironomus dilutus*	<u>TWA Bulk Sediment</u> NOAEC: 2.7 µg a.i./kg LOAEC: 5.0 µg a.i./kg <u>OC-Normalized Sediment</u> NOAEC: 0.095 µg a.i./g OC LOAEC: 0.18 µg a.i./g OC <u>Pore Water</u> NOAEC: 0.013 µg a.i./L LOAEC: 0.039 µg a.i./L	NOAEC based on 8% reduction in female emergence Effects to body weight, male emergence, and eggs/mass observed in study	MRID 49599102 Supplemental QUAN
<u>Aquatic plants</u>: Standing crop or biomass and growth	<u>Non-vascular</u> Freshwater green algae, cyanobacteria or diatom EC_{50} 5-day	Freshwater green algae *Selenastrum capricornutum* Static	EC_{50} > 3.9 µg a.i./L NOAEC ≥ 3.9 µg a.i./L •*Values based on initial measured test concentrations*	Cell density A 13% reduction in algal growth was observed at 3.9 µg a.i./L.	MRID 43850108 Acceptable
	<u>Vascular</u> Freshwater EC_{50} 14-day	Duckweed *Lemna gibba* Static	EC_{50} >94 µg a.i./L NOAEC ≥ 94 µg a.i./L •*Values based on initial measured test concentrations*	Frond biomass	MRID 43850109 Acceptable

[1] No chronic toxicity data available for estuarine/marine fish; therefore, chronic toxicity values estimated via acute to chronic ratio [fathead minnow: 96-hr LC_{50} of 640 µg/L/NOAEC of 6.5 µg a.i./L* LC_{50} of 1430 µg a.i./L sheepshead minnow / X, chronic estimate for SW fish x=14.5 µg/L]

[2]An additional acute waterflea study was submitted (MRID 44007901) with an EC_{50} >728 µg a.i./L, presumably on a degradate of emamectin benzoate (see May 8, 1998 memo: D226628, D227718, D228127, D231325, D238388).

[3] Highly erratic test concentrations were observed throughout the study. Measurements were made of dissolved and sorbed material; thus, true dissolved concentrations and toxicity parameters may be lower than reported. Test concentrations decreased over time; as a result, mean-concentrations from days 1 to 14 and from days 15 to 28 were used to bracket the NOAECs. The 28-day mean measured NOAEC is reported. Also, as a result, had the exposure concentrations been maintained at a constant level during the entire 28-day study duration, effects may have occurred at or below the identified NOAEC.

[4] An additional chronic mysid study was submitted (MRID 44305601) with a NOAEC = 0.018 µg a.i./L (LOAEC of 0.028 µg a.i./L) also on the TGAI. Adult survival and length were adversely affected. However, the test concentrations varied considerably over the duration of the study and the study was also classified supplemental.

[†] Based on EC_{50} (mg/L): < 0.1 very highly toxic; 0.1-1 highly toxic; >1-10 moderately toxic; >10-100 slightly toxic; >100 practically nontoxic.

B. Terrestrial Organisms

Birds

On an acute exposure basis, emamectin benzoate is classified as "highly toxic" to birds based on an acute oral LD_{50} value of 46 mg a.i./kg-bw for the mallard duck (MRID 42743601). In this test, there was also reduced bodyweight gain, and long lasting clinical signs of neurotoxicity were observed at all tested concentrations. The newly submitted acute oral study with a passerine species is not acceptable for quantitative use due to issues with regurgitation and the age of the test organisms; however, the study does suggest that the current endpoint for the mallard represents the most sensitive bird tested. On a subacute dietary exposure basis, the 8-day test indicated "moderate toxicity" to the mallard based on the LC_{50} of 570 mg a.i./kg-diet (MRID 42851528). However, in this test the NOAEC was reported to be 20 mg a.i./kg-diet based on the clinical signs of neurotoxicity observed at >20 mg a.i./kg-diet. On a chronic exposure basis, the two-generation reproduction study with the mallard duck reported no effects up to the highest dose tested (the study report noted occasional findings such as leg tremors and lameness but the occurrences were typically associated with incidental injuries), thus the NOAEC of 40 mg a.i./kg-diet is based on the highest test concentration (MRID 44007910). The three submitted studies for the Northern bobwhite quail (MRID 42868905, 42851527, and 44007911) all suggest less sensitivity than the mallard.

Mammals
On an acute exposure basis, emamectin benzoate is classified as “highly toxic” to the mouse based on an LD_{50} value of 22 mg a.i./kg-bw and additional toxic signs including tremors, ataxia (*i.e.*, loss of muscle coordination), bradypnea (*i.e.*, abnormally slow breathing rate), and loss of the righting reflex (MRID 42743612). For chronic exposure, the two-generation reproduction rat study had a NOAEL: 0.6 mg a.i./kg-bw, based on decreased fecundity and fertility indices and clinical signs (tremors and hind limb extension) in offspring of both generations at doses as low as 1.8 mg/kg/day (MRID 42851511). It is noted from the literature that several populations of mammals lacking adequate P-glycoprotein (P-gp) expression including CF-1 mice, a small population of humans, and collie dogs are considered highly sensitive to the neurological effects of emamectin benzoate (Lankas *et al.* 1997, Habashi 2006, Kerb 2005). P-gp resides in the plasma membrane and actively transports foreign substances from within the cell out for excretion outside the body (Marzolini *et al.*, 2004); without its activity, a buildup of foreign chemicals could occur in the brain, gonads, and fetus. It is uncertain which additional populations of mammals are particularly sensitive to emamectin due to inadequate expression of P-gp. Altogether, the chronic mammalian endpoint for reproductive effects is a sensitive endpoint in this assessment.

Terrestrial invertebrates
Emamectin benzoate (TGAI) is very highly toxic to bees on an acute contact basis (96-hr LD_{50}: 0.0035 µg a.i./bee; MRID 42851530) and foliar residues can remain lethal for 8-24 hours post-application (MRID 43393006, based on a spray application rate of 0.015 lb a.i./A). New data are also available for a formulated product and the toxicity values are generally similar to the TGAI (oral LD_{50}: 0.0063 µg a.i./bee; contact LC_{50}: 0.0028 µg a.i./bee; MRID 48257501). In the contact portion of the study, mortality and apathy/immobility were reported at all treatment levels, thus, resulting in a NOAEC of <: 0.0025 µg a.i./bee.

Terrestrial plants
Data were recently submitted for terrestrial plants. Based on the vegetative vigor study, there were no effects in the Tier I test, thus the EC_{25} was not determined and the resulting NOEC is 0.27 lb a.i./A (MRID 49227403). Based on the seedling emergence data, there were no effects to monocots (NOEC: 0.30 lb a.i./A) and for dicots, based on a reduction in dry weight for the tomato, the EC_{25}=0.232 lb a.i./A (NOAEC=0.038 lb a.i./A; MRID 49227402). **Table 9**. provides a summary of the most sensitive acute and chronic toxicity endpoints for terrestrial organisms.

Table 9. Summary of the Most Sensitive Measures of Effects for Terrestrial Organisms

Assessment Endpoint	Measures of Effect	Species	Toxicity Value	Endpoint	Reference / Study classification
Birds: Abundance (*i.e.*, survival, reproduction, and growth) of individuals and populations	Avian acute oral LD_{50} 14-days	Mallard duck *(Anas platyrhynchos)*	LD_{50}: 46 mg a.i./kg-bw NOAEC:<12 mg a.i./kg-bw[1]	Lethality Reduced bw gain and clinical signs of neurotoxicity were observed at all tested concentrations.	MRID 42743601 Acceptable *Highly toxic*[†]
	Avian sub-acute dietary LC_{50} 8-days	Mallard duck *(Anas platyrhynchos)*	LC_{50}: 570 mg a.i./kg-diet NOAEC: 20 mg a.i./kg-diet/LOAEC: 40 mg a.i./kg-diet	Lethality Clinical signs of neurotoxicity were observed at >20 mg a.i./kg-diet	MRID 42851528 Acceptable *Moderately toxic*[Δ]
	Avian reproduction NOAEL 2-generation	Mallard duck *(Anas platyrhynchos)*	NOAEC: 40 mg a.i./kg-diet LOAEC>40 mg a.i./kg-diet	No adverse effects observed at doses tested	MRID 44007910 Acceptable (if EECS <40 mg.a.i./kg diet)[2]
Mammals: Abundance (*i.e.*, survival, reproduction, and growth) of individuals and populations	Mammalian acute oral LD_{50}	Laboratory mouse *(Mus musculus)*	♂ LD_{50}: 22 mg a.i./kg-bw ♀ LD_{50}: 31 mg a.i./kg	Lethality	MRID 42743612 Acceptable *Highly toxic*[†]
	Mammalian Inhalation LC_{50}	Rat	♂LC_{50} > 1.049 mg/L 0.239<♀LC_{50} <0.506 mg/L (for technical, 96.2%a.i.)	Mortality Salivation, reduced stability, hunched posture, shaking.	MRID 47002107 Acceptable *Toxicity Category II*
Mammals (Chronic)	Mammalian reproductive NOAEL; 2-generation	Sprague-Dawley Rat *(Rattus norvegicus)*	NOAEL: 0.6 mg/kg-bw/day LOAEL=1.8 mg/kg/day	Based on decreased fecundity and fertility indices and clinical signs (tremors and hind limb extension) in offspring of both generations.	MRID 42851511 Acceptable
Insect: Survival of populations	Honey bee acute contact LD_{50} 96-hour	Honey bee *(Apis mellifera)*	LD_{50} 3.5 ng a.i./bee (0.0035 µg a.i. /bee) NOAEC = 0.8 ng a.i./bee (0.0008 µg a.i. /bee)	Lethality	MRID 42851530 Acceptable *Highly toxic*[§]
	Honey bee acute oral LD_{50} 96-hour (FORM-SG)		LD_{50} 6.3 ng a.i./bee (0.0063 µg a.i. /bee) NOAEC = 3.9 ng a.i./bee (0.0039 µg a.i./bee)	Lethality	*Highly toxic*[§]
	Honey bee acute contact LD_{50} 96-hour (FORM-SG)		LD_{50} 2.8 ng a.i./bee (0.0028 µg a.i. /bee) NOAEC = <2.5ng a.i./bee (0.0025 µg a.i./bee)	Lethality	*Highly toxic*[§]

	Residues on foliage 24-hour		Sprayed at 0.015 lbs a.i./A remain lethal to honeybees for 8 to 24 hrs post-application At 3-hr, 99.6% died; At 8-hr, 46.1% died; At 24-hr, 2.5% died	Lethality	MRID 43393006 Acceptable
Terrestrial Plants	Seedling Emergence		**<u>Monocot:</u>** Most sensitive, could not be determined due to lack of toxicity. EC_{25}/IC_{25}: >0.30 lb a.i./A NOEC: 0.30 lb a.i./A **<u>Dicot:</u>** Most sensitive- tomato EC_{25}/IC_{25}: 0.232 lb a.i./A NOEC: 0.038 lb a.i./A	Monocot: No Effects Dicot: NOAEC based on a 25% reduction in dry weight	MRID 49227402 Acceptable
	Vegetative Vigor Test		**Most sensitive monocot:** Could not be determined; Tier I NOEC: 0.27 lb a.i./A for all monocot species and endpoints; <0.27 lb a.i./A for corn. **Most sensitive dicot:** Could not be determined; Tier I NOEC: 0.27 lb a.i./A for all dicot species and endpoints.	Monocots: No Effects Dicots: No Effects	MRID 49227403 Acceptable

[1] Reduced body weight and clinical signs of neurotoxicity was observed at all dosages. The NOAEC for mortality was 12 mg a.i./kg-bw

[2] This study is classified as core (acceptable) for EECS < 40 ppm and if EECs > 40 ppm, classified as supplemental.

[†] Acute Oral (avian/mammal): Based on LD_{50} (mg/kg) <10 very highly toxic; 10-50 highly toxic; 51-500 moderately toxic; 501-2000 slightly toxic; >2000 practically nontoxic

[Δ] Acute Dietary (avian): Based on LC_{50} (mg/kg) <50 very highly toxic; 50-500 highly toxic; 501-1000 moderately toxic; 1001-5000 slightly toxic; >5000 practically nontoxic

[§] Based on acute contact LD_{50} (µg a.i./bee) <2 highly toxic; 2-10.99 moderately toxic; ≥11 practically non-toxic

III. RISK ESTIMATION

A. Estimated Exposures to Aquatic Animals and Plants

In this assessment, RQs were calculated with EECs that represent the total concentration of parent (emamectin benzoate) and the four degradates of concern (8,9-Z MAB isomer, AB, FAB, and MFB) using a total toxic residues (TTR) approach. For comparison, EECs representing parent-only (not TTR) are included in **Appendix G**. Since application timing for labeled uses is based on pest pressure, the PWC inputs were based on days from emergence instead of absolute dates for most applications.

Aquatic exposures will be characterized using three groups of EECs: 1-in-10 year values following EFED guidance on calculating aquatic metabolism half-lives (upper bound), 1-in-10 year values considering an anaerobic aquatic metabolism half-life of 429 days and an aerobic aquatic metabolism half-life of 301 days (lower bound), and values characterizing exposure after only two total applications (single year).

A summary of upper bound aquatic EECs for each crop group used to calculate acute and chronic RQs for animals and plants are given in **Table 10**. These values are 1-in-10 year values obtained from PWC (v. 1.52) when considering aquatic metabolism half-lives based on EFED policy. Acute RQs are calculated using daily average EECs, and chronic RQs are calculated using 21-day and 60-day EECs for aquatic invertebrates and fish, respectively. Toxicity endpoints used in acute and chronic RQ calculations were summarized previously in **Table 8**.

Table 10. Tier II Surface Water Estimated Environmental Concentrations (EECs) for Registered Uses of Emamectin Benzoate (EFED guidance EECs)

Use	App. Type	PWC Scenario	Water Column EEC (µg/L)			Pore Water EEC (µg/L)		Sediment EEC (µg/kg)	
			Average	21-day	60-day	Peak	21-day	Peak	21-day
Brassica vegetables; cole crops; leafy greens *(3 crop cycles)*	Aerial	CAlettuceSTD	2.44	2.39	2.35	2.37	2.35	1905	1889
		CAColeCropRLF_V2	1.64	1.56	1.55	1.55	1.55	1246	1246
		FLcabbageSTD	1.60	1.48	1.46	1.46	1.46	1174	1174
	Ground	CAlettuceSTD	2.39	2.33	2.29	2.32	2.29	1865	1841
		CAColeCropRLF_V2	1.55	1.47	1.46	1.46	1.46	1174	1174
		FLcabbageSTD	1.52	1.40	1.38	1.38	1.38	1110	1110
Fruiting vegetables; brassica vegetables; cole crops; leafy greens *(1 crop cycle)*	Aerial	CAtomato_WirrigSTD	0.218	0.199	0.197	0.193	0.193	155	155
		FLpeppersSTD	0.729	0.681	0.678	0.675	0.675	543	543
		FLtomatoSTD_V2	0.829	0.782	0.774	0.772	0.771	621	620
		PAtomatoSTD	1.42	1.33	1.32	1.32	1.32	1061	1061
		PAvegetableNMC	1.81	1.60	1.58	1.58	1.58	1270	1270
		STXvegetableNMC	0.995	0.912	0.910	0.907	0.907	729	729
	Ground	CAtomato_WirrigSTD	0.163	0.150	0.148	0.146	0.146	117	117
		FLpeppersSTD	0.707	0.655	0.653	0.651	0.651	523	523
		FLtomatoSTD_V2	0.809	0.762	0.754	0.752	0.752	605	605
		PAtomatoSTD	1.42	1.32	1.32	1.32	1.32	1061	1061
		PAvegetableNMC	1.83	1.61	1.59	1.59	1.59	1278	1278
		STXvegetableNMC	0.985	0.900	0.895	0.892	0.892	717	717
Corn, field; for seed only *(Puerto Rico)*	Ground	PRcoffeeSTD	0.704	0.641	0.630	0.621	0.621	499	499
		FLsweetcornOP	0.358	0.333	0.330	0.329	0.328	265	264
Cotton, unspecified	Aerial	CAcotton_WirrigSTD	0.213	0.195	0.190	0.188	0.188	151	151
		MScottonSTD	1.19	1.09	1.08	1.08	1.07	868	860
		NCcottonSTD	1.30	1.19	1.18	1.17	1.17	941	941

Use	App. Type	PWC Scenario	Water Column EEC (µg/L)			Pore Water EEC (µg/L)		Sediment EEC (µg/kg)	
			Average	21-day	60-day	Peak	21-day	Peak	21-day
		STXcottonNMC	0.796	0.716	0.708	0.707	0.706	568	568
		TXcottonOP	1.04	0.970	0.943	0.931	0.931	749	749
Ornamental	Aerial	CAnurserySTD_V2	0.891	0.847	0.843	0.838	0.838	674	674
		FLnurserySTD_V2	0.708	0.666	0.662	0.662	0.661	532	531
		MInurserySTD_V2	0.648	0.589	0.587	0.586	0.586	471	471
		NJnurserySTD_V2	0.902	0.822	0.818	0.818	0.818	658	658
		NurseryBSS_V2	0.411	0.388	0.384	0.382	0.382	307	307
		ORnurserySTD_V2	0.293	0.276	0.272	0.269	0.269	216	216
		TNnurserySTD_V2	0.862	0.828	0.824	0.824	0.823	662	662
	Airblast	CAnurserySTD_V2	0.850	0.773	0.770	0.769	0.768	618	617
		FLnurserySTD_V2	0.666	0.598	0.593	0.593	0.593	477	477
		MInurserySTD_V2	0.570	0.503	0.500	0.499	0.499	401	401
		NJnurserySTD_V2	0.835	0.748	0.745	0.744	0.744	598	598
		NurseryBSS_V2	0.332	0.302	0.297	0.297	0.297	239	239
		ORnurserySTD_V2	0.186	0.173	0.172	0.172	0.172	138	138
		TNnurserySTD_V2	0.789	0.758	0.754	0.753	0.753	605	605
Tree nuts; pistachio; pome fruit	Airblast	CAalmond_WirrigSTD	0.100	0.0910	0.0892	0.0891	0.0891	72	72
		CAfruit_WirrigSTD	0.052	0.0443	0.0424	0.0415	0.0415	33	33
		GAPecansSTD	0.512	0.453	0.446	0.446	0.446	359	359
		NCappleSTD	0.469	0.390	0.378	0.376	0.376	302	302
		ORappleSTD	0.157	0.145	0.143	0.143	0.142	115	114
		ORfilbertsSTD	0.153	0.143	0.141	0.140	0.140	113	113
		PAappleSTD_V2	0.476	0.423	0.418	0.417	0.417	335	335
		OrchardBSS	0.343	0.304	0.298	0.296	0.296	238	238
		WAorchardsNMC	0.0491	0.0426	0.0406	0.0396	0.0396	32	32
Research crops, for seed only *(Puerto Rico)*	Ground	PRcoffeeSTD	0.704	0.641	0.630	0.621	0.621	499	499
Tobacco	Ground	NCtobaccoSTD	0.252	0.227	0.224	0.224	0.224	180	180

Due to the fate properties of emamectin benzoate, PWC model outputs suggest accumulation of emamectin benzoate in the pond (**Figure 2**). The resulting EEC is therefore not a true measure of the 1-in-10 year return, since peak values for each year are dependent on the emamectin benzoate concentration from previous years. Therefore, RQs based on the model output (**Table 10**) are conservative and take into consideration up to 30 years of accumulation. The reasons for this type of accumulation for emamectin benzoate relate to its chemical properties – notably, its high sorption to sediment and slow degradation. Of particular importance is the lack of aquatic metabolism data (aerobic or anaerobic), which adds uncertainty to the modeling. In the absence of aquatic metabolism data, EFED policy is to use twice the half-life of corresponding soil metabolism data, which has been done for aerobic aquatic metabolism (301 days x 2 = 602 days). However, the calculated half-life for aerobic soil metabolism was based on 8 different half-lives, while only one anaerobic soil metabolism study (with one soil) has been submitted, with a half-life of 429 days. EFED policy would also require a 3x factor be applied to soil metabolism studies with only one soil. This would mean that the anaerobic aquatic half-life would be 2574 days (429 days x 3 x 2), with very low confidence in the value. In order to provide a more reasonable bounding for the persistence of emamectin benzoate in the modeled farm pond, an aerobic aquatic metabolism half-life of 301 days (aerobic soil metabolism half-life) and anaerobic aquatic metabolism half-life of 429 days (anaerobic soil metabolism half-life of a single soil) was also modeled (**Table 11**; **Figure 3**). Lastly, in order to characterize the lowest bounding, EECs were also calculated based on only two applications of the maximum rate and minimum retreatment interval made aerially in a single year with the CALettuceSTD PWC scenario (**Table 12**).This scenario is considering the typical number of applications as supported by usage data and is only reflective of a single year of applications over a 30-year simulation (no accumulation from multiple years of applications), thus, is provided for characterization only.

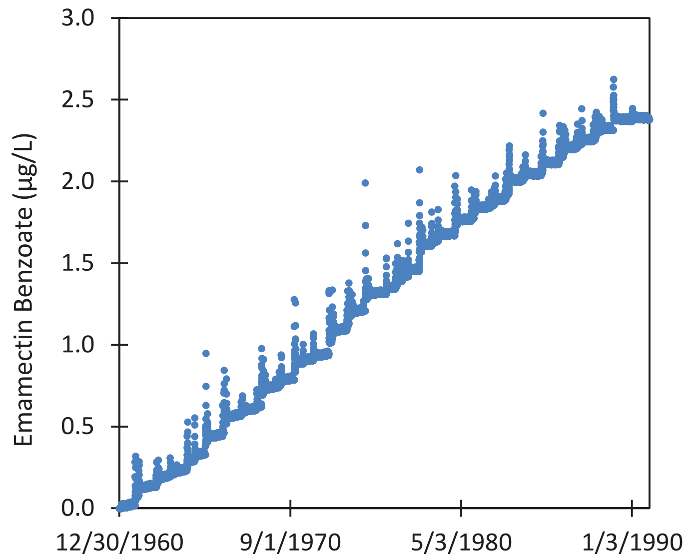

Figure 2. Daily average (upper bound) concentrations for aerial applications of emamectin benzoate in three crop cycles over 30 years of application (PWC scenario: CALettuceSTD; EFED guidance EECs).

Table 11. Tier II Surface Water Estimated Environmental Concentrations (EECs) for Registered Uses of Emamectin Benzoate (lower bound half-lives for aquatic metabolism)

Use	App. Type	Water Column EEC (µg/L)		Pore Water EEC (µg/L)		Sediment EEC (µg/kg)	
		Average	21-day	Peak	21-day	Peak	21-day
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	0.803	0.485	0.441	0.434	355	349
	Ground	0.819	0.483	0.436	0.429	351	345
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	0.552	0.313	0.254	0.252	204	203
	Ground	0.558	0.316	0.256	0.255	206	205
Field Corn	Ground	0.201	0.0838	0.0637	0.0634	51	51

Cotton	Aerial	0.429	0.163	0.121	0.12	97	96
Ornamentals	Aerial	0.324	0.145	0.122	0.121	98	97
	Airblast	0.327	0.141	0.116	0.116	93	93
Tree nuts; pistachio; pome fruit	Airblast	0.192	0.0714	0.0568	0.0562	46	45
Research crops	Ground	0.201	0.0838	0.0637	0.0634	51	51
Tobacco	Ground	0.0800	0.0395	0.0327	0.0324	26	26

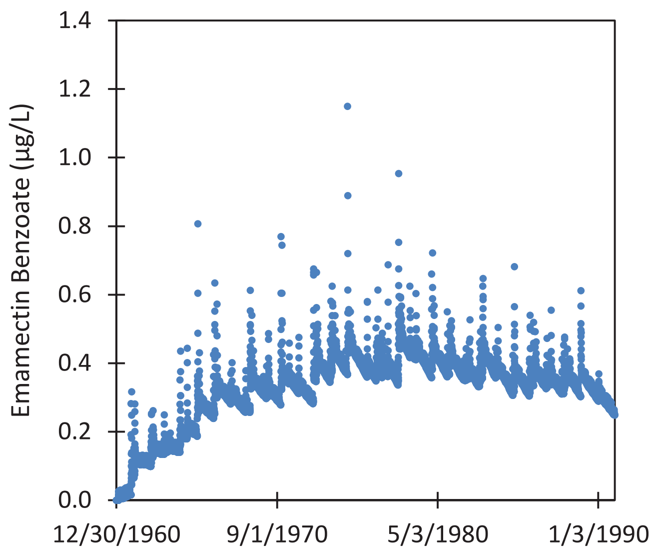

Figure 3. Daily average (lower bound) concentrations for aerial applications of emamectin benzoate in three crop cycles over 30 years of application (PWC scenario: CALettuceSTD; lower bound aquatic half-lives).

Table 12. Tier II Surface Water Estimated Environmental Concentrations (EECs) for Only Two Applications of Emamectin Benzoate (EFED guidance EECs/Single Year)

PWC Scenario	App. Type	Water Column EEC (µg/L)		Pore Water EEC (µg/L)		Sediment EEC (µg/kg)	
		Average	21-day	Peak	21-day	Peak	21-day
CALettuceSTD	Aerial	0.0263	0.0177	0.0174	0.0174	14	14

Monitoring Data

Few sites monitored for emamectin benzoate in water. The only database which reported data for emamectin benzoate is USEPA STORET, which monitored for emamectin benzoate in water at several stations in Arizona. No detectable levels of emamectin benzoate were reported in those data, or in the following databases: USGS Water Quality Portal (https://www.waterqualitydata.us/); the California Department of Pesticide Regulation (http://cdpr.ca.gov/docs/emon/surfwtr/surfcont.htm); the USGS/EPA pilot reservoir monitoring program.

B. Risk Estimation for Aquatic Organisms

To estimate risk to non-target organisms, the Risk Quotient (RQ value) is compared to the respective LOC (for aquatic organisms the LOC is 0.5 and 1.0 for acute and chronic risk, respectively, and 0.05 for listed species).

Fish (aquatic phase amphibians)
For all uses of emamectin benzoate, there are no LOC exceedances for fish (surrogate for aquatic phase amphibians) for acute or chronic exposures. It is noted that the EECs provided in **Table 10** account for the potential of accumulation that may occur if emamectin benzoate is applied over multiple years. However, with no LOC exceedances under this higher exposure scenario, further analysis is not provided for fish (see aquatic invertebrates for more details on the impact of accumulation). **Table 13** provides an overview of the maximum modeled exposure from each use, toxicity, and resulting Risk Quotients (RQ values).

Table 13. Risk Quotients for Fish and Aquatic Phase Amphibians (EFED guidance EECs)

Use	App. Type	Water Column EEC (µg/L)		FW Fish RQs		E/M Fish RQs	
		Average	60-day	Acute Toxicity (174 µg/L)	Chronic Toxicity (6.5 µg/L)	Acute Toxicity (1430 µg/L)	Chronic Toxicity (14.5 µg/L)
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	2.44	2.35	0.014	0.362	0.002	0.162
	Ground	2.39	2.29	0.014	0.352	0.002	0.158
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	1.81	1.58	0.010	0.243	0.001	0.109
	Ground	1.83	1.59	0.011	0.245	0.001	0.110
Field Corn	Ground	0.704	0.630	0.004	0.097	<0.001	0.043
Cotton	Aerial	1.30	1.18	0.007	0.182	0.001	0.081
Ornamentals	Aerial	0.902	0.818	0.005	0.126	0.001	0.056
	Airblast	0.850	0.770	0.005	0.118	0.001	0.053
Tree nuts; pistachio; pome fruit	Airblast	0.512	0.446	0.003	0.069	<0.001	0.031
Research crops	Ground	0.704	0.630	0.004	0.097	<0.001	0.043
Tobacco	Ground	0.252	0.224	0.001	0.034	<0.001	0.015

Aquatic Invertebrates (water column)
Because emamectin benzoate has the potential to accumulate in the receiving water body, EECs were calculated to consider the accumulation over time (**Table 14**) that could occur in addition to the lower

bound EECs (**Table 15**) which include a value of 301 days for the aerobic aquatic half-life and a value of 429 days for the anaerobic aquatic half-life. For E/M water column invertebrates, the acute and chronic LOC is exceeded in both scenarios for nearly all of the uses (with chronic RQs up to 275 and 56 for the upper and lower bound scenarios, respectively). Further characterization of the accumulation and impact is discussed in the **Risk Description Section.**

Table 14. Risk Quotients for Aquatic Invertebrates (EFED guidance EECs)

Use	App. Type	Water Column EEC (µg/L)		FW Invertebrate RQs		E/M Invertebrate RQs	
		Average	21-day	Acute Toxicity (1.0 µg/L)	Chronic Toxicity (0.088 µg/L)	Acute Toxicity (0.04 µg/L)	Chronic Toxicity (0.0087 µg/L)
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	2.44	2.39	**2.4**	**27**	**61**	**275**
	Ground	2.39	2.33	**2.4**	**26**	**60**	**268**
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	1.81	1.60	**1.8**	**18**	**45**	**184**
	Ground	1.83	1.61	**1.8**	**18**	**46**	**185**
Field Corn	Ground	0.704	0.641	**0.7**	**7**	**18**	**74**
Cotton	Aerial	1.30	1.19	**1.3**	**14**	**33**	**137**
Ornamentals	Aerial	0.902	0.822	**0.9**	**9**	**23**	**94**
	Airblast	0.850	0.773	**0.9**	**9**	**21**	**89**
Tree nuts; pistachio; pome fruit	Airblast	0.512	0.453	**0.5**	**5**	**13**	**52**
Research crops	Ground	0.704	0.641	**0.7**	**7**	**18**	**74**
Tobacco	Ground	0.252	0.227	**0.3**	**3**	**6**	**26**
Shading indicates acute or chronic LOC exceedance. BOLD indicates Endangered species LOC exceedance							

Table 15. Risk Quotients for Aquatic Invertebrates (lower bound EECs)

Use	App. Type	Water Column EEC (µg/L)		FW Invertebrate RQs		E/M Invertebrate RQs	
		Average	21-day	Acute Toxicity (1.0 µg/L)	Chronic Toxicity (0.088 µg/L)	Acute Toxicity (0.04 µg/L)	Chronic Toxicity (0.0087 µg/L)
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	0.803	0.485	**0.8**	**5.5**	**20**	**56**
	Ground	0.819	0.483	**0.8**	**5.5**	**20**	**56**
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	0.552	0.313	**0.6**	**3.6**	**14**	**36**
	Ground	0.558	0.316	**0.6**	**3.6**	**14**	**36**
Field Corn	Ground	0.201	0.0838	**0.2**	**1.0**	**5**	**10**
Cotton	Aerial	0.429	0.163	**0.4**	**1.9**	**11**	**19**
Ornamentals	Aerial	0.324	0.145	**0.3**	**1.6**	**8**	**17**
	Airblast	0.327	0.141	**0.3**	**1.6**	**8**	**16**
Tree nuts; pistachio; pome fruit	Airblast	0.192	0.0714	**0.2**	**0.8**	**5**	**8**
Research crops	Ground	0.201	0.0838	**0.2**	**1.0**	**5**	**10**
Tobacco	Ground	0.08	0.0395	**0.1**	**0.4**	**2**	**5**
Shading indicates acute or chronic LOC exceedance. BOLD indicates Endangered species LOC exceedance.							

Benthic Invertebrates

For benthic invertebrates, the toxicity is presented in terms of both the exposure through pore water and sediment, thus, RQs are paired with pore water EECs and also the sediment EECS (µg a.i./kg) (**Table 16**). The sediment EECs are in terms of dry weight and are not organic carbon normalized because the organic carbon did not explain the partitioning of the chemical better than the dry sediment. While the subchronic exposure resulted in lower toxicity, the subchronic toxicity is based on an E/M species (*Leptocheirus plumulosus*) and the chronic data are from a FW species (*Chironomus dilutus*). To gauge the general sensitivity of the benthic invertebrates in light of the different exposure routes (pore water; sediment), when comparing the chronic toxicity (acute duration is not comparable), the measured toxicity for the benthic invertebrate in pore water is generally close to the chronic mysid toxicity value from a water column exposure study so this may be an indication that the pore water is the most relevant medium for assessing exposure. Either way, there are exceedances both ways (pore water and sediment).

Table 16. Risk Quotients for Benthic Dwelling Aquatic Invertebrates (EFED guidance EECs)

Use	App. Type	Pore Water EEC (µg/L)		Sediment EEC (µg/L)		Benthic Invertebrate RQ (Pore water)		Benthic Invertebrate RQ (Sediment EEC)	
		Peak	21-day	Peak	21-day	Sub-chronic Toxicity (2.3 µg/L)	Chronic Toxicity (0.013 µg/L)	Sub-chronic Toxicity (1100 µg a.i./kg-dw)	Chronic Toxicity (2.7 µg a.i./kg-dw)
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	2.37	2.35	1905	1889	**1.02**	**181**	**1.7**	**700**
	Ground	2.32	2.29	1865	1841	**1.00**	**176**	**1.7**	**682**
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	1.58	1.58	1270	1270	0.69	**122**	**1.2**	**470**
	Ground	1.59	1.59	1278	1278	0.69	**122**	**1.2**	**473**
Field Corn	Ground	0.621	0.621	499	499	0.27	**48**	0.5	**185**
Cotton	Aerial	1.17	1.17	941	941	0.51	**90**	0.9	**349**
Ornamentals	Aerial	0.818	0.818	658	658	0.36	**63**	0.6	**244**
	Airblast	0.769	0.768	618	617	0.33	**59**	0.6	**229**
Tree nuts; pistachio; pome fruit	Airblast	0.446	0.446	359	359	0.19	**34**	0.3	**133**
Research crops	Ground	0.621	0.621	499	499	0.27	**48**	0.5	**185**
Tobacco	Ground	0.224	0.224	180	180	0.10	**17**	0.2	**67**

Table 17. Risk Quotients for Benthic Dwelling Aquatic Invertebrates (lower bound EECs)

Use	App. Type	Pore Water EEC (µg/L)		Sediment EEC (µg/kg)		Benthic Invertebrate RQ (Pore water)		Benthic Invertebrate RQ (Sediment EEC)	
		Peak	21-day	Peak	21-day	Sub-chronic Toxicity (2.3 µg/L)	Chronic Toxicity (0.013 µg/L)	Sub-chronic Toxicity (1100 µg a.i./kg-dw)	Chronic Toxicity (2.7 µg a.i./kg-dw)
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	0.441	0.434	355	349	0.19	**33**	0.32	**129**
	Ground	0.436	0.429	351	345	0.19	**33**	0.31	**128**
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	0.254	0.252	204	203	0.11	**19**	0.18	**75**
	Ground	0.256	0.255	206	205	0.11	**20**	0.19	**76**
Field Corn	Ground	0.0637	0.0634	51	51	0.03	**5**	0.05	**19**
Cotton	Aerial	0.121	0.120	97	96	0.05	**9**	0.09	**36**
Ornamentals	Aerial	0.122	0.121	98	97	0.05	**9**	0.09	**36**
	Airblast	0.116	0.116	93	93	0.05	**9**	0.08	**34**
Tree nuts; pistachio; pome fruit	Airblast	0.0568	0.0562	46	45	0.02	**4**	0.04	**17**
Research crops	Ground	0.0637	0.0634	51	51	0.03	**5**	0.05	**19**
Tobacco	Ground	0.0327	0.0324	26	26	0.01	**2**	0.02	**10**
Shading indicates acute or chronic LOC exceedance. BOLD indicates Endangered species LOC exceedance									

Aquatic Plants

For aquatic plants, all toxicity studies had EC_{50} values that were greater than the highest test level. Because these studies did not yield definitive toxicity endpoints, RQs could not be calculated. Instead, a conservative screen was conducted by comparing the average EECs to the highest test levels in the toxicity test (**Table 18**). These maximum test levels represent exposure levels which are less than the LD_{50} or LC_{50}, and, therefore, this comparison offers a conservative estimation and adverse effects on plants are not anticipated.

Table 18. Estimated Risk Screen for Aquatic Plants (EFED guidance EECs)

Use	App. Type	Water Column EEC (µg/L)	Aquatic Non-Vascular Plants (Proxy RQ)	Aquatic Vascular Plants (Proxy RQ)
		Average	EC50/NOAEC (>3.9 µg a.i./L)	EC50/NOAEC (>94 µg a.i./L)
Brassica vegetables; cole crops; leafy greens (3 cc)	Aerial	2.44	0.63	0.03
	Ground	2.39	0.61	0.03
Brassica vegetables; cole crops; leafy greens (1 cc)	Aerial	1.81	0.46	0.02
	Ground	1.83	0.47	0.02
Field Corn	Ground	0.704	0.18	0.01
Cotton	Aerial	1.30	0.33	0.01
Ornamentals	Aerial	0.902	0.23	0.01
	Airblast	0.850	0.22	0.01
Tree nuts; pistachio; pome fruit	Airblast	0.512	0.13	0.01
Research crops	Ground	0.704	0.18	0.01
Tobacco	Ground	0.252	0.06	<0.01

C. Exposure and Risk Estimation for Terrestrial Organisms

1. Birds and Mammals (Foliar Spray Applications)

For birds and mammals, peak terrestrial EECs were calculated with the T-REX model (version 1.5.2).[17] Because the terrestrial modelling is not site or method specific, the use sites were grouped into different scenarios for assessment purposes by the unique use patterns (**Table 19**). Given that the exposures and resulting RQS are similar for the differing use scenarios, this section is focused on presenting the results from the highest use pattern (use rate scenario 1) and the others are detailed in the **Appendix A** when not included in the general discussion. It is noted that some of the uses have restrictions to switch to another mode of action (MOA) after two or three consecutive applications. Use of the MOA rotation (assuming a 7-day interval for alternative MOA) did not have an impact on the conclusions and the alternative modelling scenario is available for reference in **Appendix A, Tables A12-17**. Data are not available for refining the foliar half-life so the default value of 35 days was used and a bounding exercise is included in the **Risk Description** section.

[17] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#terrestrial

Table 19. Terrestrial Assessment Scenarios

Use Rate Scenario	Representative Use Sites	Rate (lbs a.i./A)	Number of Apps.	MRI (d)
1	Brassica/cole; leafy vegetables; ornamentals	0.015	6	7
2	Cotton; Tobacco	0.015	4	5
3	Corn; pome fruit; tree nuts	0.015	3	7

Table 20. provides the resulting dietary- and dose-based EECs for the highest use rate pattern (Scenario 1: 0.015 lb a.i./A applied 6 times at 7-day intervals). The dose-based EECs presented are for the smallest bird and mammal classes as they lead to the highest EECs by bodyweight and the full Input and Output is available in **Appendix A.**

Table 20. Dietary-Based Peak EECs for Emamectin Benzoate

Dietary Item	Dietary-Based EEC (mg a.i./kg-diet)	Maximum Dose-Based EECs (mg a.i./kg-bw)	
		Birds (20 g)	Mammals (15g)
Short Grass	15.7	17.9	15.0
Tall Grass	7.2	8.2	6.9
Broadleaf plants	8.8	10.1	8.4
Fruits/pods/seeds	1.0	1.1	0.9
Arthropods	6.2	7.0	5.9

Acute Risk Estimation

For birds, based on the dose-based EECs, the only acute LOC exceedances were for the 20-gram bird feeding on short grass in scenarios 1 and 2 with **RQs of 0.75** and **0.6**, respectively (LOC =0.5). **Table 21** provides the dose-based EECS and resulting risk quotients (RQs) for birds from acute exposure. The dietary-based RQs were all well below the LOC and are presented in **Appendix A**. Similar to the avian results, despite being highly toxic to mammals on an acute exposure basis, the risk is balanced by the low estimated exposure. For mammals, the acute LOC was narrowly exceeded under Scenario 1 for the 15-gram mammal foraging on short grass **(RQ=0.58**; **Table 22**).

Table 21. Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotient

Scenario	Size Class (grams)	Adjusted LD50	EECs and RQs											
			Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
			EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1	20	23.88	17.89	**0.75**	8.20	**0.34**	10.06	**0.42**	1.12	0.05	7.01	**0.29**	0.25	0.01
	100	30.41	10.20	**0.34**	4.67	**0.15**	5.74	**0.19**	0.64	0.02	3.99	**0.13**	0.14	0.00
	1000	42.95	4.57	**0.11**	2.09	0.05	2.57	0.06	0.29	0.01	1.79	0.04	0.06	0.00
2	20	23.88	14.22	**0.60**	6.52	**0.27**	8.00	**0.33**	0.89	0.04	5.57	**0.23**	0.20	0.01
	100	30.41	8.11	**0.27**	3.72	**0.12**	4.56	**0.15**	0.51	0.02	3.18	**0.10**	0.11	0.00
	1000	42.95	3.63	0.08	1.66	0.04	2.04	0.05	0.23	0.01	1.42	0.03	0.05	0.00
3	20	23.88	10.78	**0.45**	4.94	**0.21**	6.06	**0.25**	0.67	0.03	4.22	**0.18**	0.15	0.01
	100	30.41	6.15	**0.20**	2.82	0.09	3.46	**0.11**	0.38	0.01	2.41	0.08	0.09	0.00
	1000	42.95	2.75	0.06	1.26	0.03	1.55	0.04	0.17	0.00	1.08	0.03	0.04	0.00

Table 22. Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients

Scenario	Size Clas s (g)	Adjusted LD50	EECs and RQs											
			Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/ Seeds		Arthropods		Granivore	
			EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1	15	25.92	14.97	**0.58**	6.86	**0.26**	8.42	**0.32**	0.94	0.04	5.86	**0.22**	0.208	0.01
	35	20.97	10.35	**0.49**	4.74	**0.23**	5.82	**0.28**	0.65	0.03	4.05	**0.19**	0.1437	0.01
	1000	9.07	2.40	**0.26**	1.10	**0.12**	1.35	**0.15**	0.15	0.02	0.94	**0.10**	0.0333	<0.01
2	15	25.92	11.91	**0.46**	5.46	**0.21**	6.70	**0.26**	0.74	0.03	4.66	**0.18**	0.1654	0.01
	35	20.97	8.23	**0.39**	3.77	**0.18**	4.63	**0.22**	0.51	0.02	3.22	**0.15**	0.1143	0.01
	1000	9.07	1.91	**0.21**	0.87	0.10	1.07	**0.12**	0.12	0.01	0.75	0.08	0.0265	<0.01
3	15	25.92	9.02	**0.35**	4.13	**0.16**	5.07	**0.20**	0.56	0.02	3.53	**0.14**	0.1253	<0.01
	35	20.97	6.24	**0.30**	2.86	**0.14**	3.51	**0.17**	0.39	0.02	2.44	**0.12**	0.0866	<0.01
	1000	9.07	1.45	**0.16**	0.66	0.07	0.81	0.09	0.09	0.01	0.57	0.06	0.0201	<0.01

Chronic Risk Estimation

With EECs below the NOAEC (no effects at the highest concentration tested), there were no exceedances for birds, however, for mammals, there were exceedances in several size/dietary class combinations. Dietary based RQ values ranged from 0.05-1.31 with exceedances for mammals feeding on short grass from Scenarios 1 and 2 (**Table 23**). Dose based RQs reach higher levels of exceedance with RQs ranging from 0.04-11.4. **Table 24** provides an overview of the anticipated risk to mammals from exposure to emamectin benzoate.

Table 23. Upper Bound Kenaga, Chronic Mammalian Dietary-Based Risk Quotients

Scenario	NOAEC (ppm)	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1	12	15.71	**1.31**	7.20	0.60	8.83	0.74	0.98	0.08	6.15	0.51
2		12.49	**1.04**	5.72	0.48	7.02	0.59	0.78	0.07	4.89	0.41
3		9.46	0.79	4.34	0.36	5.32	0.44	0.59	0.05	3.71	0.31

Table 24. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients

Scenario	Size Class (grams)	Adjusted NOAEL	EECs and RQs											
			Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
			EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1	15	1.32	14.97	**11.35**	6.86	**5.20**	8.42	**6.39**	0.94	0.71	5.86	**4.45**	0.21	0.16
	35	1.07	10.35	**9.70**	4.74	**4.45**	5.82	**5.46**	0.65	0.61	4.05	**3.80**	0.14	0.13
	1000	0.46	2.40	**5.20**	1.10	**2.38**	1.35	**2.92**	0.15	0.32	0.94	**2.04**	0.03	0.07
2	15	1.32	11.91	**9.03**	5.46	**4.14**	6.70	**5.08**	0.74	0.56	4.66	**3.54**	0.17	0.13
	35	1.07	8.23	**7.71**	3.77	**3.54**	4.63	**4.34**	0.51	0.48	3.22	**3.02**	0.11	0.11
	1000	0.46	1.91	**4.13**	0.87	**1.89**	1.07	**2.33**	0.12	0.26	0.75	**1.62**	0.03	0.06
3	15	1.32	9.02	**6.84**	4.13	**3.14**	5.07	**3.85**	0.56	0.43	3.53	**2.68**	0.13	0.10
	35	1.07	6.24	**5.84**	2.86	**2.68**	3.51	**3.29**	0.39	0.37	2.44	**2.29**	0.09	0.08
	1000	0.46	1.45	**3.13**	0.66	**1.44**	0.81	**1.76**	0.09	0.20	0.57	**1.23**	0.02	0.04

Chronic LOC=1

2. Risk Estimation for Piscivorous Birds and Mammals

The KABAM (K_{ow} (based) Aquatic Bioaccumulation Model) model was used to estimate the potential exposures to birds and mammals from trophic transfer in the aquatic food chain. This analysis was included because Emamectin benzoate has a K_{ow} >4. In this analysis, the model calculates the pesticide tissue residues for different levels of the aquatic food web and then calculates the estimated dose and dietary exposures using an approach that is similar to the TREX model. The inputs and outputs are available in (**Appendix F**). The default model assumption is for zero metabolism of emamectin benzoate within the organism, however, because the measured fish Bioconcentration Factor (BCF) was low at 69, further refinement steps were taken to factor in the metabolism using the metabolism rate constant

(Km). Details on calculating the Km are available in the User's Guide for the KABAM model[18]. Further discussion follows in the **Risk Description** section. As a screen, two scenarios were modelled to provide bounding. **Table 25** reflects the RQs for the maximum exposure EECS (EFED guidance half-lives) and **Table 26** reports the RQs for the same use but at the lower bound EECs (previously defined in aquatic sections).

Table 25. Calculation of RQ values for mammals and birds consuming fish contaminated by emamectin benzoate (Upper bound EECS; Brassica/Leafy 3 Crop Cycle)

Wildlife Species	Acute		Chronic	
	Dose Based	Dietary Based	Dose Based	Dietary Based
Mammalian				
fog/water shrew	**0.221**	N/A	**4.310**	0.773
rice rat/star-nosed mole	**0.211**	N/A	**4.122**	0.607
small mink	**0.111**	N/A	**2.166**	0.347
large mink	**0.123**	N/A	**2.393**	0.347
small river otter	**0.132**	N/A	**2.576**	0.347
large river otter	0.072	N/A	**1.407**	0.175
Avian				
sandpipers	**0.314**	0.013	N/A	0.181
cranes	0.015	0.011	N/A	0.162
rails	**0.157**	0.014	N/A	0.196
herons	0.021	0.012	N/A	0.168
small osprey	0.019	0.007	N/A	0.104
white pelican	0.004	0.004	N/A	0.052

[18] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/kabam-version-10-users-guide-and-technical-1

Table 26. Calculation of RQ values for mammals and birds consuming fish contaminated by emamectin benzoate (lower bound EECs; Brassica/Leafy 3 Crop Cycles)

Wildlife Species	Acute		Chronic	
	Dose Based	Dietary Based	Dose Based	Dietary Based
Mammalian				
fog/water shrew	0.043	N/A	0.831	0.149
rice rat/star-nosed mole	0.041	N/A	0.794	0.117
small mink	0.021	N/A	0.417	0.067
large mink	0.024	N/A	0.460	0.067
small river otter	0.025	N/A	0.495	0.067
large river otter	0.013	N/A	0.262	0.033
Avian				
sandpipers	0.060	0.002	N/A	0.035
cranes	0.003	0.002	N/A	0.031
rails	0.030	0.003	N/A	0.038
herons	0.004	0.002	N/A	0.032
small osprey	0.004	0.001	N/A	0.020
white pelican	0.001	0.001	N/A	0.010

3. Terrestrial Invertebrates (Foliar Applications)
Estimating risks to bees associated with the proposed uses of emamectin benzoate follows OPP's recently published guidance entitled: *"Guidance for Assessing Pesticide Risks to Bees."*[19] This guidance presents an iterative, tiered process for assessing risks that considers multiple lines of evidence related to exposure and effects of pesticides to bees.

Potential for Pesticide Exposure of Bees

The first step in this process involves a qualitative assessment of the potential for exposure of bees to the pesticides. This exposure potential is a function of the application method, timing, location (*e.g.,* indoor vs. outdoor), attractiveness of the crop to bees, agronomic practices (*e.g.,* timing of harvest), and the availability of alternative forage sources. **Table 27** provides information from the USDA on the pollinator attractiveness for each of the registered use patterns for Emamectin Benzoate. The

[19] http://www2.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf

determination for potential on-field exposure is based on whether the crop is attractive to bees and the agricultural practices, such as whether the crop is harvested prior to or after the bloom period. The potential for on-field exposure is presumed for crops harvested after bloom and which are attractive to visiting honey bees, while off-field exposure is pertinent whether the crop is attractive to bees or not, as a result of spray drift (assuming the off field habitat may be attractive). As noted in **Table 27**, there are several crops/uses that are pollinator attractive and the timing is relevant for exposure, thus, the potential for on-field exposure is more certain for these uses.

Table 27. Bee Attractiveness for Registered Foliar Uses (as indicated by USDA, 2014)

Use Site	App. Equip.	Attractiveness			Requires bees for pollination	Potential for on-field Exposure? (Y/N)	Comments
		Honey Bee (Y/N)	Bumble Bee (Y/N)	Solitary Bee (Y/N)			
BRASSICA (HEAD AND STEM) VEGETABLES; COLE	Aerial; Ground	Y (Pollen, Nectar)	Yes	Yes	Yes	No	Exposure is limited to when crop is grown for seed.
FRUITING VEGETABLES	Aerial; Ground	Y (Pollen, Nectar	Yes	Yes	No	**Yes**	
LEAFY GREENS	Aerial; Ground	Y (Pollen, Nectar)	Yes	Yes	Yes	No	Exposure is limited to when crop is grown for seed.
FIELD CORN (grown for seed)[20]	Ground	Yes (pollen)	Yes	Yes	No	**Yes**	Wind pollinated but can be visited by bees when pollen shedding.
COTTON	Aerial	Yes (Nectar)	Yes	Yes	No	**Yes**	
ORNAMENTAL[21]	Aerial; Airblast; Ground	Assumed	Assumed	Assumed	Assumed	**Assumed**	
TREE NUTS; PISTACHIO; POME FRUIT	Airblast sprayer; Ground	Y (Pollen, Nectar)	Yes	Yes	Yes	**Yes**	Not harvested prior to bloom
TOBACCO	Ground	Yes (Pollen)	Yes	Yes	No	No	Typically, de-flowered as a standard production practice.

For the foliar applications of emamectin benzoate, all of the application rates are the same (single rate = 0.015 lb a.i./A), thus, a single screen of the potential estimated environmental concentrations (EECs) was calculated using the Bee-REX model (**Table 28 and Appendix B**) and the EECs were compared to the available acute toxicity values in order to explore the likelihood of adverse effects (**Table 29**). The Bee-Rex model is a screening level tool that is intended for use in a Tier I risk assessment and is individual-

[20] Label is for Use in Puerto Rico only (PR160002-SLN)
[21] Outdoor-grown plants in commercial nursery production

based (*i.e.,* not intended to assess exposures and effects at the colony-level). The Tier I exposure method is intended to account for the major routes of pesticide exposure that are relevant to bees (*i.e.*, through diet and contact). It is noted that without crop specific residue values for pollen and nectar, the exposure estimates are based on default model values (high end values). Exposure routes for bees differ based on application type. In the model, bees foraging in a field treated with a pesticide through foliar spray could potentially be exposed to the pesticide through direct spray as well as through consuming contaminated food. Foraging honey bees may also be exposed to pesticides via contact with dust from seed treatments or via consumption of water from surface water, puddles, dew droplet formation on leaves and guttation fluid; however, methods are not currently available for accurately quantifying exposure via these matrices. More information on the Bee-Rex model (including the equations used for estimating EECs) is available on the web.[22]

Using the application rate of 0.015 lb. a.i./A (only a single application is modelled in BEEREX), the estimated concentrations in pollen and nectar are 0.00165 µg a.i./mg (**Table 25**). Based on the available toxicity data, the acute contact and oral LD_{50}/LD_{50} concentrations are 0.0028 and 0.0063 µg a.i./bee, respectively, thus, emamectin benzoate is very highly toxic to the honey bee (a surrogate of other terrestrial invertebrates). As seen in **Table 26**, the resulting **RQ** values range from **1.4-76.5** with the highest values for the nectar foraging workers and drones. The RQ for exposure via contact is 14.5 (**Table 28**).

Table 28. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
Foliar spray	1.65	0.00165

Table 29. Daily consumption of food, pesticide dose and resulting dietary RQs for all bees

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	0.110	**17.5**
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	0.247	**39.2**
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	0.102	**16.2**
	Worker (foraging for pollen)	>18	0	43.5	0.041	0.072	**11.4**
	Worker (foraging for nectar)	>18	0	292	0.041	0.482	**76.5**
	Worker (maintenance of hive in winter)	0-90	0	29	2	0.051	**8.1**
	Drone	>10	0	235	0.0002	0.388	**61.5**
	Queen (laying 1500 eggs/day)	Entire life	525	0	0	0.009	**1.4**

[22] https://www.epa.gov/pollinator-protection/pollinator-risk-assessment-guidance; https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment

Table 30. Risk Summary (highest RQS)

Exposure	Adults	Larvae
Acute contact	14.5	Uncertain
Acute dietary	76.5	Uncertain
Chronic dietary	Uncertain	Uncertain

Spray Drift Considerations/Off Field Exposure

While there are several uses identified as pollinator attractive risk to invertebrates "off the field," exposure was also assessed using the AgDRIFT model. **Table 31** provides the distance from the treated field at which the LOC is no longer exceeded[23,24]. In this analysis, the lowest and highest RQs were used to gain a better understanding of the range and based on the highest RQ for the nectar foraging worker, all of the methods except the ground application with low boom and med-coarse droplets result in a buffer in excess of 100 feet to no longer exceed the LOC.

Table 31. Spray Drift Buffer Analysis for Emamectin Benzoate

Method	Boom Height	Droplet size	Distance in Feet Based on Lowest RQ (1.4)	Distance in Feet based on Highest RQ (76.5)
Ground	Low Boom	Very fine	3.28	206
	Low Boom	Med Coarse	3.28	85
	High	Very fine	9.84	416
	High	Med Coarse	3.28	154
Aerial		Very fine	59	Out of range
		Med Coarse	13	Out of range
Airblast			0	131

3. Terrestrial Plants

The TerrPlant model was used to estimate risk to terrestrial plants using the most conservative input parameters (*e.g.,* aerial/air blast application) and toxicity estimates. The estimated EECs were well below the toxicity endpoints, thus, risk to plants from emamectin benzoate exposure is considered low for all assessed uses. **Table 32** and **Table 33** provide the toxicity endpoints and resulting RQs and the full output is available in **APPENDIX C**

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[23] Initial Average Deposition = (Fraction of applied) x (Application rate); where Fraction of applied = (LOC) / [RQ]. SAMPLE Calculation: Initial Average Deposition = (Fraction of applied) x (Application rate) 0.005 *0.015; where Fraction of applied = (LOC= 0.4) / [RQ (as calculated by Bee-REX)] 0.4/76.5(worker foraging for nectar) =0.005

[24] U.S., EPA (2012). Distribution of Guidance for Using AgDRIFT/AGDISP in Ecological Risk Assessments for use in the Environmental Fate and Effects Division

Table 32. Plant Survival and Growth Data for RQ derivation (units in lbs a.i./A)

	Seedling Emergence		Vegetative Vigor	
Plant type	EC_{25}	NOAEC	EC_{25}	NOAEC
Monocot	>0.3	0.3	>0.27	0.27
Dicot	0.232	0.038	>0.27	0.27

Table 33. RQ values for plants in dry and semi-aquatic areas exposed to Emamectin Benzoate through runoff and Spray Drift

Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	<0.1	<0.1	<0.1
Monocot	listed	<0.1	<0.1	<0.1
Dicot	non-listed	<0.1	<0.1	<0.1
Dicot	listed	<0.1	<0.1	<0.1

D. Exposure and Risk Estimation for the Tree Injection Use

The previous risk assessment for emamectin benzoate use as a tree injection was conducted in 2009 (DP351736), however, the assessment was a conservative screen and residue data are now available to refine the exposure estimates. A newly submitted study (MRID 49927401) provides data on the magnitude of residues in bing cherry and white ash trees following a single application of 4% emamectin benzoate at the maximum label rate[25]. In this study, the injections were made in the fall and the residues of emamectin benzoate and its 8,9 Z isomer were measured at different intervals depending on the tree part (*e.g.,* leaves, buds, flowers, pollen/nectar etc.). A total toxic residue approach was used for estimating exposure and it is assumed that the two compounds exhibit equal toxicity in this assessment. Since the study did not specify an analytical limit of detection (LOD), any statistical analyses of these data substituted the limit of quantification (LOQ) for values <LOD or <LOQ for each chemical. The LOQ for plant matrices for emamectin benzoate and the 8,9-Z isomer was 1 ppb. For this assessment, the potential routes of exposure to terrestrial organisms is expected to be through consumption of various tree parts (*i.e.,* foliage, fruit, seeds, and pollen).

1. Birds and Mammals

The highest EECs from any tree part are from the leaves of the bing cherry tree. When using the average and maximum EECs from the sampling time closest to the time of application, the average and maximum EECs are 13.8 and 45.4 mg a.i./kg (wet weight), respectively. For the ash trees sampled at 13 days after application, the EECs are lower with a maximum of 9.6 mg a.i./kg. **Table 34** provides an overview of the dietary EECs measured in cherry and ash leaves. With respect to the other tree parts that may be dietary items for birds and mammals, the measured residues in the fruit, buds, flowers, and seed are well below the values measured for the leaves (*e.g.,* max values ranged from 0.05-0.165 mg a.i./kg). **However, because the application was in the fall, there is uncertainty given the magnitude of residues lost via the fall leaf drop. For example, if an application was made in the spring or summer, there could be much higher residues available in fruit, buds, flowers, and seed.** Therefore, the residue

[25] Rates are based on tree size. For the bing cherry trees the 10-inch diameter trees received 165 mL/tree; for the ash trees the trunk diameter ranged from 5.7-18.2 inches, thus, the injected volume ranged from 75-225 mL/tree.

values from the leaves at the sampling interval closest to the injection (days 8, 13) will serve as a conservative proxy for dietary exposures to birds and mammals.

Table 34. Dietary Based EECS for Cherry and Ash Leaves after Tree Injection

Dietary EEC mg/kg (Based on sampling time closest to Application, 8 days or 13 (ash)			
Cherry		Ash	
AVG	MAX	AVG	MAX
13.8	45.3	4.2	9.6

As depicted in **Figure 4,** there is a large degree of variability in the samples taken on Day 8, and the next sampling interval available is in the following spring. Given that applications may be made at any time, this analysis is using the first sampling interval (*i.e.,* pre leaf drop). Further discussion of the uncertainties related to using the data is included in the **Risk Description** section.

The following box-and-whisker plot demonstrates the variation in total residue concentration (emamectin benzoate and 8,9-Z isomer) in leaf samples for bing cherry trees over the duration of the experiment. The upper and lower bounds of each box represent the upper and lower quartiles of the data, while the black line within each box signifies the median. Whiskers encompass the full range of data points for each sampling date (including outliers).

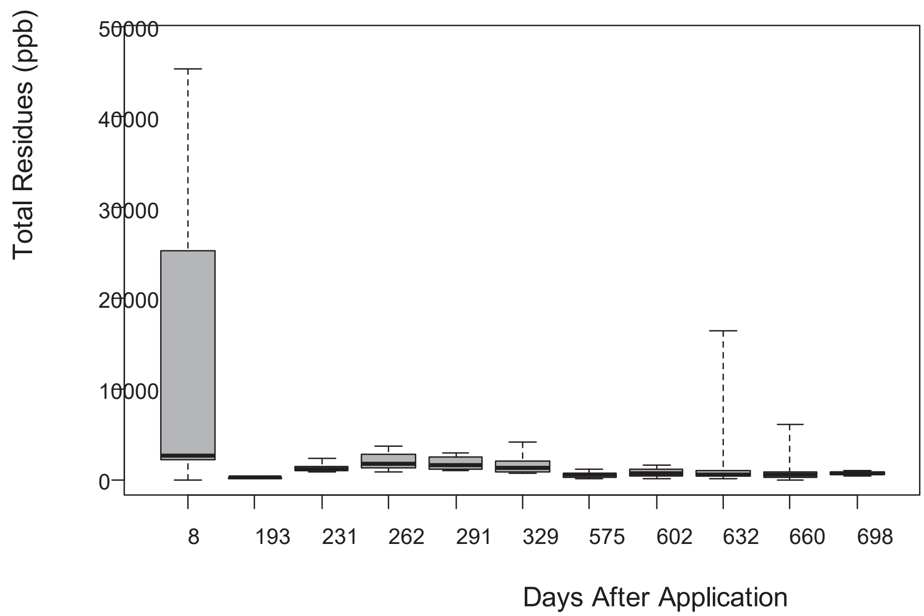

Figure 4. Total Residues in Bing Cherry Tree Leaves (First Interval is Pre leaf drop)

The dose-based EECs for birds and mammals are provided in **Table 35** along with the RQ values. For the bing cherry tree leaves, the mammalian RQs narrowly exceeded for the small 15 g mammal only based on the average EECs, and the RQs ranged 0.7-1.7 based on body weight using the maximum EEC. For birds, the acute LOC was exceeded for the 20-gram bird only based on the average EECs and the RQs ranged from 0.3-2.2 based on body weight class using the maximum EEC. For ash trees, the only RQ approaching the LOC was for the 20 g bird (RQ=0.46) and based on the maximum EEC. **Table 35** provides a summary of the dose based EECs and RQ values for the bing cherry tree leaves. On a chronic exposure basis, there is LOC exceedance identified for all weight classes for both the average and maximum values with RQs up to 9.9 for the average and 32.6 for the maximum EECs (**Table 36**).

Table 35. Dose Based EECS and RQ Values for Birds and Mammals Feeding on Cherry Tree Leaves

Taxa	Size Class (grams)	Dose based EEC (mg a.i./kg-bw)		Adjusted LD50	Dose Based RQ	
		AVG	MAX		AVG	MAX
Mammals (herbivore)	15	13.1	43.0	25.92	**0.5**	**1.7**
	35	9.1	29.9	20.97	**0.4**	**1.4**
	1000	2.1	6.8	9.07	**0.2**	**0.7**
Birds (herbivore)	20	15.7	51.6	23.88	**0.7**	**2.2**
	100	9.0	29.4	30.41	**0.3**	**1.0**
	1000	4.0	13.1	42.95	**0.1**	**0.3**

Table 36. Chronic Mammalian Dose-Based RQs for Mammals Feeding on Cherry Tree Leaves

Taxa	Size Class (grams)	Dose based EEC (mg a.i./kg-bw)		Adjusted NOAEL	Dose Based RQ	
		AVG	MAX		AVG	MAX
Mammals (herbivore)	15	13.1	43.0	1.32	**9.9**	**32.6**
	35	9.1	29.9	1.07	**8.5**	**27.9**
	1000	2.1	6.8	0.46	**4.5**	**14.8**

2. Terrestrial Invertebrates

For the tree injection use, there was measured residue data for pollen and nectar from the bing cherry trial and only pollen measured from the ash trees as they are not nectar producing. Given that the applications were made in the fall, there is a long period (including leaf drop) between application and sampling for residues (*e.g.,* 170-515 days). There were also many non-detects/<LOQ within the dataset, however, across both species of trees, the maximum values were similar. Because the injection occurred <u>in the fall before leaf drop</u>, there is a noted uncertainty with respect to the available emamectin benzoate that had accumulated in the fall leaves and was removed from the tree at the time of leaf drop, and thus unavailable for movement into spring flowers (and pollen/nectar). This is important because both of these species flower in early spring at the time of or just prior to spring leaf expansion.

For the purpose of clarity, the exposure estimation is broken into three sections, the first being a high level screen based on the labelled rate followed by a second screen using the maximum leaf residues as a surrogate for the pollen and nectar under the 'post leaf drop' application scenario, and the last approach is relevant for the 'pre-leaf drop' timing and is based on the measured residues for pollen and nectar.

- Bee-Rex Model Scenario using the labeled rate for Injection
- Post Leaf Drop (Fall application and beyond) ***Surrogate Based Risk Estimation***
- Pre Leaf Drop (Fall application) ***Empirically Based Risk Estimation***

Bee-Rex Model Scenario using the labeled rate for Injection

When the BeeREX model was run with the labeled application rate from the submitted study (165 ml product/tree which converts to 7.118 mg a.i./tree) along with the estimated leaf mass per bing cherry tree of 4,230 grams of leaf mass per tree,[26] and under the assumption that all of the injected material is transported to the leaves/edible tree parts, the modelled Tier 1 estimated EECs for leaves was calculated as 1683 mg a.i./kg. Comparing the Tier 1 modelled estimates to the empirical leaf residues at 8 days, the modelled estimate is approximately 40 and 120 times the measured maximum and average bing cherry tree leaf concentration residues, respectively (13.8 mg a.i./kg=average; 45 mg a.i./kg = maximum).

BEErex Refinement/ Surrogate Based Risk Estimation for Post Leaf Drop (Fall application and beyond)

Considering the discrepancy with the predicted vs measured residues, further refinement is required in the model to better predict exposure to emamectin benzoate, thus, the maximum leaf concentration from the 8-day sampling interval (*i.e.*, 45 mg a.i./kg for the bing cherry tree) was used as a proxy for pollen and nectar residues in the BEEREX model. **Table 37** provides the resulting dietary exposure (assuming leaf concentrations are a surrogate for pollen and nectar) and the resulting Dose-based EECs and RQ values. However, these estimates are considered conservative and further discussion and refinement is provided in the **Risk Description** section.

Table 37. Estimated EECS for Pollen and Nectar (using leaf residue as a surrogate) and resulting RQ Values for Terrestrial Invertebrates

Adults Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ
Worker (cell cleaning and capping)	0-10	0	60	6.7	3.0	476
Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	6.7	1069
Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	2.8	441
Worker (foraging for pollen)	>18	0	43.5	0.0	2.0	311
Worker (foraging for nectar)	>18	0	292	0.0	13.1	2086
Worker (maintenance of hive in winter)	0-90	0	29	2.0	1.4	221
Drone	>10	0	235	0.0	10.6	1679

Scenario Representing a Pre Leaf Drop-Fall Application (*Empirically Based Risk Estimation)*

The available pollen and nectar residue data represent the scenario of a single tree injection applied in the fall prior to leaf drop. These residues are in the range of 2.6-3.3 ppb (**Table 38**). These measured values were used in the BEE-Rex model to assess the dietary exposure and the resulting Dose-based EECs and RQ values are presented in **Table 39**. Using these measured values, the RQ values representing a Fall application prior to leaf drop are below the LOC for all castes of bees.

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[26] Calculated using the Leaf Mass per Area and Canopy Leaf Area of Bing Cherry Trees reported for a Washington orchard from: Barria. AJA, (2006). The impact of deficit irrigation on sweet cherry (Prunus avium L) physiology and spectral reflectance. http://www.dissertations.wsu.edu/Dissertations/Fall2006/a_antunez_101606.pdf

Table 38. Measured total residues for Pollen and Nectar following Tree Injection of Emamectin Benzoate

Tree	Measured Total Residues from samples taken in the Spring (mg a.i./kg)	
Ash Pollen (177 days)	AVG	0.0027
	MAX	0.0033
Cherry Pollen (170-178 days)	AVG	0.0026
	MAX	0.0029
Cherry Nectar (515 days)*	AVG	NC
	MAX	0.0026

* Nectar residues of EB only observed in the second year (not the first year), so there is uncertainty if emamectin would be in nectar right after injection

Table 39. Estimated EECS for Pollen and Nectar (using empirical residue data) and resulting RQ Values Terrestrial Invertebrates

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	0.00018	0.028
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	0.00040	0.063
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	0.00016	0.026
	Worker (foraging for pollen)	>18	0	43.5	0.041	0.00011	0.018
	Worker (foraging for nectar)	>18	0	292	0.041	0.00076	0.121
	Worker (maintenance of hive in winter)	0-90	0	29	2	0.00008	0.013
	Drone	>10	0	235	0.0002	0.00061	0.097
	Queen (laying 1500 eggs/day)	Entire life	525	0	0	0.00000	0

Uncertainties

As noted, there are several uncertainties in estimating the risk to invertebrates exposed via tree injection. The major uncertainty with using the available pollen and nectar data to directly assess risk, is that there is a major dissipation route (*i.e.,* loss of mass through leaf drop) that is not relevant to applications made post leaf drop (an allowable labeled timing). When using the first tier of estimation with the BeeREX default approach for tree injection (assuming all of the mass injected into the trees ends up in the leaves/pollen/nectar the following year), the leaf concentrations were estimated to be 1683 mg a.i./kg which was up to 40 times the maximum empirical leaf residues at 8 days (45 mg a.i./kg = maximum). Considering the variability of the measured leaf residues and use of the maximum in the comparison, there is low confidence with this exposure estimate. A second screen using the maximum 8-day leaf residue of 45 mg a.i./kg in the model as a surrogate for pollen and nectar residues was modelled in the BeeREX model and provides an upper bound exposure estimate of up to 13 µg ai/bee and is based on the assumption that the leaf concentrations are representative of pollen and nectar. Further discussion and a bounding exercise is included in the **Risk Description Section**. Altogether, the available data leaves a high degree of uncertainty with regard to exposure to pollinators/bees when the application is made post leaf drop and prior to or during bloom.

IV. RISK DESCRIPTION

A. Aquatic Organisms

Due to the accumulation of emamectin benzoate in the simulated pond, particularly due to uncertainty in aquatic metabolism inputs, RQs were also calculated based on model inputs with an aerobic aquatic metabolism half-life of 301 days and an anaerobic aquatic metabolism half-life of 429 days (see **Model Input Parameters** section). This provides a lower bounding of aqueous concentrations with a reasonable amount of metabolism in the pond, rather than solely relying on the 1-in-10 year EECs which take into account almost 30 years of accumulation. RQ values for the upper bound EECs (based on EFED guidance) and lower-bound EECs (revised aquatic metabolism half-lives) are both discussed. Additionally, based on pesticide usage data[27] provided by the Biological and Economic Division (BEAD), emamectin benzoate is typically applied 1 to 2 times per year (depending on the crop), so the impact of the reduced number of applications per year will be discussed for further characterization, although, this is coupled into a "best case" scenario as the modelling also is only considering one year of applications over the 30-year simulation (*i.e.,* does not factor accumulation from repeated uses). Therefore, this characterization is useful to demonstrate that LOC exceedances occur under the least conservative scenario.

Fish (aquatic phase amphibians)

Emamectin benzoate is moderately to highly toxic to fish on an acute exposure basis but the risk is balanced by the anticipated exposure. On a chronic exposure basis, the toxicity endpoints were relatively similar for FW and E/M fish (*e.g.,* 6.5 and 14.5 µg/L for FW and E/M fish, respectively). With no LOC exceedances using the upper bound EECs (*i.e.,* factoring accumulation and maximum labelled rates), adverse effects to fish are not anticipated.

Aquatic Invertebrates (water column)

Emamectin benzoate is very highly toxic to aquatic invertebrates, with acute toxicity endpoints (LC_{50}) of 1.0 and 0.04 µg/L for FW and E/M invertebrates, respectively. For FW invertebrates, the RQs range up from 0.3-2.4 and if considering the shorter half-lives (lower bound scenario), the RQs are below the acute LOC for all uses except for brassica and leafy greens. **For E/M invertebrates, the RQ values range from 6-61 and the lower bound RQs are all above the LOC ranging from 2-20**. It is also noted that emamectin benzoate has a steep dose response, thus, the likelihood of adverse effects is more certain for E/M invertebrates. For acute exposure, the EECs from spray drift alone (using the label-specified 150 ft aerial and 25ft ground buffer distances) also led to LOC exceedances for the current use patterns, even though runoff is noted as the dominant route of exposure for the vast majority of the modelled scenarios. For further characterization, when modelling the typical use patterns and representing a single year, for FW species, the RQs are below the acute LOC, however, for E/M species, the acute LOC is exceeded with an RQ of 0.7 and the EEC of 0.026 µg/L is approaching the LC_{100} at 0.07 µg/L.

On a chronic exposure basis, for both FW and E/M invertebrates there were effects to reproduction and growth at very low concentrations. The chronic toxicity endpoint for the for the daphnid was 0.088 µg/L (based on 86% reduction in young survival, 27% reduction in young per female and 48% reduction in weight at 0.016 µg/L) and the E/M mysid was an order of magnitude more sensitive with a NOAEC of

[27] Market Research Data (2011-2015); National Ag. Statistics Service (NASS-2011-2015); California Department of Pesticide Regulation (Cal DPR-2011-2015)

0.0087 µg/L (based on 11% reduction in weight at 0.013 µg/L and it is noted that the NOAEC for survival was 0.013 µg/L, based on 81% reduction). Based on these endpoints, the FW RQ values ranged from 3-27 and under the lower bound scenario, the RQs ranged from 0.4-5.5**. For E/M invertebrates, the RQ values range from 26-275 and the lower bound RQs are all above the LOC ranging from 5 to 56.** For further characterization, when modelling the typical use patterns and representing a single year only, for FW species, the RQs are below the LOC, however, for E/M species, the chronic LOC is exceeded (RQ =2.4).

Benthic Invertebrates

For benthic invertebrates, based on the subchronic exposure data (both sediment and pore water), the LOC is narrowly exceeded for the Brassica-Leafy uses only. On a chronic exposure basis, the LOC is exceeded for all uses with RQs ranging from 17-181 and 67-700 for pore water and sediment based EECs. One uncertainty with the benthic invertebrate toxicity study design is what concentration medium (*i.e.,* the sediment or pore water, or both) is driving the toxicity. For comparison, the water column invertebrate RQ (*i.e.,* for the FW daphnid) was generally similar in range to the benthic pore water RQ (water column RQ up to 275 vs 181 for the benthic invertebrate based on pore water). For further characterization, when modelling the typical use patterns and representing a single year only, the acute RQs are below the LOC. However, there are LOC exceedances for chronic exposure (pore water RQ=1.6 and sediment RQ=6.1) and given that both porewater and sediment based exposures exceed under this scenario, there is further support to the risk conclusion.

Aquatic Plants

There is low likelihood of adverse effects for aquatic plants.

B. Terrestrial Organisms

Birds and Mammals- Foliar Uses

Birds

For birds, based on the dose-based EECs, the only acute LOC exceedances were for the 20-gram bird feeding on short grass in scenarios 1 and 2 with **RQs of 0.75** and **0.6**, respectively (LOC =0.5). Altogether, the likelihood of adverse effects from the lower use pattern (Scenario 3- 0.015 lbs a.i./A applied 3X at 7-day interval), is considered low. Similar levels of risk are identified for Scenarios 1 (0.015 lbs a.i./A applied 6X at 7-day interval) and 2 (0.015 lbs a.i./A applied 4 X with 5-day interval), and while the LOC exceedances are modest, there is a chance of adverse effects to birds based on the reported long-lasting sublethal effects including clinical signs of neurotoxicity from days 1-5 for the lowest dose (resulting NOAEL for sublethal effects <12 mg a.i./kg-bw). For characterization, if using the sublethal NOAEL proxy (12 mg a.i./kg-bw), the RQs range up to 2.8. In order to fully characterize the risk, when using the typical number of applications (1 or 2 per year), all scenarios are below the LOC (for lethality) and sublethal effects are expected to be minimal for a single application.

On a chronic exposure basis, there is some uncertainty because a LOAEC was not defined based on a lack of effects up to the highest test concentration (40 mg a.i./kg diet). However, based on the anticipated exposures, the available data is considered to be adequate for screening effects from chronic exposure in birds. Given that the EECs are below the LOC, there is low likelihood of adverse effects from chronic exposure.

Mammals

Acute

Similar to the avian results, despite being highly toxic to mammals on an acute exposure basis, the risk is balanced by the low estimated exposure. For mammals, the acute LOC was narrowly exceeded under Scenario 1 for the 15-gram mammal foraging on short grass **(RQ=0.58**). If using typical number of applications, there is low likelihood of adverse effects.

Chronic Risk to Mammals

For all size classes of mammals for the 3 scenarios assessed, there were chronic LOC exceedances for mammals feeding on short grass, tall grass, broadleaf plants, and arthropods (RQs in excess of LOC ranged from **1.2-11.4,** using the upper bound EECs). When plotting the highest dose-based EECs with the NOAEL/LOAEL from the 2-gen reproduction study with the rat, both endpoints are exceeded by the second application (the NOAEL exceeded after a single application; **Figure 5).** It is also noted that there are LOC exceedances when using the mean EEC values (same dietary classes with exceedances and RQs up to 4).

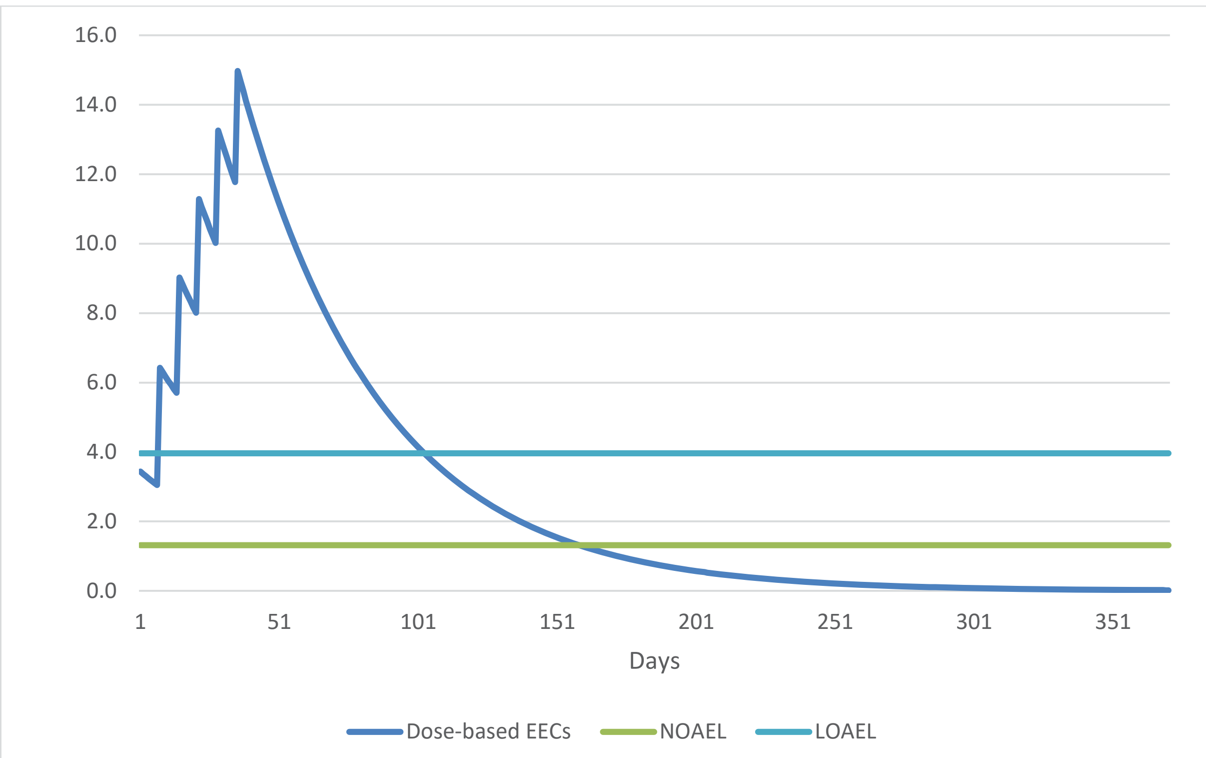


Figure 5. Dose Bases EECs for Small Mammals and Chronic Endpoints

Additionally, based on a 15-day neurotoxicity study used for human health assessment (MRID 42851503, HED 2003[28]), there were effects at even lower levels for the CF mouse (*e.g.,* tremors on day 3 and decrease in body weight consumption and degeneration of the sciatic nerve). In this dietary study, the test material was a plant metabolite of emamectin benzoate (L-660599) and the resulting NOAEL is 0.075 mg/kg/day (LOAEL=0.1) and it is noted that there was a steep dose response with severe effects at

[28] U.S. EPA. (2003) D291065

the LOAEL (including death and neuropathology). Using the NOAEL of 0.075 mg/kg/day as an endpoint in TREX, resulted in exceedances (*e.g.,* greater than 150X the LOC for small mammals/short grass) for every dietary and size class combination. While this neurotoxicity study is not part of the typical suite of studies EFED uses in risk assessment, the effects can be related to survival and fitness of the organism, thus, this assessment considers the data as a line of evidence that effects to mammals are possible given the current use patterns and available toxicity data.

One uncertainty with respect to exposure is the foliar half-life of emamectin benzoate. In order to depart from the 35-day foliar half-life, data are needed from a minimum of 3 magnitude of residue studies (or similar) with ample data points to derive a 90th percentile half-life. Data are not available at this time, however, when exploring the potential impact of an extreme case for a bounding exercise (*e.g.,* 1-day half-life), the conclusions are generally the same as there are still multiple applications being made at short (5-7 day) intervals, thus, the greatest risk reductions would come from longer application intervals/reduced number of applications. **Figure 6.** depicts the exposure scenario with a hypothetical shorter half-life as, and as seen below, the EECs are still in excess of the NOAEL for several days after each application. The more sensitive endpoint for neurotoxic effects is also plotted to show the EECs exceed this endpoint for the entire application period even in this refined bounding exercise.

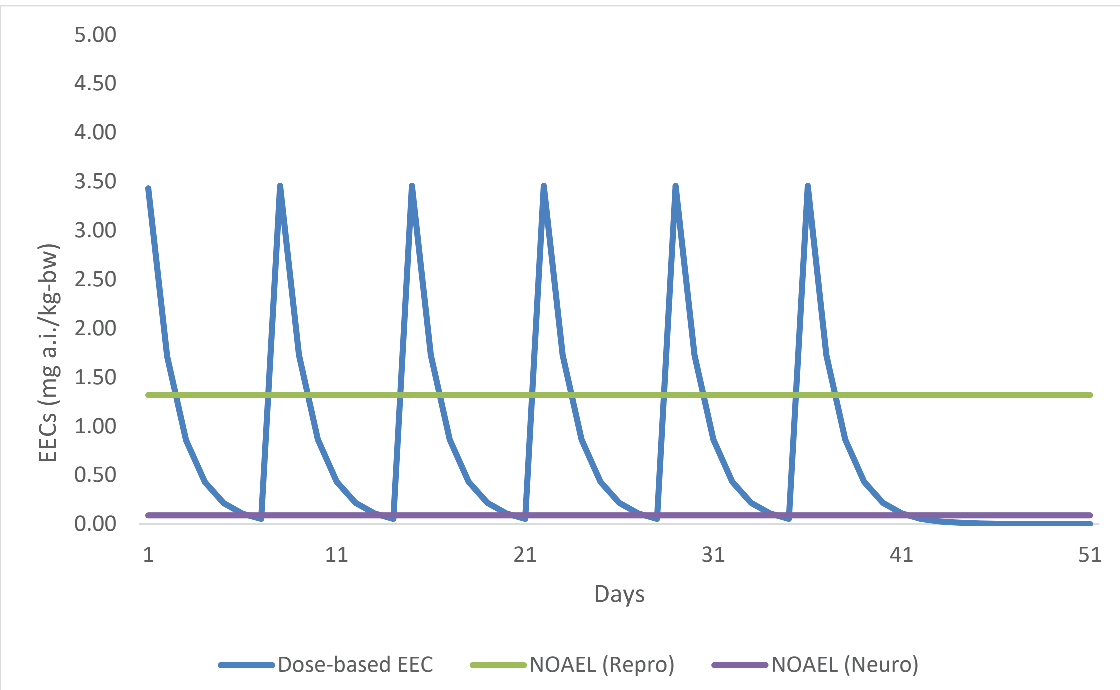


Figure 6. Bounding Exercise Using 1-day Half-life

As discussed earlier, according to pesticide usage data, emamectin benzoate is typically applied either one or two times per year (depending on the crop). Thus, to consider the impact of a reduction in the number of applications, additional modeling was conducted for a single application. **Table 40** provides the chronic dose based RQ values for a single application of 0.015 lb a.i./A.

Table 40. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients (SINGLE Application).

Size Class (grams)	Adjusted NOAEL	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	1.32	3.4	2.6	1.6	1.2	1.9	1.5	0.2	0.2	1.3	1.0	0.05	0.04
35	1.07	2.4	2.2	1.1	1.0	1.3	1.3	0.1	0.1	0.9	0.9	0.03	0.03
1000	0.46	0.6	1.2	0.3	0.5	0.3	0.7	0.0	0.1	0.2	0.5	0.01	0.02

Spray Drift Considerations

Mammals may readily be exposed both on and off the treated field, thus, to consider the distance "off field" that emamectin spray drift residues may reach the levels of concern, the AgDRIFT model was used to simulate the distance off field that triggers an exceedance[29,30]. From this simulation, the risk from spray drift deposition depends on the method and droplet size and ranges from 3-33 feet off field for ground applications and 33-361 feet off field for aerial applications (**Table 41**). As seen in **Table 41**, the use of ground equipment and med-coarse droplets reduces the off-field footprint. When comparing the distance based on the typical usage RQ (*i.e.,* RQ=2.6) the offsite risks range from 3-6.5 feet off field for all equipment/droplet combinations except for the aerial with fine droplets (19 feet).

Table 41. Distance Off-Field to Avert Adverse Effects from Spray Drift

Method	Boom Height	Droplet size	Scenario 1 (Based on RQ=11.5)	Scenario 2 (Based on RQ=9.0)	Scenario 3 (Based on RQ=6.8)
Ground	Low Boom	Very fine	13	10	7
	Low Boom	Med-Coarse	3	3	3
	High	Very fine	33	26	20
	High	Med Coarse	7	7	3
Aerial		Very fine	**361**	**269**	**187**
		Med-Coarse	**72**	**52**	33

[29] Initial Average Deposition = (Fraction of applied) x (Application rate); where Fraction of applied = (LOC) / [RQ]. Sample Calculation: Fraction of Applied: LOC=1 / [RQ as calculated by T-REX=11.5] 1/11.5=0.086: Initial Average Deposition = 0.086 *0.015

[30] U.S., EPA (2012). Distribution of Guidance for Using AgDRIFT/AGDISP in Ecological Risk Assessments for use in the Environmental Fate and Effects Division

Bioaccumulation Considerations for Piscivorous Birds and Mammals

Based on the refined KABAM analysis factoring in the metabolism of Emamectin benzoate, there are no acute exceedances for birds or mammals based on the upper bound aquatic EECs for the highest use pattern (Brassica/Leafy-3 crop cycle). On a chronic exposure basis, there are LOC exceedances with RQ's ranging from 1.4-2.1 for the piscivorus species and the RQs for the animals that consume a primarily aquatic invertebrate diet (*e.g.,* the shrew and mole), are higher (e.g. RQs of 4.1 and 4.3) because the model refinement is only considering the fish metabolism, thus, the default of zero metabolism is used of these dietary items. There are no chronic LOC exceedances based on the lower bound EECs. Considering the upperbound EEC's reflect the maximum use pattern (including 3 crop cycles per year), and the LOC is only exceeded marginally (<2) for the shrew and mole when using the LOAEC, there is a low likelihood of adverse effects from exposure via food chain transfer to aquatic dietary items.

Birds and Mammals-Tree Injection Use

For birds and mammals, the calculated RQ values narrowly exceeded the acute LOC based on the average day 8 bing cherry leaf residues as a proxy for all feed items (RQs ranged from 0.1-**0.7** for birds and 0.2-**0.5** for mammals). Based on the maximum residues the acute LOC was exceeded (RQs ranged from 0.3-**2.2** for birds and 0.7-**1.7** for mammals). There was not an LOC exceedance based on chronic exposure for birds, however, there are exceedances identified for mammals (RQs based on average leaf EEC values ranged from **5-10** and for the maximum RQs ranged from **15-33**).

When considering the level of exceedance and that the worst case scenario leaf residues were considered (*i.e.,* Day 8), the overall acute risk to birds and mammals is considered relatively low. On a chronic exposure basis, there is a risk identified for mammals, although there is also considerable uncertainty. While the degree that a mammal will forage from the same tree or multiple treated trees in a day is uncertain, based on the RQs up to 10 for the average EECS, the LOC would also be reached with only 10% of daily diet from treated tree parts. However, another uncertainty is the timing of application in the available magnitude of residues study. Based on the study design, the injection was made in the fall prior to leaf drop, thus, the 8 day values were used as a conservative proxy, however, given that many of the observed residues from other sampling intervals and tree parts were well below the maximum and average EECS, it is uncertain how representative these values are in terms of the real world application and also the degree that leaves serve as a surrogate for the other tree parts (*e.g.,* seeds, buds, flowers etc.). To provide additional bounding, if using the average leaf residue value from all other sampling intervals (all post leaf drop intervals) as an alternative exposure estimate, the day 193-698 average is 1.26 ppm and there are no LOC exceedances.

For further characterization, typical application timing information was requested from the Biological and Economic Division (BEAD). From this information, the main target pest for the tree injection use in trees such as white ash appears to be the emerald ash borer (*Agrilus planipennis*) and the optimal timing for this use is early May to mid-June (Herms *et al*. 2009),[31] thus, a late spring/early summer, in-season application is the most likely timing. Therefore, for a tree such as ash, the seeds could be in development at this time, thus, is it unknown how high the residues could be based on the available data. White ash seeds are utilized as dietary items for wildlife such as wood ducks, bobwhite quail,

[31] Herms D.A., D.G. McCullough, D.R. Smitley, C. Sadof, R.C. Williamson, and P.L. Nixon. 2009. Insecticide options for protecting ash trees from emerald ash borer. North Central IPM Center Bulletin. 12 pp.

purple finch, pine grosbeak, and fox squirrel[32]. Although, for small mammals such as mice and voles, the seeds of common ash (*Fraxinus excelsior*) were not preferred (*e.g.,* ranked lowest in preference of seeds from 12 tree species) in a study with the wood mouse (*Apodemus sylvaticus*).[33] **Overall, there is a risk identified for mammals but given the high level of uncertainty with respect to exposure, the likelihood of adverse effects from the tree injection use is relatively low.**

C. Terrestrial Invertebrates

Emamectin benzoate is highly toxic to the honeybee and the risk from foliar uses was estimated using the BeeREX model. At this time, foliar residue data are not available for refining the estimated exposures via the diet. Additionally, data are not available for assessing chronic risk to adults and acute or chronic risk during the larval life stage, thus, there are major uncertainties with respect to the toxicity to honey bees and non-apis terrestrial invertebrates. Based on the BeeREX analysis for the adult life-stage, a single application of 0.015 lb a.i./A, is sufficient to trigger the LOC (0.4) for all castes (RQs range from 1.4 for the queen **to 76.5** for the nectar foraging worker). Based on contact exposure, the RQ is **14.5**.

As noted earlier, there are several use sites that have a potential for on field exposure based on crop attractiveness and agronomic factors. In summary, the brassica/cole, leafy greens, and tobacco crops are of lesser concern because the crop is harvested prior to bloom (unless grown for seed). All other field uses, have a potential for exposure and further considerations are detailed in **Table 42**. The current label language states not to apply when bees are actively foraging, but does not explicitly restrict on crops stage (*e.g.,* bloom etc.).

Table 42. Crop Biology/Agronomic Factors Influencing Exposure

Use Site	Potential for On-field Exposure? (Y/N)	U.S Bearing Crop Acreage[34]	Representative Crop Usage (Max Percent of the Crop treated)[35]	Crop Biology Factors/other comments
Brassica/Cole	No	163,730 (broccoli and cauliflower); cabbage: 60,180	Broccoli, cauliflower (20%); cabbage (25%)	Exposure is limited to when crop is grown for seed.
Fruiting Vegetables	**Yes**	Tomatoes: 93,600 (fresh)/277,000 (processing	Tomatoes (20%), peppers (15%)	Duration of bloom: Varies
Leafy Greens	No	Lettuce: 259,100 Spinach: 31,440	Lettuce (20%), Spinach (10%)	Exposure is limited to when crop is grown for seed.

[32] https://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fraxinus/americana.htm
[33] Forestry Commission-Research Note (March 2013) https://www.forestry.gov.uk/pdf/FCRN013.pdf/$FILE/FCRN013.pdf
[34] USDA. Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Pollen and Nectar. 2017.
[35] According to Screening Level Use Analysis (Table 2 in assessment)

Use Site	Potential for On-field Exposure? (Y/N)	U.S Bearing Crop Acreage[34]	Representative Crop Usage (Max Percent of the Crop treated)[35]	Crop Biology Factors/other comments
Field Corn (grown for seed)[36]	**Yes (pollen only)**	Puerto Rico only	Puerto Rico SLN only (minor use)	Wind pollinated but can be visited by bees when pollen shedding.
Cotton	**Yes (nectar only)**	7,664,400	<2.5%	Duration of bloom: Indeterminate
Ornamental [37]	**Assumed**	Uncertain	Uncertain	Duration of bloom: Varies
Tree Nuts; Pistachio; Pome Fruit	**Yes**	Apples: 327,800 Almonds: 780,000	Apples (20%), Almonds (10%)	Not harvested prior to bloom. Requires bees for pollination. Duration of bloom: Varies
Tobacco	No	355,700	<2.5%	Typically, de-flowered as a standard production practice.

Terrestrial Invertebrates-Tree Injection

As discussed earlier, the submitted study on tree injection residues in tree parts took place during the Fall before leaf drop. As a result, there is a noted uncertainty with respect to the available emamectin benzoate that was contained in the fall leaves and, thus, unavailable for movement into spring flowers (and pollen/nectar). For clarity, this assessment considers the potential for effects from two time periods. **For applications made prior to leaf drop, the available residue data were representative and the RQ values were all below the LOC, thus, risk to pollinators or other terrestrial invertebrates foraging on nectar and pollen is considered low.**

For the application scenario that is "post leaf drop" timing (for example, the leaves drop in the fall and an injection either occurs anytime between the leaf drop and new spring growth), there is more uncertainty. Because the data from the available study are insufficient for assessing the risk at this timing interval and the surrogate approach using the leaf residues is highly uncertain, further analysis was conducted using a leaf drop adjustment factor in order to gain a better understanding of the potential pollen and nectar concentrations. The adjustment factor was based concentrations based on the fall pre-leaf drop leaf concentrations and a spring leaf:pollen ratio. The ratio was calculated using the measured pollen from the first spring and the measured leaf residue from the closest interval to the pollen measurement (*e.g.*, for cherry tree: 171-178 DAA for pollen and 193 DAA for leaves). Using this approach, the resulting estimate after adjusting for the leaf drop factor is 0.115 and 0.390 mg a.i./kg (155 and 390 ppb) for the pollen of cherry and ash trees, respectively. For the nectar, because residues were only measured the second year, there is more uncertainty in estimating the concentration, thus, for assessment purposes, the estimated upper bound pollen values serve as a proxy for nectar. These values based on the adjusted empirical residue values were used in the BEE-Rex model to assess the

[36] Label is for Use in Puerto Rico only (PR160002-SLN)

[37] Outdoor-grown plants in commercial nursery production

dietary exposure and the resulting Dose-based EECs and RQ values (ranging up to **5.3** and **18.1** for the bing cherry and ash trees respectively) are presented in **Table 43**.

Table 43. RQ values for Bees based on the Measured Pollen (Adjusted for leaf drop factor) and also the TREX Default for Tree Injection

Adult life stage-caste	RQ values for Bing Cherry using Adjusted Empirical Residue Values	RQ values for Ash using Adjusted Empirical Residue Values
Worker (cell cleaning and capping)	1.2	4.1
Worker (brood and queen tending, nurse bees)	2.7	9.3
Worker (comb building, cleaning and food handling)	1.1	3.8
Worker (foraging for pollen)	0.8	2.7
Worker (foraging for nectar)	**5.3**	**18.1**
Worker (maintenance of hive in winter)	0.6	1.9
Drone	4.3	14.6

From this analysis, the refined RQs result in LOC exceedances across all the adult castes for both of the tested tree types. When comparing the highest RQs to the LOC, the cherry tree RQ of 5.3 is 13 times greater than the LOC and the Ash tree is 45 times the LOC of 0.4.

When considering what may be more typical as far as the application timing, information was requested from the Biological and Economic Division (BEAD) to help further characterize the risk to terrestrial invertebrates. According to information from BEAD, the main target pest for the tree injection use in trees such as white ash appears to be the emerald ash borer (*Agrilus planipennis*) and the optimal timing for this use is early May to mid-June (Herms *et al*. 2009),[38] thus, a late spring/early summer, in-season application (after bloom, for flowering trees) is the most likely timing for most usage of emamectin tree injections. Altogether, while the risk to pollinators and terrestrial invertebrates cannot be precluded for the tree injection use when applications are made after the fall leaf drop (for example, in the early spring), the most likely exposure from real world applications is better represented with the empirical residue data from the submitted study because the application is likely to be after bloom. A magnitude of residue study with timing set to best represent the typical field practice for emamectin benzoate would reduce the uncertainty in this assessment.

D. Review of Ecological Incident Data

A review of the Ecological Incident Information System (EIIS, version 2.1) combined with the OPP Aggregate Incident Data System (IDS) was conducted on May 26, 2017 and there were no reported incidents for emamectin benzoate. The absence of documented incidents does not necessarily mean that such incidents did not occur. Mortality incidents must be seen, reported, investigated, and

[38] Herms D.A., D.G. McCullough, D.R. Smitley, C. Sadof, R.C. Williamson, and P.L. Nixon. 2009. Insecticide options for protecting ash trees from emerald ash borer. North Central IPM Center Bulletin. 12 pp.

submitted to the Agency in order to be recorded in the incident databases. Incidents may not be noticed because the carcasses decayed, were removed by scavengers, or were in out-of-the-way or hard-to-see locations. Due to the voluntary nature of incident reporting, an incident may not be reported to appropriate authorities capable of investigating it. In addition, incident reports for non-target organisms typically provide information only on mortality events and plant damage. Sublethal effects in organisms such as abnormal behavior, reduced growth and/or impaired reproduction are rarely reported, except for phytotoxic effects in terrestrial plants.

E. Endangered Species Assessments

In November 2013, the EPA, along with the U.S. Fish & Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS) (collectively, the Services), and the U.S. Department of Agriculture (USDA) released a summary of their joint Interim Approaches for assessing risks to listed species from pesticides. The Interim Approaches were developed jointly by the agencies in response to the National Academy of Sciences' (NAS) recommendations and reflect a common approach to risk assessment shared by the agencies as a way of addressing scientific differences between the EPA and the Services. The NAS report outlines recommendations on specific scientific and technical issues related to the development of pesticide risk assessments that EPA and the Services must conduct in connection with their obligations under the Endangered Species Act (ESA) and FIFRA.

The joint Interim Approaches were released prior to a stakeholder workshop held on November 15, 2013. In addition, the EPA presented the joint Interim Approaches at the December 2013 Pesticide Program Dialogue Committee (PPDC) and State-FIFRA Issues Research and Evaluation Group (SFIREG) meetings, and held a stakeholder workshop in April 2014, allowing additional opportunities for stakeholders to comment on the Interim Approaches. As part of a phased, iterative process for developing the Interim Approaches, the agencies will also consider public comments on the Interim Approaches in connection with the development of upcoming Registration Review decisions. The details of the joint Interim Approaches are contained in the white paper "*Interim Approaches for National-Level Pesticide Endangered Species Act Assessments Based on the Recommendations of the National Academy of Sciences April 2013 Report*," dated November 1, 2013.

Given that the agencies are continuing to develop and work toward implementation of the Interim Approaches to assess the potential risks of pesticides to listed species and their designated critical habitat, this preliminary risk assessment for emamectin benzoate does not contain a complete ESA analysis that includes effects determinations for specific listed species or designated critical habitat. Although EPA has not yet completed effects determinations for specific species or habitats, for this preliminary assessment EPA conducted a screening-level assessment for all taxa of non-target wildlife and plants that assumes for the sake of the assessment that listed species and designated critical habitats may be present in the vicinity of the application of emamectin. This screening level assessment will allow EPA to focus its future evaluations on the types of species where the potential for effects exists once the scientific methods being developed by the agencies have been fully vetted. This screening-level risk assessment for emamectin benzoate indicates potential risks of direct acute effects to listed birds, terrestrial-phase amphibians and reptiles, mammals, and terrestrial invertebrates. There is also risk for potential chronic effects to listed mammals, FW and E/M aquatic invertebrates, and benthic invertebrates. Once the agencies have fully developed and implemented the scientific methods necessary to complete risk assessments for endangered and threatened (listed) species and their designated critical habitats, these methods will be applied to subsequent analyses for emamectin benzoate as part of completing this registration review.

F. Endocrine Disruptor Screening Program

As required by FIFRA and the Federal Food, Drug, and Cosmetic Act (FFDCA), EPA reviews numerous studies to assess potential adverse outcomes from exposure to chemicals. Collectively, these studies include acute, subchronic and chronic toxicity, including assessments of carcinogenicity, neurotoxicity, developmental, reproductive, and general or systemic toxicity. These studies include endpoints which may be susceptible to endocrine influence, including effects on endocrine target organ histopathology, organ weights, estrus cyclicity, sexual maturation, fertility, pregnancy rates, reproductive loss, and sex ratios in offspring. For ecological hazard assessments, EPA evaluates acute tests and chronic studies that assess growth, developmental and reproductive effects in different taxonomic groups. As part of this Registration Review Preliminary Risk Assessment, EPA reviewed these data and selected the most sensitive endpoints for relevant risk assessment scenarios from the existing hazard database. However, as required by FFDCA section 408(p), emamectin benzoate is subject to the endocrine screening part of the Endocrine Disruptor Screening Program (EDSP).

EPA has developed the EDSP to determine whether certain substances (including pesticide active and other ingredients) may have an effect in humans or wildlife similar to an effect produced by a "naturally occurring estrogen, or other such endocrine effects as the Administrator may designate." The EDSP employs a two-tiered approach to making the statutorily required determinations. Tier 1 consists of a battery of 11 screening assays to identify the potential of a chemical substance to interact with the estrogen, androgen, or thyroid (E, A, or T) hormonal systems. Chemicals that go through Tier 1 screening and are found to have the potential to interact with E, A, or T hormonal systems will proceed to the next stage of the EDSP where EPA will determine which, if any, of the Tier 2 tests are necessary based on the available data. Tier 2 testing is designed to identify any adverse endocrine-related effects caused by the substance, and establish a dose-response relationship between the dose and the E, A, or T effect.

Under FFDCA section 408(p), the Agency must screen all pesticide chemicals. Between October 2009 and February 2010, EPA issued test orders/data call-ins for the first group of 67 chemicals, which contains 58 pesticide active ingredients and 9 inert ingredients. A second list of chemicals identified for EDSP screening was published on June 14, 2013[39] and includes some pesticides scheduled for registration review and chemicals found in water. Neither of these lists should be construed as a list of known or likely endocrine disruptors. Emamectin benzoate is not on List 1 or List 2. For further information on the status of the EDSP, the policies and procedures, the lists of chemicals, future lists, the test guidelines and Tier 1 screening battery, please visit our website at http://www.epa.gov/endo/.

[39] See http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPPT-2009-0477-0074 for the final second list of chemicals.

APPENDIX A. TREX INPUTS/OUTPUTS

INPUTS

Chemical Identity and Application Information

Chemical Name:	Emmamectin Benzoate	
Seed Treatment? (Check if yes)	☐ FALSE	Seeding Rate (lbs/acre)
Use:	corn, all or unspecified	33.2
Product name and form:		
% A.I. (leading zero must be entered for formulations <1% a.i.):	100.00%	
Application Rate (lb ai/acre)	0.015	
Half-life (days):	35	
Application Interval (days):	7	
Number of Applications:	6	
Are you assessing applications with variable rates or intervals?	no	

Assessed Species Inputs (optional, use defaults for RQs for national level assessments)

What body weight range is assessed (grams)?	Birds	Mammals
Small	20	15
Medium	100	35
Large	1000	1000

Avian

Endpoint	Toxicity value	Indicate test species below	Optional Test Organism Body weight (g)	Optional Test Species Nam
LD50 (mg/kg-bw)	46.00	Mallard duck		
LC50 (mg/kg-diet)	570.00	Mallard duck		
NOAEL (mg/kg-bw)		Bobwhite quail		
NOAEC (mg/kg-diet)	40.00	Mallard duck		

Enter the Mineau et al. Scaling Factor 1.15

Mammalian

		Acute Study	Chronic Study
Size (g) of mammal used in toxicity study Default rat body weight is 350 grams		28.9	350
Endpoint	**Toxicity value**		**Reference (MRID)**
LD50 (mg/kg-bw)	22.00		
LC50 (mg/kg-diet)			
Reported Chronic Endpoint	0.60	mg/kg-bw	
Is dietary concentration (mg/kg-diet) reported from the available chronic mammal study? (yes or no)	no		

Estimated Chronic Diet Concentration Equivalent to Reported Chronic Daily Dose	12	mg/kg-diet based on standard FDA lab rat conversion

TREX-Results for Scenario 1: 0.015 lb a.i./A applied 6 times at 7-day intervals

Table A.1. Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotients

Size Class (grams)	Adjusted LD50	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
20	23.88	17.89	0.75	8.20	0.34	10.06	0.42	1.12	0.05	7.01	0.29	0.25	0.01
100	30.41	10.20	0.34	4.67	0.15	5.74	0.19	0.64	0.02	3.99	0.13	0.14	0.00
1000	42.95	4.57	0.11	2.09	0.05	2.57	0.06	0.29	0.01	1.79	0.04	0.06	0.00

Table A.2. Upper Bound Kenaga, Subacute Avian Dietary Based Risk Quotients

	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
LC50	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
570	15.71	0.03	7.20	0.01	8.83	0.02	0.98	0.00	6.15	0.01

Table A.3. Upper Bound Kenaga, Chronic Avian Dietary Based Risk Quotients

	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
NOAEC (ppm)	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
40	15.71	0.39	7.20	0.18	8.83	0.22	0.98	0.02	6.15	0.15

Table A.4. Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients

Size Class (grams)	Adjusted LD50	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	25.92	14.97	0.58	6.86	0.26	8.42	0.32	0.94	0.04	5.86464	0.2263	0.208	0.008
35	20.97	10.35	0.49	4.74	0.23	5.82	0.28	0.65	0.03	4.05325	0.1933	0.1437	0.0069
1000	9.07	2.40	0.26	1.10	0.12	1.35	0.15	0.15	0.02	0.93976	0.1036	0.0333	0.0037

Table A.5. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients										
NOAEC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
12	15.71	1.31	7.20	0.60	8.83	0.74	0.98	0.08	6.15	0.51

Table A.6. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted NOAEL	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	1.32	14.97	11.35	6.86	5.20	8.42	6.39	0.94	0.71	5.86	4.45	0.21	0.16
35	1.07	10.35	9.70	4.74	4.45	5.82	5.46	0.65	0.61	4.05	3.80	0.14	0.13
1000	0.46	2.40	5.20	1.10	2.38	1.35	2.92	0.15	0.32	0.94	2.04	0.03	0.07

<u>Rate Scenario 2: 0.015 lbs a.i./A applied 4 X with a 5-day interval</u>

Table A.7. Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted LD50	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
20	23.88	14.22	0.60	6.52	0.27	8.00	0.33	0.89	0.04	5.57	0.23	0.20	0.01
100	30.41	8.11	0.27	3.72	0.12	4.56	0.15	0.51	0.02	3.18	0.10	0.11	0.00
1000	42.95	3.63	0.08	1.66	0.04	2.04	0.05	0.23	0.01	1.42	0.03	0.05	0.00

Table A.8. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients										
NOAEC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
12	12.49	1.04	5.72	0.48	7.02	0.59	0.78	0.07	4.89	0.41

Table A.9. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients														
Size Class (grams)	Adjusted NOAEL	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	1.32	11.91	9.03	5.46	4.14	6.70	5.08	0.74	0.56	4.66	3.54	0.17	0.13
35	1.07	8.23	7.71	3.77	3.54	4.63	4.34	0.51	0.48	3.22	3.02	0.11	0.11
1000	0.46	1.91	4.13	0.87	1.89	1.07	2.33	0.12	0.26	0.75	1.62	0.03	0.06

Rate Scenario 3: 0.015 lbs a.i./A applied 3 X with a 7-day interval

Note: For this Scenario, RQ Tables are only provided for mammals as there were no Acute LOC exceedances for birds.

Table A.10. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients										
NOAEC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
12	9.46	0.79	4.34	0.36	5.32	0.44	0.59	0.05	3.71	0.31

Table A.11. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted NOAEL	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	1.32	9.02	6.84	4.13	3.14	5.07	3.85	0.56	0.43	3.53	2.68	0.13	0.10
35	1.07	6.24	5.84	2.86	2.68	3.51	3.29	0.39	0.37	2.44	2.29	0.09	0.08
1000	0.46	1.45	3.13	0.66	1.44	0.81	1.76	0.09	0.20	0.57	1.23	0.02	0.04

TREX-Results for Scenario 1- Alternative (using variable Rate Interval): 0.015 lb a.i./A applied 6 times at 7-day intervals (with MOA switch after two applications of emamectin benzoate)

Table A-12. Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotients														
Size Class (grams)	Adjusted LD50	EECs and RQs												
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore		
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	
20	23.88	15.61	0.65	7.15	**0.30**	8.78	**0.37**	0.98	0.04	6.11	**0.26**	0.22	0.01	
100	30.41	8.90	**0.29**	4.08	**0.13**	5.01	**0.16**	0.56	0.02	3.49	**0.11**	0.12	0.00	
1000	42.95	3.98	0.09	1.83	0.04	2.24	0.05	0.25	0.01	1.56	0.04	0.06	0.00	

Table A-13.. Upper Bound Kenaga, Subacute Avian Dietary Based Risk Quotients										
	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
LC50	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
570	13.70	0.02	6.28	0.01	7.71	0.01	0.86	0.00	5.37	0.01

Table A-14. Upper Bound Kenaga, Chronic Avian Dietary Based Risk Quotients										
	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
NOAEC (ppm)	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
40	13.70	0.34	6.28	0.16	7.71	0.19	0.86	0.02	5.37	0.13

Table A-15. Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted LD50	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	25.92	13.06	0.50	5.99	**0.23**	7.35	**0.28**	0.82	0.03	5.11673	**0.1974**	0.1814	0.007
35	20.97	9.03	**0.43**	4.14	**0.20**	5.08	**0.24**	0.56	0.03	3.53635	**0.1686**	0.1254	0.006
1000	9.07	2.09	**0.23**	0.96	**0.11**	1.18	**0.13**	0.13	0.01	0.81991	0.0904	0.0291	0.0032

Table A-16. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients										
NOAEC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
12	13.70	1.14	6.28	0.52	7.71	0.64	0.86	0.07	5.37	0.45

Table A-17. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients														
Size Class (grams)	Adjusted NOAEL	EECs and RQs												
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore		
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	
15	1.32	13.06	9.91	5.99	4.54	7.35	5.57	0.82	0.62	5.12	3.88	0.18	0.14	
35	1.07	9.03	8.46	4.14	3.88	5.08	4.76	0.56	0.53	3.54	3.31	0.13	0.12	
1000	0.46	2.09	4.54	0.96	2.08	1.18	2.55	0.13	0.28	0.82	1.78	0.03	0.06	

APPENDIX B. BEEREX INPUT/OUTPUT

A. FOLIAR SPRAY-Risk Estimation

Table 1. User inputs (related to exposure)

Description	Value
Application rate	0.015
Units of app rate	lb a.i./A
Application method	foliar spray
Are empirical residue data available?	no

Table 2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	0.0028
Adult oral LD50	0.0063
Adult oral NOAEL	No Data
Larval LD50	No Data
Larval NOAEL	No Data

Table 3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	1.65	0.00165

Table 4. Daily consumption of food, pesticide dose and resulting dietary RQs for all bees

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	0.1099725	17.4559524
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	0.24684	39.1809524
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	0.101805	16.1595238
	Worker (foraging for pollen)	>18	0	43.5	0.041	0.07184265	11.4035952
	Worker (foraging for nectar)	>18	0	292	0.041	0.48186765	76.4869286
	Worker (maintenance of hive in winter)	0-90	0	29	2	0.05115	8.11904762
	Drone	>10	0	235	0.0002	0.38775033	61.5476714
	Queen (laying 1500 eggs/day)	Life	525	0	0	0.0086625	1.375

B. Tree Injection-Using Labeled Rate for Bounding/Line of Evidence

Table 6. User inputs (related to exposure)	
Description	**Value**
Application rate	7118
Units of app rate	mg a.i./tree
Application method	tree trunk
Mass of tree vegetation (kg-wet weight)	4.23
Are empirical residue data available?	no

Table 7. Toxicity data	
Description	**Value (µg a.i./bee)**
Adult contact LD50	0.0028
Adult oral LD50	0.0063
Adult oral NOAEL	
Larval LD50	
Larval NOAEL	

Table 8. Estimated concentrations in pollen and nectar		
Application method	**EECs (mg a.i./kg)**	**EECs (µg a.i./mg)**
tree trunk	1682.7	1.7

Table 9. Daily consumption of food, pesticide dose and resulting dietary RQs for all bees

Adults_Caste or task in hive	**Average age (in days)**	**Jelly (mg/day)**	**Nectar (mg/day)**	**Pollen (mg/day)**	**Total dose (µg a.i./bee)**	**Acute RQ**
Worker (cell cleaning and capping)	0-10	0	60	6.65	112.2	17802
Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	251.7	39958
Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	103.8	16480
Worker (foraging for pollen)	>18	0	43.5	0.041	73.3	11630
Worker (foraging for nectar)	>18	0	292	0.041	491.4	**78005**
Worker (maintenance of hive in winter)	0-90	0	29	2	52.2	8280
Drone	>10	0	235	0.0002	395.4	62769
Queen (laying 1500 eggs/day)	Entire lifestage	525	0	0	8.83	1402

APPENDIX C. TERR PLANT INPUT/OUTPUT

Table 1. Chemical Identity.	
Parameter	**User Inputs**
Chemical Name	Emamectin Benzoate
PC code	
Use	
Application Method	Aerial
Application Form	liquid
Solubility in Water (ppm)	93

Table 2. Input parameters used to derive EECs.			
Input Parameter	**Symbol**	**Value (user inputs)**	**Units**
Application Rate	A	0.015	
Incorporation	I	1	none
Runoff Fraction	R	0.02	none
Drift Fraction	D	0.05	none

Table 3. EECs for Emamectin Benzoate. Units in .		
Description	**Equation**	**EEC**
Runoff to dry areas	(A/I)*R	0.0003
Runoff to semi-aquatic areas	(A/I)*R*10	0.003
Spray drift	**A*D**	**0.00075**
Total for dry areas	**((A/I)*R)+(A*D)**	**0.00105**
Total for semi-aquatic areas	**((A/I)*R*10)+(A*D)**	**0.00375**

Table 4. Plant survival and growth data used for RQ derivation. Units are in . All values are user inputs				
	Seedling Emergence		**Vegetative Vigor**	
Plant type	**EC25**	**NOAEC**	**EC25**	**NOAEC**
Monocot	0.3	0.3	0.27	0.27
Dicot	0.232	0.038	0.27	0.27

Table 5. RQ values for plants in dry and semi-aquatic areas exposed to Emamectin Benzoate through runoff and/or spray drift.*				
Plant Type	**Listed Status**	**Dry**	**Semi-Aquatic**	**Spray Drift**
Monocot	non-listed	<0.1	<0.1	<0.1
Monocot	listed	<0.1	<0.1	<0.1
Dicot	non-listed	<0.1	<0.1	<0.1
Dicot	listed	<0.1	<0.1	<0.1
*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.				

APPENDIX D. EMAMECTIN CROP CYCLE CALCULATIONS

The following calculations represent a conservative effort to estimate the maximum allowable label use for emamectin on a field rotating these crops, based on assumptions provided in Table D-1 (U.S. EPA, 2007; U.S. EPA, 2016).

Table D-1. Potential harvest times and crop rotations found in California.

Crop	Planting Dates	Days to Harvest	Harvest (days)	Total Days[1]	Comments
Broccoli	All year	50 (transplant)	14	92	2 crops/yr, rotate with lettuce
Lettuce	Dec 15 – Sept 7	80	1	109	1-2 crops/yr in rotation
Spinach	All year	62	1	91	2-3 crops/yr consecutive

[1] Including 28-day buffer between crops for soil preparation.

Scenario: Broccoli and lettuce rotation

1. Broccoli, transplanted January 1
   Potential applications (days since planting): +0, +7, +21, +28, +42
   **Note: Label specifies 7-day re-treatment interval, with no more than two sequential applications before pesticide rotation. Therefore, every two applications are followed by a 14-day interval.*
   Totals: 92 days, 5-6 applications

2. Lettuce, planted April 3
   Potential applications (days since planting): +25, +32, +46, +53, +67, +74
   Totals: 109 days, 6 applications

3. Broccoli, transplanted July 21
   Potential applications (days since planting): +0, +7, +21, +28, +42
   Totals: 92 days, 5-6 applications
   ANNUAL: 293 days, 16 applications = 0.24 lb a.i./acre

Based on these calculations, it is reasonable to assume that emamectin could be applied to a California field at an annual rate of 0.24 lb a.i./acre based on label specifications. Table D-2 outlines an example time series for use in the Pesticide Water Calculator (PWC) as inputs for the timing of emamectin applications on a Scenario 1 (broccoli-lettuce-broccoli) rotation, assuming 16 total applications. Other input parameters for aerial application include 95% efficiency and a drift factor of 0.042, based on a Tier I Aquatic assessment for emamectin in AgDRIFT with a label-specified 150 ft buffer.

Table D-2. Schematic for inputs to PWC for application timing.

Crop	Days Since Emergence	Date	Description
Broccoli Transplant	+0	Jan-1	0.015 lb a.i./acre emamectin[1]
	+7	Jan-8	0.015 lb a.i./acre emamectin
	+14	Jan-15	Pesticide rotation
	+21	Jan-22	0.015 lb a.i./acre emamectin
	+28	Jan-29	0.015 lb a.i./acre emamectin
	+35	Feb-5	Pesticide rotation
	+42	Feb-12	0.015 lb a.i./acre emamectin
	+50	Feb-20	Start harvest
	+64	Mar-6	End 14-day harvest
Soil Prep	+92	Apr-3	End 28-day soil preparation for next crop
Lettuce	+97	Apr-8	4-day allowance for sprout
	+117	Apr-28	0.015 lb a.i./acre emamectin, +20 from emergence
	+124	May-5	0.015 lb a.i./acre emamectin
	+131	May-12	Pesticide rotation
	+138	May-19	0.015 lb a.i./acre emamectin
	+145	May-26	0.015 lb a.i./acre emamectin
	+152	Jun-2	Pesticide rotation
	+159	Jun-9	0.015 lb a.i./acre emamectin
	+166	Jun-16	0.015 lb a.i./acre emamectin
	+173	Jun-23	1-day harvest
Soil Prep	+201	Jul-21	End 28-day soil preparation for next crop
Broccoli Transplant	+202	Jul-22	Planting, 0.015 lb a.i./acre emamectin
	+209	Jul-29	0.015 lb a.i./acre emamectin
	+216	Aug-5	Pesticide rotation
	+223	Aug-12	0.015 lb a.i./acre emamectin
	+230	Aug-19	0.015 lb a.i./acre emamectin
	+237	Aug-26	Pesticide rotation
	+244	Sep-2	0.015 lb a.i./acre emamectin

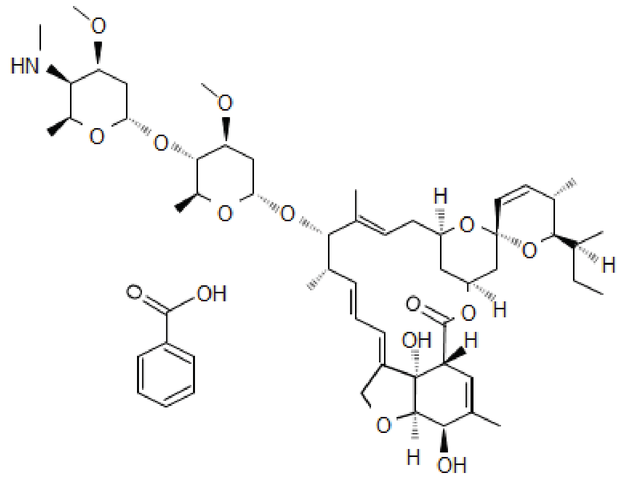
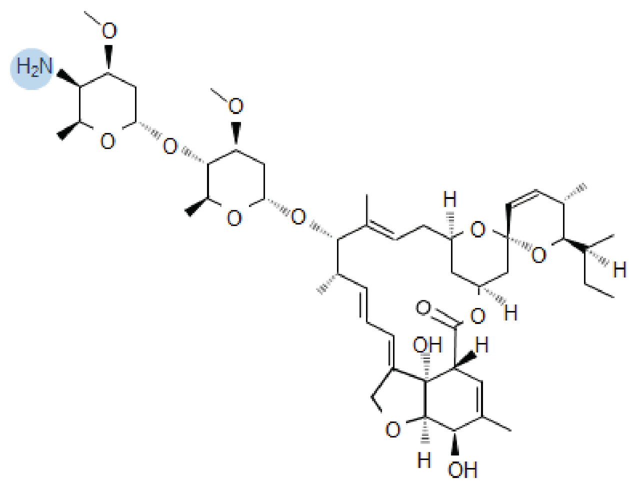
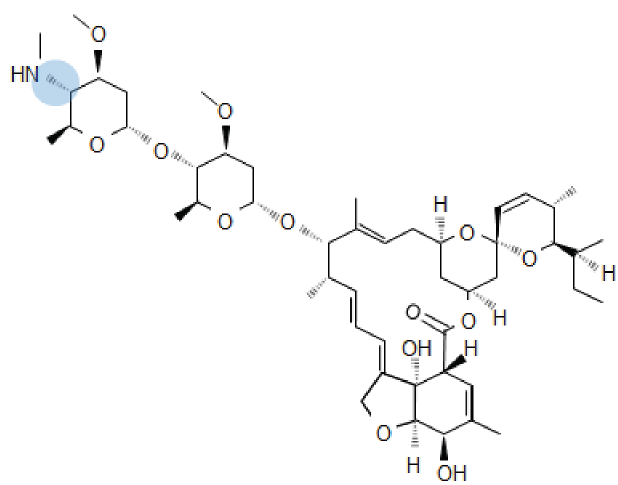
[1] Rate equivalent to 0.0168 kg/ha

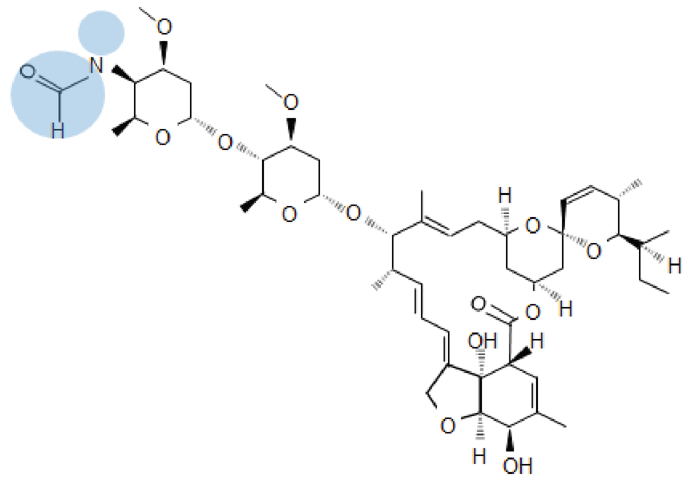
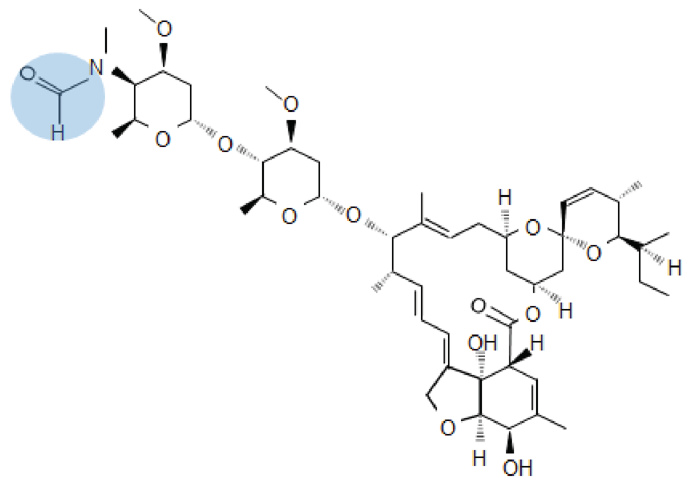
Appendix D References

U.S. EPA. 2007. Maximum Number of Crop Cycles Per Year in California for Methomyl Use Sites. February 28, 2007. U.S. Environmental Protection Agency, Office of Pesticide Programs, Biological and Economic Analysis Division. Arlington, VA.

U.S. EPA. 2016. Draft. Determining Typical Multiple Crop Rotations of Annual Fruits and Vegetables on a Single Field for California, Florida, Michigan, and Texas. January 15, 2016. U.S. Environmental Protection Agency, Office of Pesticide Programs, Biological and Economic Analysis Division. Arlington, VA.

APPENDIX E. EMAMECTIN BENZOATE TOTAL TOXIC RESIDUES

Residue	Maximum Formation	Structure[1]
Emamectin benzoate, MAB_{1a}	--	
AB_{1a}	**Aerobic Soil Metabolism** <u>MRID 48480102</u> 18 Acres Soil: 1.2% Gartenacker Soil: 1.7% Marsillargues Soil: 0.8%	
8,9-Z MAB_{1a} isomer	**Aqueous Photolysis** <u>MRID 43850114</u> Buffered Water: 12% Natural Water: 17%	

Residue	Maximum Formation	Structure[1]
FAB_{1a}	**Not quantified/ identified**	
MFB_{1a}	**Aerobic Soil Metabolism** <u>MRID 48480103</u> 40% MWC low rate: 6.2% 20% MWC low rate: 3.1% 40% MWC high rate: 4.7%	

[1] Highlighting indicates differences between parent emamectin benzoate and transformation products.

APPENDIX F. KABAM MODEL INPUT/OUTPUT

KABAM INPUT/OUTPUT for (Maximum upper bound -21-day EECs-Brassica/Leafy 3 CC Rotation)

Table 1. Chemical characteristics of Emamectin.		
Characteristic	**Value**	**Comments/Guidance**
Pesticide Name	**Emamectin**	**Required input**
Log K_{OW}	**5**	**Required input** Enter value from acceptable or supplemental study submitted by registrant or available in scientific literature.
K_{OW}	**100000**	No input necessary. This value is calculated automatically from the Log K_{OW} value entered above.
K_{OC} (L/kg OC)	**804**	**Required input** Input value used in PRZM/EXAMS to derive EECs. Follow input parameter guidance for deriving this parameter value (USEPA 2002).
Time to steady state (T_S; days)	**30**	No input necessary. This value is calculated automatically from the Log K_{OW} value entered above.
Pore water EEC (µg/L)	**2.39**	**Required input** Enter value generated by PRZM/EXAMS benthic file. PRZM/EXAMS EEC represents the freely dissolved concentration of the pesticide in the pore water of the sediment. The appropriate averaging period of the EEC is dependent on the specific pesticide being modeled and is based on the time it takes for the chemical to reach steady state. Select the EEC generated by PRZM/EXAMS which has an averaging period closest to the time to steady state calculated above. In cases where the time to steady state exceeds 365 days, the user should select the EEC representing the average of yearly averages. The peak EEC should not be used.

Water Column EEC (µg/L)	**2.35**	**Required input** Enter value generated by PRZM/EXAMS water column file. PRZM/EXAMS EEC represents the freely dissolved concentration of the pesticide in the water column. The appropriate averaging period of the EEC is dependent on the specific pesticide being modeled and is based on the time it takes for the chemical to reach steady state. The averaging period used for the water column EEC should be the same as the one selected for the pore water EEC (discussed above).

Table 2. Input parameters for rate constants. "calculated" indicates that model will calculate rate constant.

Trophic level	**k_1 (L/kg*d)**	**k_2 (d^{-1})**	**k_D (kg-food/kg-org/d)**	**k_E (d^{-1})**	**k_M* (d^{-1})**
phytoplankton	calculated	calculated	0*	0*	0
zooplankton	calculated	calculated	calculated	calculated	0
benthic invertebrates	calculated	calculated	calculated	calculated	0
filter feeders	calculated	calculated	calculated	calculated	0
small fish	calculated	calculated	calculated	calculated	0.1866
medium fish	calculated	calculated	calculated	calculated	0.1866
large fish	calculated	calculated	calculated	calculated	0.1866

* Default value is 0.

k_1 and k_2 represent the uptake and elimination constants respectively, through respiration.

k_D and k_E represent the uptake and elimination constants, respectively, through diet.

k_M represents the metabolism rate constant.

Table 3. Mammalian and avian toxicity data for Emamectin. These are required inputs.				
Animal	**Measure of effect (units)**	**Value**	**Species**	**If selected species is "other," enter body weight (in kg) here.**
Avian	LD_{50} (mg/kg-bw)	46	mallard duck	
	LC_{50} (mg/kg-diet)	570	mallard duck	
	NOAEC (mg/kg-diet)	40	mallard duck	
	Mineau Scaling Factor	1.15	Default value for all species is 1.15 (for chemical specific values, see Mineau et al. 1996).	
Mammalian	LD_{50} (mg/kg-bw)	22	other	0.028
	LC_{50} (mg/kg-diet)	N/A	other	
	Chronic Endpoint	0.6	laboratory rat	
	units of chronic endpoint*	mg/kg-bw		

*ppm = mg/kg-diet

Table 16. Calculation of RQ values for mammals and l consuming fish contaminated by Emamectin.			
Wildlife Species	Acute		Cl
	Dose Based	Dietary Based	Dose Based
Mammalian			
fog/water shrew	**0.221**	N/A	**4.310**
rice rat/star-nosed mole	**0.211**	N/A	**4.122**
small mink	**0.111**	N/A	**2.166**
large mink	**0.123**	N/A	**2.393**
small river otter	**0.132**	N/A	**2.576**
large river otter	0.072	N/A	**1.407**
Avian			
sandpipers	**0.314**	0.013	N/A
cranes	0.015	0.011	N/A
rails	**0.157**	0.014	N/A
herons	0.021	0.012	N/A
small osprey	0.019	0.007	N/A
white pelican	0.004	0.004	N/A

KABAM INPUT/OUTPUT for (Based on lowerbound-21-day EECs-Brassica/Leafy 3 CC Rotation)

Table 1. Chemical characteristics of Emamectin.		
Characteristic	**Value**	**Comments/Guidance**
Pesticide Name	**Emamectin**	**Required input**
Log K_{OW}	**5**	**Required input** Enter value from acceptable or supplemental study submitted by registrant or available in scientific literature.
K_{OW}	**100000**	No input necessary. This value is calculated automatically from the Log K_{OW} value entered above.
K_{OC} (L/kg OC)	**804**	**Required input** Input value used in PRZM/EXAMS to derive EECs. Follow input parameter guidance for deriving this parameter value (USEPA 2002).
Time to steady state (T_S; days)	**30**	No input necessary. This value is calculated automatically from the Log K_{OW} value entered above.
Pore water EEC (µg/L)	**0.803**	**Required input** Enter value generated by PRZM/EXAMS benthic file. PRZM/EXAMS EEC represents the freely dissolved concentration of the pesticide in the pore water of the sediment. The appropriate averaging period of the EEC is dependent on the specific pesticide being modeled and is based on the time it takes for the chemical to reach steady state. Select the EEC generated by PRZM/EXAMS which has an averaging period closest to the time to steady state calculated above. In cases where the time to steady state exceeds 365 days, the user should select the EEC representing the average of yearly averages. The peak EEC should not be used.
Water Column EEC (µg/L)	**0.434**	**Required input** Enter value generated by PRZM/EXAMS water column file. PRZM/EXAMS EEC represents the freely dissolved concentration of the pesticide in the water column. The appropriate averaging period of the EEC is dependent on the specific pesticide being modeled and is based on the time it takes for the chemical to reach steady state. The averaging period used for the water column EEC should be the same as the one selected for the pore water EEC (discussed above).

Table 2. Input parameters for rate constants. "calculated" indicates that model will calculate rate constant.					
Trophic level	k_1 (L/kg*d)	k_2 (d^{-1})	k_D (kg-food/kg-org/d)	k_E (d^{-1})	k_M* (d^{-1})
phytoplankton	calculated	calculated	0*	0*	0
zooplankton	calculated	calculated	calculated	calculated	0
benthic invertebrates	calculated	calculated	calculated	calculated	0
filter feeders	calculated	calculated	calculated	calculated	0
small fish	calculated	calculated	calculated	calculated	0.18664
medium fish	calculated	calculated	calculated	calculated	0.18664
large fish	calculated	calculated	calculated	calculated	0.18664

* Default value is 0.

k_1 and k_2 represent the uptake and elimination constants respectively, through respiration.

k_D and k_E represent the uptake and elimination constants, respectively, through diet.

k_M represents the metabolism rate constant.

Table 3. Mammalian and avian toxicity data for Emamectin. These are required inputs.				
Animal	Measure of effect (units)	Value	Species	If selected species is "other," enter body weight (in kg) here.
Avian	LD_{50} (mg/kg-bw)	46	mallard duck	
	LC_{50} (mg/kg-diet)	570	mallard duck	
	NOAEC (mg/kg-diet)	40	mallard duck	
	Mineau Scaling Factor	1.15	Default value for all species is 1.15 (for chemical specific values, see Mineau et al. 1996).	
Mammalian	LD_{50} (mg/kg-bw)	22	other	0.028
	LC_{50} (mg/kg-diet)	N/A	other	
	Chronic Endpoint	0.6	laboratory rat	
	units of chronic endpoint*	mg/kg-bw		

Wildlife Species	Acute		Chronic	
	Dose Based	Dietary Based	Dose Based	Dietary Based
Mammalian				
fog/water shrew	0.043	N/A	0.831	0.149
rice rat/star-nosed mole	0.041	N/A	0.794	0.117
small mink	0.021	N/A	0.417	0.067
large mink	0.024	N/A	0.460	0.067
small river otter	0.025	N/A	0.495	0.067
large river otter	0.013	N/A	0.262	0.033
Avian				
sandpipers	0.060	0.002	N/A	0.035
cranes	0.003	0.002	N/A	0.031
rails	0.030	0.003	N/A	0.038
herons	0.004	0.002	N/A	0.032
small osprey	0.004	0.001	N/A	0.020
white pelican	0.001	0.001	N/A	0.010

APPENDIX G. ESTIMATED ENVIRONMENTAL CONCENTRATIONS FOR PARENT-ONLY ANALYSIS

The following EECs are for emamectin benzoate, not following a TTR approach. These EECs assume the upper bound half-life calculations (EFED guidance for applying soil metabolism data to aquatic metabolism) and maximum application rates and frequencies.

Use	App. Type	PWC Scenario	Water Column EEC (µg/L)			Pore Water EEC (µg/L)		Sediment EEC (µg/kg)	
			Average	21-day	60-day	Peak	21-day	Peak	21-day
Brassica vegetables; cole crops; leafy greens *(3 crop cycles)*	Aerial	CAlettuceSTD	2.39	2.33	2.3	2.32	2.29	1865	1841
		CAColeCropRLF_V2	1.6	1.53	1.51	1.52	1.51	1222	1214
		FLcabbageSTD	1.56	1.44	1.43	1.43	1.43	1150	1150
	Ground	CAlettuceSTD	2.34	2.27	2.24	2.26	2.24	1817	1801
		CAColeCropRLF_V2	1.52	1.44	1.43	1.43	1.42	1150	1142
		FLcabbageSTD	1.49	1.37	1.35	1.35	1.35	1085	1085
Fruiting vegetables; brassica vegetables; cole crops; leafy greens *(1 crop cycle)*	Aerial	CAtomato_WirrigSTD	0.214	0.195	0.193	0.19	0.19	153	153
		FLpeppersSTD	0.711	0.665	0.661	0.659	0.658	530	529
		FLtomatoSTD_V2	0.81	0.763	0.756	0.753	0.753	605	605
		PAtomatoSTD	1.4	1.3	1.3	1.3	1.3	1045	1045
		PAvegetableNMC	1.79	1.58	1.56	1.56	1.56	1254	1254
		STXvegetableNMC	0.973	0.89	0.888	0.885	0.885	712	712
	Ground	CAtomato_WirrigSTD	0.16	0.147	0.146	0.143	0.143	115	115
		FLpeppersSTD	0.689	0.639	0.637	0.635	0.635	511	511
		FLtomatoSTD_V2	0.79	0.743	0.736	0.734	0.734	590	590
		PAtomatoSTD	1.4	1.3	1.29	1.29	1.29	1037	1037
		PAvegetableNMC	1.8	1.59	1.57	1.56	1.56	1254	1254
		STXvegetableNMC	0.962	0.878	0.873	0.871	0.87	700	699
Corn, field; for seed only *(Puerto Rico)*	Ground	PRcoffeeSTD	0.69	0.628	0.616	0.608	0.607	489	488
		FLsweetcornOP	0.349	0.325	0.321	0.32	0.32	257	257
Cotton, unspecified	Aerial	CAcotton_WirrigSTD	0.209	0.191	0.187	0.184	0.184	148	148
		MScottonSTD	1.17	1.07	1.06	1.05	1.05	844	844
		NCcottonSTD	1.28	1.17	1.15	1.15	1.15	925	925
		STXcottonNMC	0.78	0.7	0.692	0.691	0.691	556	556
		TXcottonOP	1.02	0.95	0.924	0.912	0.912	733	733
Ornamental	Aerial	CAnurserySTD_V2	0.876	0.83	0.826	0.822	0.822	661	661
		FLnurserySTD_V2	0.695	0.651	0.647	0.646	0.646	519	519
		MInurserySTD_V2	0.638	0.58	0.577	0.577	0.577	464	464
		NJnurserySTD_V2	0.887	0.806	0.803	0.802	0.802	645	645

Use	App. Type	PWC Scenario	Water Column EEC (µg/L)			Pore Water EEC (µg/L)		Sediment EEC (µg/kg)	
			Average	21-day	60-day	Peak	21-day	Peak	21-day
		NurseryBSS_V2	0.402	0.38	0.375	0.373	0.373	300	300
		ORnurserySTD_V2	0.289	0.271	0.267	0.265	0.265	213	213
		TNnurserySTD_V2	0.845	0.812	0.808	0.807	0.807	649	649
	Airblast	CAnurserySTD_V2	0.842	0.757	0.753	0.753	0.753	605	605
		FLnurserySTD_V2	0.657	0.583	0.579	0.579	0.578	466	465
		MInurserySTD_V2	0.562	0.494	0.492	0.491	0.491	395	395
		NJnurserySTD_V2	0.821	0.734	0.73	0.73	0.729	587	586
		NurseryBSS_V2	0.324	0.295	0.29	0.29	0.29	233	233
		ORnurserySTD_V2	0.183	0.17	0.168	0.168	0.168	135	135
		TNnurserySTD_V2	0.774	0.742	0.738	0.738	0.738	593	593
Tree nuts; pistachio; pome fruit	Airblast	CAalmond_WirrigSTD	0.0977	0.0892	0.0874	0.0873	0.0873	70	70
		CAfruit_WirrigSTD	0.0512	0.0436	0.0416	0.0407	0.0407	33	33
		GAPecansSTD	0.501	0.443	0.436	0.436	0.436	351	351
		NCappleSTD	0.462	0.383	0.372	0.369	0.369	297	297
		ORappleSTD	0.154	0.142	0.14	0.139	0.139	112	112
		ORfilbertsSTD	0.15	0.14	0.138	0.137	0.137	110	110
		PAappleSTD_V2	0.469	0.415	0.411	0.41	0.41	330	330
		OrchardBSS	0.339	0.297	0.292	0.289	0.289	232	232
		WAorchardsNMC	0.0486	0.0421	0.0401	0.0391	0.0391	31	31
Research crops, for seed only *(Puerto Rico)*	Ground	PRcoffeeSTD	0.69	0.628	0.616	0.608	0.607	489	488
Tobacco	Ground	NCtobaccoSTD	0.246	0.222	0.22	0.219	0.219	176	176

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MRID	Citation Reference

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14.83-6 Developmental Neurotoxicity

MRID	Citation Reference
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16.85-3 123-2 Aquatic plant growth

MRID	Citation Reference
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MRID	Citation Reference
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44007903	Dunbar, D. (1996) Dissipation of Dislodgeable MK-0244 0.16 EC Residues from Foliage of Celery when Applied with Non-ionic Surfactants by Ground Equipment: Lab Project Number: 618-244-93859: 001-93-5010R: 93859. Unpublished study prepared by Merck Research Labs; Plant Sciences, Inc.; and Agvise Labs. 943 p.
44007904	Wehner, T. (1996) Method Validation: HPLC-Fluorescence Method to Determine the Foliar Dislodgeable Total Toxic Residues of MK-0244 and Its Metabolites in Leaf Disk Extracts: Analytical Research Method 244-93-2: Lab Project Number: 618-244-93902: 93902: 3902. Unpublished study prepared by Merck Research Labs. 939 p.

18.141-1 Honey bee acute contact

MRID	Citation Reference
42851530	Hoxter, K. (1993) MK-244: An Acute Contact Toxicity Study with the Honeybee (Apis mellifera L.): Lab Project Number: 105-146. Unpublished study prepared by Wildlife International, Ltd. 29 p.

19.141-2 Honey bee residue on foliage

MRID	Citation Reference
43393006	Palmer, S. (1994) MK-244: A Foliage Residue Toxicity Study with the Honey Bee (Apis mellifera L.): Lab Project Number: 105-147A. Unpublished study prepared by Wildlife International, Ltd. 90 p.

20.152-12 Acute Inhalation Toxicity

MRID	Citation Reference
49009001	Pinto, P. (2007) Emamectin Benzoate Technical: 5 Day Preliminary Inhalation Toxicity Study in Mice: Final Report. Project Number: MM0235/REG, MM0235, T007132/05. Unpublished study prepared by Central Toxicology Lab. (Syngenta). 191p.

21.161-1 Hydrolysis

MRID	Citation Reference
42743642	Chukwudebe, A. (1992) MK-0244:Hydrolysis of 4"-Deoxy-4"-Epimethylamino Avermectin B1a Benzoate as a Function of pH at 25C (ENC-3): Lab Project Number: ENC-3. Unpublished study prepared by Merck & Co., Inc. Merck Research Labs. 240 p.

22.161-2 Photodegradation-water

MRID	Citation Reference
43404301	Ballantine, L. (1994) Artificial Sunlight Photolysis of (carbon 14)4"-Epimethylamino-4"-Deoxyavermectin B1a Benzoate ((carbon 14)MAB1a) in Aqueous Media: Lab Project Number: 618-244-93444: 6411-100. Unpublished study prepared by Hazleton Wisconsin, Inc. and Merck Research Labs. 129 p.
43850114	Mushtaq, M. (1995) Photodegradation of (carbon 14)- 4"-Deoxy-4"-epimethylaminoavermectin B1a (MAB1a) Benzoate in Aqueous Media: Final Report: Lab Project Number: ENC-6: 93992: 3992. Unpublished study prepared by Merck Research Labs. 449 p.

23.161-3 Photodegradation-soil

MRID	Citation Reference
43404302	Chukwudebe, A. (1994) Photodegradation of (carbon 14)4"-Epimethylamino-4"-Deoxyavermectin B1a Benzoate ((carbon 14)MAB1a) on soil: Lab Project Number: 93845: 3401: 618-244-93845. Unpublished study prepared by Merck Research Lab and Agrisearch Inc. 210 p.
44010001	O'Grodnick, J. (1995) Response to the EFGWB Environmental Fate Review for Emamectin Benzoate Regarding Soil Photolysis and Aerobic Soil Metabolism: Lab Project Number: 618-244-R/EFATE. Unpublished study prepared by Merck Research Laboratories. 9 p.

24.161-4 Photodegradation-air

MRID	Citation Reference
44007906	Crouch, L. (1996) Assay and Characterization of Polar Photodegradates of MK244 and (carbon 14)-MK244: Lab Project Number: 93692 (PMES TCR-1). Unpublished study prepared by Merck Research Labs; Galbraith Labs, Inc.; and Ricerca, Inc. 128 p.
44007907	Wrzesinski, C. (1996) Comparison, Characterization, and/or Identification of Polar MK-0244 Plant and Thin Film Photolysis Residues: Lab Project Number: PLM9: 94404 (PMES PLM-9): PMES/DMII/MRL. Unpublished study prepared by Merck Research Labs. 406 p.

25.162-1 Aerobic soil metabolism

MRID	Citation Reference
43235101	Chukwudebe, A. (1994) Aerobic Soil Metabolism of (carbon 14) MAB1a: Interim Report: Lab Project Number: 587: 93257. Unpublished study prepared by PTRL East, Inc. 90 p.
43404303	Chukwudebe, A. (1994) Aerobic Soil Metabolism of (carbon 14)4"-Epimethylamino-4"-Deoxyavermectin B1a Benzoate ((carbon 14)MAB1a): Lab Project Number: 618-244-93257: 3257: 93257. Unpublished study prepared by Merck Research Labs and PTRL East, Inc. 173 p.
43850115	Chukwedebe, A. (1995) Aerobic Soil Metabolism of (carbon 14)- 4"-Epimethylamino-4"-Deoxyavermectin B1a Benzoate (carbon 14)-MAB1a: Characterization of the Unextractable Residues in Soil: Lab Project Number: MK-244/93257: 63257: 618-244-93257. Unpublished study prepared by Merck Research Labs. 31 p.
44007905	Atkins, R. (1995) Determination of the Degradation Rate of (hydrogen 3)MAB1a in Sandy Loam Soil Under Aerobic Conditions: Lab Project Number: 618-244-94169: 94169: 900. Unpublished study prepared by PTRL East, Inc. 67 p.
44010001	O'Grodnick, J. (1995) Response to the EFGWB Environmental Fate Review for Emamectin Benzoate Regarding Soil Photolysis and Aerobic Soil Metabolism: Lab Project Number: 618-244-R/EFATE. Unpublished study prepared by Merck Research Laboratories. 9 p.

26.162-2 Anaerobic soil metabolism

MRID	Citation Reference
43850116	Chukwudebe, A. (1995) Anaerobic Soil Metabolism of (carbon 14)- 4"-Epimethylamino-4"-Deoxyavermectin B1a Benzoate ((carbon 14)- MAB1a) in Sandy Loam Soil: Lab Project Number: 93258: 588: 3258. Unpublished study prepared by PTRL East, Inc. and Merck Research Labs. 181 p.

27.163-1 Leach/adsorp/desorption

MRID	Citation Reference
42743643	Feely, W. (1992) Soil Thin-Layer Chromatography (TLC) of (carbon 14)-MK-0244: Lab Project Number: PMES ENC #4. Unpublished study prepared by Merck & Co., Inc. Merck Research Labs. 48 p.
43850117	Reynolds, J. (1995) Aged Column Leaching of (carbon 14)- Labeled-4"-Deoxy-4"-Epimethylamino Avermectin B1a (MAB1a) Benzoate in Four Soils: Lab Project Number: XBL94171: RPT00233: 4310. Unpublished study prepared by XenoBiotic Labs, Inc. and Agvise Labs. 175 p.

28.164-1 Terrestrial field dissipation

MRID	Citation Reference
43404304	Norton, J. (1994) Dissipation and Leaching of MK-244 Following Multiple Applications of MK-244 0.16 EC Applied with Non-Ionic Surfactant to Bare Soil with Ground Equipment: Interim Report: Lab Project Number: 618-244-93601: 93601: 3601. Unpublished study prepared by A.C.D.S. Research, Inc.; Pan-Agricultural Labs, Inc.; and Research Designed for Agriculture. 2569 p.
43850118	Norton, J. (1995) Dissipation and Leaching of MK-244 Following Multiple Applications of MK-244 0.16 ED Applied with Non-Ionic Surfactant to Baresoil with Ground Equipment: Final Report: Lab Project Number: 618-244-93601: 93601: 001-92-6010R. Unpublished study prepared by A.C.D.S Research, Inc. and Pan-Agricultural Labs, Inc. 2020 p.

29.165-1 Confined rotational crop

MRID	Citation Reference
43850119	Chukwudebe, A. (1995) Confined Rotational Crop Study on MK-0244: Lab Project Number: 618-244-93259: ML-91-727: 93259. Unpublished study prepared by ABC Labs, Pan-Ag Division. 123 p.

30.171-11 Tobacco Uses: Total Residues and Pyrolysis Products

MRID	Citation Reference
44715103	Campbell, D. (1998) CGA-293343 and Emamectin--Magnitude of the Residue in or on Tobacco: Interim Report: Lab Project Number: 133-98: OS-IR-606-98/NC: NE-IR-202-98/KY. Unpublished study prepared by Novartis Crop Protection, Inc. 105 p. {OPPTS 860.1000, 860.1500}

31.171-4B Residue Analytical Methods

MRID	Citation Reference
42868904	Wehner, T. (1993) Method Validation: HPLC-Fluorescence Method to Determine the Total Toxic Residue of MK-244 and its Metabolites, on Vegetables, Including Leafy Vegetables and Cole Crops: Lab Project Number: 93670: 244-92-3: 618-244-93670. Unpublished study prepared by Merck Research Labs. 1120 p.
43404307	Kvaternick, V. (1994) Validation of Method 244-93-3 for the Total Toxic Residue of MK-0244 in Various Vegetable Crops: Lab Project Number: 618-244-1355S: 1355S-1: 1355S. Unpublished study prepared by Analytical Dev. Corp. 901 p.
43850123	Morneweck, L. (1995) Radio-Validation of Analytical Research HPLC-Fluorescence Method 244-92-3: Lab Project Number: 618-244-94391. Unpublished study prepared by Merck Research Labs. 143 p.
43850124	Conrath, B. (1995) Multiresidue Method Testing for B1a and B1b Components of MK-0244, L'649, L'831, and L'599, and the B1a Component of the 8,9-Z Isomer of MK-0244 According to PAM I, Appendix II, as Updated January, 1994: Lab Project Number: 42803: ACFS-42803: 618-244-42803. Unpublished study prepared by Analytical Bio-Chemistry Labs. 118 p.
43850125	Baldi, B. (1995) Independent Method Validation Ruggedness Trial For the Determination of Emamectin Benzoate (MK-0244) and its Photodegradate on Vegetables using Merck Method No. 244-92-3, Revision 1, Entitled HPLC Fluorescence Method to Determine the Total Toxic Residues of MK-0244 and its Metabolites on Vegetables, Including Leafy Vegetables and Cole Crops: Lab Project Number: 95-0014: 94406: 244-92-3. Unpublished study prepared by EN-CAS Analytical Labs. 124 p.
44300102	Kvaternick, V. (1995) Validation of Method 244-92-3 for the Total Toxic Residue of MK-0244 on Various Fruiting Vegetable Crops: Lab Project Number: 618-244-1462S-1: 1462S: 1462S-1. Unpublished study prepared by Analytical Development Corp. 842 p.
44313201	Hampton, L.; Wehner, T. (1996) Method Validation for Fruiting Vegetables: HPLC-Fluorescence Method to Determine the Total Toxic Residue of MK-0244, and Its Metabolites, on Vegetables Including Leafy Vegetables and Cole Crops: Lab Project Number: 0618-0244-93905: 244-92-3: 93905. Unpublished study prepared by Merck Research Labs. 498 p.
44596301	James, J.; Pruitt, W.; Ediger, K. (1998) Validation of Analytical Method AG-684 for the Confirmation of Emamectin Benzoate (MK-0244) and its Isomer, 8,9-Z, in or on Representative Samples of Crop Group 4: Leafy Vegetables and Crop Group 5: Brassica (Cole) Leafy Vegetables by LC/MS: Lab Project Number: 98-0012: 264-98: 684. Unpublished study prepared by EN-CAS Analytical Labs. 87 p. {OPPTS 860.1340}
44883712	Wehner, T.; Morneweck, L. (1997) Method Validation of the HPLC-Fluorescence Method to Determine Residues of MK-0244 and its 8,9-Z Isomer in Bovine Tissues, Milk and Plasma: Final Report: Lab Project Number: 103-99: 0618-244-94454: 244-

95-1. Unpublished study prepared by Merck Research Laboratories. 644 p. {OPPTS 860.1340}

44883713	Kvaternick, V. (1997) Independent Laboratory Validation for the Determination of Emamectin Benzoate (MK-0244) Residues in Bovine Liver Tissue and Milk: Final Report: Lab Project Number: 1033-99: 94731: 0397. Unpublished study prepared by Analytical Development Corporation. 172 p. {OPPTS 860.1340}
45209801	Kvaternick, V. (1997) Validation of MK-0244 Total Toxic Residues in/on Leafy Brassica (Mustard Greens and Bok Choy): Lab Project Number: 1643: 502-96. Unpublished study prepared by Analytical Development Corporation. 191 p. {OPPTS 860.1340}

32.171-4C Magnitude of the Residue [by commodity]

MRID	Citation Reference
42851520	Norton, J. (1993) Determination of the Magnitude of Residues of MK-244 and its Metabolites in/on the Raw Agricultural Commodity Group, Cole Crops, from MK-244 0.16 EC Applied with Non-Ionic Surfactant by Ground Equipment: Lab Project Number: 618-244-93336: 93336: 3336. Unpublished study prepared by Merck Research Labs., ACDS, Inc., Carolina Ag-Research Services, AG-Consulting, Inc., Roger Boren, Inc., Entocon, Inc. 1566 p.
42851521	Wehner, T. (1993) 0, 1, and 3 Month Freezer Storage Stability of MK-0244 and Metabolites (or Degradation Products) in Leafy Vegetables and Cole Crops: Interim Report: Lab Project Number: 618-244-93698: 93698: 3698. Unpublished study prepared by Merck Research Labs. 343 p.
42868903	Norton, J. (1993) Determination of the Magnitude of Residues of MK-244 and its Metabolites in/on the Raw Agricultural Commodity Group, Leafy Vegetables, from MK-244 0.16 EC Applied with Non-Ionic Surfactant by Ground Equipment: Lab Project Number: 618-244-92856: 92856: 2856. Unpublished study prepared by Merck Research Labs. 1626 p.
43393011	Norton, J. (1994) Determination of the Magnitude of Residues of MK-244 and Its Metabolites in/on the Raw Agricultural Commodity Group, Leafy Vegetables, from MK-244 0.16 EC Applied with Non-ionic Surfactant by Ground Equipment: Lab Project Number: 618-244-92856: 92856: 001-90-0004R. Unpublished study prepared by Merck & Co., Inc. 2848 p.
43393012	Wehner, T. (1994) 6, 12, and 18 Month Freezer Storage Stability of MK-0244 and Metabolites (or Degradation Products) in Leafy Vegetables and Cole Crops: Interim Report: Lab Project Number: 618-244-93698: 93698. Unpublished study prepared by Merck Research Labs. 395 p.
43415301	Norton, J. (1994) Determination of the Magnitude of Residues of MK-244 and its Metabolites in/on the Raw Agricultural Commodity Group, Cole Crops, from MK-244 0.16 EC Applied with Non-Ionic Surfactant by Ground Equipment: Lab Project Number: 618-244-93336: 3336: 93336. Unpublished study prepared by Research

Designed for Agriculture; South Texas Ag. Research; and Hickey's Agri-Services Lab, Inc. 2532 p.

43850121 Crouch, L. (1995) Metabolism of (carbon 14)-MK-0244 in Cabbage: Lab Project Number: 3130: 93130: PMES-PLM7. Unpublished study prepared by ABC Labs. 475 p.

43850122 Crouch, L. (1995) Metabolism of (carbon 14)-MK-0244 in Sweet Corn: Lab Project Number: 93583: PMES-PLM8: PLM8. Unpublished study prepared by ABC Labs. 340 p.

44030602 Wehner, T.; Dunbar, D. (1996) Determination of the Magnitude of Residues of MK-244 and Its Metabolites in/on the Raw Agricultural Commodity Groups, Leafy Vegetables and Cole Crops, from MK-244 5 SG Applied with a Non-Ionic Surfactant by Ground Equipment: Lab Project Number: 618-244-94405: 94405: 4405. Unpublished study prepared by Merck & Co., Inc. 3359 p.

44300101 Wehner, T.; Dunbar, D. (1996) Determination of the Magnitude of Residues of MK-244 and Its Metabolites in/on the Raw Agricultural Commodity Group, Fruiting Vegetables, from MK-244 0.16 EC Applied with Non-Ionic Surfactants by Ground Equipment: Lab Project Number: 618-244-93860: 93860: 3860. Unpublished study prepared by Merck & Co., Inc. 6597 p.

44300103 Kvaternick, V. (1996) Storage Stability of Total Toxic Residues of MK-244 on Various Fruiting Vegetables: Interim Report: (0, 1, 3, and 6 Month Intervals): Lab Project Number: 120294: 618-244-1462C: 4163. Unpublished study prepared by Analytical Development Corp. 741 p.

44300106 Morneweck, L.; Wehner, T. (1997) The Determination of Freezer Storage Stability of Residues of MK-0244 and Its Metabolites, on Leafy Vegetables and Cole Crops: (0 to 36 Month Interval Data): Lab Project Number: 618-244-93698: 93698: 3698. Unpublished study prepared by Merck Research Labs. 418 p.

44795001 Vincent, T. (1999) Emamectin: Determination of the Magnitude of Residues of MK-0244 and its Metabolites in/on the Raw Agricultural Commodities Cottonseed and Gin Trash, from MK-244 Applied with Non-Ionic Surfactant by Ground Equipment: Final Report: Lab Project Number: ABR-98062: 94636: 446-97. Unpublished study prepared by Novartis Crop Protection, Inc. 262 p. {OPPTS 860.1500}

44883707 Ediger, K. (1999) Emamectin--Magnitude of the Residues in or on Representative Commodities of Crop Group 4: Leafy Vegetables: Final Report: Lab Project Number: 135-98: OW-IR-510-98: OW-IR-533-98. Unpublished study prepared by Novartis Crop Protection, Inc. 132 p. {OPPTS 860.1000, 860.1500}

44883708 Ediger, K. (1999) Emamectin--Magnitude of the Residues in or on Representative Commodities of Crop Group 5: Brassica (Cole) Leafy Vegetables: Final Report: Lab Project Number: OS-IR-308-98: 136-98: 347004. Unpublished study prepared by Novartis Crop Protection, Inc. 201 p. {OPPTS 860.1000, 860.1500}

44883709 Ediger, K. (1999) Emamectin--Magnitude of the Residues in or on Representative Commodities of Crop Group 8: Fruity Vegetables: Final Report: Lab Project Number: 137-98: 347004: OW-IR-430-98. Unpublished study prepared by Novartis Crop Protection, Inc. 73 p. {OPPTS 860.1000, 860.1500}

44883715	Dunbar, D.; Wehner, T. (1996) Determination of the Magnitude of Residues of MK-244 and its Metabolites in/on The Raw Agricultural Commodity Group, Fruiting Vegetables, From MK-244 5 SG Applied with a Non-Ionic Surfactant By Ground Equipment: Final Report: Lab Project Number: 618-244-94461: 4461: 1013-99. Unpublished study prepared by Merck & Co., Inc. 64 p. {OPPTS 860.1500}
44883716	Eudy, L.; Cobin, J.; Campbell, D. (1999) CGA-293343 + Emamectin--Magnitude of the Residues in or on Cotton: Final Report: Lab Project Number: 132-98: 02-IR-022-98: 03-IR-001-98. Unpublished study prepared by Novartis Crop Protection, Inc. 416 p. {OPPTS 860.1500, 860.1520}
45209802	Cobin, J. (1998) Determination of the Magnitude of Residues of MK-244 and its Metabolites in/out the Raw Agricultural Commodity Group, Leafy Brassica Greens, from MK-244 Applied with a Non-Ionic Surfactant by Ground Equipment: Lab Project Number: ABR-98042: 448-97. Unpublished study prepared by Novartis Crop Protection, Inc. 159 p. {OPPTS 860.1500}
45209803	Vincent, T. (1998) Determination of the Magnitude of Residues of MK-0244 and its Metabolites in/on the Raw Agricultural Commodities, Leaf Lettuce and Spinach, from MK-0244 5SG Applied with a Non-Ionic Surfactant by Ground Equipment: Lab Project Number: ABR-98047: 450-97. Unpublished study prepared by Novartis Crop Protection. 202 p. {OPPTS 860.1500}
45899801	Cobin, J.; Ediger, K. (2002) MK-0244--Magnitude of the Residues in or on Crop Group 11: Pome Fruit: Emamectin Benzoate: Final Report: Lab Project Number: 37-00. Unpublished study prepared by Syngenta Crop Protection, Inc. 345 p. {OPPTS 860.1000, 860.1500 and 860.1520}

33.171-4A1 Characterization of Total Terminal Residue

MRID	Citation Reference
44007904	Wehner, T. (1996) Method Validation: HPLC-Fluorescence Method to Determine the Foliar Dislodgeable Total Toxic Residues of MK-0244 and Its Metabolites in Leaf Disk Extracts: Analytical Research Method 244-93-2: Lab Project Number: 618-244-93902: 93902: 3902. Unpublished study prepared by Merck Research Labs. 939 p.

34.171-4A2 Nature of the Residue in Plants

MRID	Citation Reference
42851522	Crouch, L. (1993) Metabolism of (carbon 14) MK-0244 in Lettuce: Lab Project Number: PLM6: PMES PLM6. Unpublished study prepared by Merck Research Labs and ABC Labs. 823 p.
43850121	Crouch, L. (1995) Metabolism of (carbon 14)-MK-0244 in Cabbage: Lab Project Number: 3130: 93130: PMES-PLM7. Unpublished study prepared by ABC Labs. 475 p.

43850122	Crouch, L. (1995) Metabolism of (carbon 14)-MK-0244 in Sweet Corn: Lab Project Number: 93583: PMES-PLM8: PLM8. Unpublished study prepared by ABC Labs. 340 p.
44007906	Crouch, L. (1996) Assay and Characterization of Polar Photodegradates of MK244 and (carbon 14)-MK244: Lab Project Number: 93692 (PMES TCR-1). Unpublished study prepared by Merck Research Labs; Galbraith Labs, Inc.; and Ricerca, Inc. 128 p.
44007907	Wrzesinski, C. (1996) Comparison, Characterization, and/or Identification of Polar MK-0244 Plant and Thin Film Photolysis Residues: Lab Project Number: PLM9: 94404 (PMES PLM-9): PMES/DMII/MRL. Unpublished study prepared by Merck Research Labs. 406 p.

35.171-4A3 Nature of the Residue in Livestock

MRID	Citation Reference
44300107	Mushtaq, M. (1995) The Elimination, Tissue Distribution, and Metabolism of (3H)4"-Deoxy-4"-Epimethylaminoavermectin B1a (MAB1a) Benzoate and (3H/(carbon 14))MAB1a Benzoate in Lactating Goats: Final Report: Lab Project Number: ARM-9: 618-MK-0244-ARM-9: 93995. Unpublished study prepared by Merck Research Labs; Analytical Development Corp.; and Colorado State University. 490 p.
44883710	Mushtaq, M. (1995) The Elimination, Tissue Distribution and Metabolism of (3-hydrogen)4-Deoxy-4-Epimethylaminoavermectin B1A (MAB1a) Benzoate and ((3-hydrogen)/(14-carbon))MAB1a Benzoate in Lactating Goats: Final Report: Lab Project Number: ARM-9: 522-94: 618-MK-0244-ARM-9. Unpublished study prepared by Merck Research Laboratories, Analytical Development Corp., Metabolic Lab. 528 p. {OPPTS 860.1300}
44883711	Crouch, L. (1997) The Elimination, Tissue Distribution and Metabolism of ((3-hydrogen)/(14-carbon))-Deoxy-4-Epimethylamino Avermectin B1a (MAB1a) Benzoate in Laying Chickens: Final Report: Lab Project Number: ABR-97116: 94706: 477-96. Unpublished study prepared by Merck Research Laboratories. 323 p. {OPPTS 860.1300}
44883714	Wehner, T.; Morneweck, L. (1997) A Study in Lactating Cows to Determine Tissue, Milk and Plasma Residues in Animals Exposed to Twenty-Eight Days of Oral Ingestion of MK-0244 (Emamectin Benzoate): Final Report: Lab Project Number: 1032-99: 94401: ASR 14601. Unpublished study prepared by Merck Research Laboratories. 1878 p. {OPPTS 860.1480}

36.830.7370 Dissociation constants in water

MRID	Citation Reference
47002103	Sparrow, K. (2006) Emamectin Benzoate Technical II: (MK244): Physical and Chemical Proerties of Emamectin Benzoate Technical II. Project Number: PC/06/126. Unpublished study prepared by Syngenta Crop Protection. 54 p.

49212304	Luo, S. (2013) Study on the Physico-Chemical Properties of Emamectin Benzoate Technical: Final Report. Project Number: 1020. Unpublished study prepared by Rotam Limited. 58p.
50127304	Kaminsky, M. (2016) TreeMec Tech: Product Chemistry Physical and Chemical Properties. Project Number: 19131/15. Unpublished study prepared by Stillmeadow, Inc. 61p.

37.830.7550 Partition coefficient (n-octanol/water), shake flask method

MRID	Citation Reference
47002103	Sparrow, K. (2006) Emamectin Benzoate Technical II: (MK244): Physical and Chemical Properties of Emamectin Benzoate Technical II. Project Number: PC/06/126. Unpublished study prepared by Syngenta Crop Protection. 54 p.
49212306	Manivelan, T. (2013) Study on the Physico-Chemical Properties of Emamectin Benzoate Technical: Final Repo. Project Number: 1018. Unpublished study prepared by Rotam Limited. 227p.
50127304	Kaminsky, M. (2016) TreeMec Tech: Product Chemistry Physical and Chemical Properties. Project Number: 19131/15. Unpublished study prepared by Stillmeadow, Inc. 61p.

38.830.7840 Water solubility: Column elution method, shake flask method

MRID	Citation Reference
47002103	Sparrow, K. (2006) Emamectin Benzoate Technical II: (MK244): Physical and Chemical Proerties of Emamectin Benzoate Technical II. Project Number: PC/06/126. Unpublished study prepared by Syngenta Crop Protection. 54 p.
49212306	Manivelan, T. (2013) Study on the Physico-Chemical Properties of Emamectin Benzoate Technical: Final Repo. Project Number: 1018. Unpublished study prepared by Rotam Limited. 227p.
50127304	Kaminsky, M. (2016) TreeMec Tech: Product Chemistry Physical and Chemical Properties. Project Number: 19131/15. Unpublished study prepared by Stillmeadow, Inc. 61p.

39.830.7950 Vapor pressure

MRID	Citation Reference
47002103	Sparrow, K. (2006) Emamectin Benzoate Technical II: (MK244): Physical and Chemical Proerties of Emamectin Benzoate Technical II. Project Number: PC/06/126. Unpublished study prepared by Syngenta Crop Protection. 54 p.

49212305	Manivelan, T. (2013) Study on the Physico-Chemical Properties of Emamectin Benzoate Technical: Final Report. Project Number: 1017. Unpublished study prepared by Rotam Limited. 43p.
50127304	Kaminsky, M. (2016) TreeMec Tech: Product Chemistry Physical and Chemical Properties. Project Number: 19131/15. Unpublished study prepared by Stillmeadow, Inc. 61p.

40.835.4100 Aerobic soil metabolism

MRID	Citation Reference
48480101	Clark, A. (2003) Emamectin Benzoate - Aerobic Soil Metabolism of (Carbon 14)-NOA426007 and (Carbon 14)-NOA422390: Final Report. Project Number: T001853/01, T001853/01/OCR. Unpublished study prepared by Syngenta Crop Protection, Inc. 139 p.
48480103	Jungmann, V.; Nicollier, G. (2006) Rate of Degradation of (Carbon 14)Emamectin Benzoate B1a ((Carbon 14)-NOA426007) in One Soil Under Various Laboratory Conditions at 20(Degrees Celsius) (Including Addendum to the Report): Final Report. Project Number: T000877/05, T000877/05/OCR. Unpublished study prepared by Syngenta Crop Protection, AG. 151 p.

41.850.1010 Aquatic invertebrate acute toxicity, test, freshwater daphnids

MRID	Citation Reference
49599101	Bradley, M. (2015) 42-Day Toxicity Test Exposing Freshwater Amphipods (Hyalella azteca) to Emamectin Benzoate Applied to Sediment Under Static-Renewal Conditions following EPA Test Methods. Project Number: 1781/6931, TK0069744. Unpublished study prepared by Smithers Viscient Laboratories. 121p.

42.850.1075 Fish acute toxicity test, freshwater and marine

MRID	Citation Reference
49227401	Shaw, A. (2013) Emamectin Benzoate - Acute Toxicity to Fathead Minnow (Pimephales promelas) Under Flow-Through Conditions: Final Report. Project Number: TK0069749, 1781/6925. Unpublished study prepared by Smithers Viscient Laboratories. 38p.

43.850.2100 Avian acute oral toxicity test

MRID	Citation Reference

49599103	Hubbard, P.; Beavers, J. (2015) Emamectin Benzoate - An Acute Oral Toxicity Study with the Canary: Final Report. Project Number: 528B/451, TK0069752. Unpublished study prepared by Wildlife International, Ltd. 80p.

44.850.3020 Honey bee acute contact toxicity

MRID	Citation Reference
48257501	Barth, M. (2001) Acute Toxicity of MK 244 05 SG (A-10324 A) to the Honeybee Apis mellifera L. Under Laboratory Conditions: Final Report. Project Number: 01/10/48/027, 2002659, TK0051703. Unpublished study prepared by Biochem Agrar. 45 p.

45.850.4100 Terrestrial plant toxicity, Tier 1 (seeding emergence)

MRID	Citation Reference
49227402	Martin, J. (2013) Emamectin - Seedling Emergence Test: Final Report. Project Number: TK0069753, 1781/6926. Unpublished study prepared by Smithers Viscient Laboratories. 351p.

46.850.4150 Terrestrial plant toxicity, Tier 1 (vegetative vigor)

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47.860.1000 Background

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48.870.1100 Acute oral toxicity

MRID	Citation Reference
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47002105	Pooles, A. (2006) Emamectin: SYN545012: Acute Oral Toxicity in the Rat - Up and Down Procedure: Final Report. Project Number: 0006/0680, T011271/06. Unpublished study prepared by Safepharm Laboratories Ltd.. 20 p.
47153906	Kuhn, J. (2006) Emamectin Benzoate RB (0.1) (A15276A): Acute Oral Toxicity Study in Rats: Final Report. Project Number: 9726/06, T001413/04. Unpublished study prepared by Stillmeadow, Inc. 14 p.
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49.870.7485 Metabolism and pharmacokinetics

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50.850.1740 Whole sediment: acute marine invertebrates

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51. 63-0 Reports of Multiple phys/chem Characteristics

MRID	Citation Reference
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43824002	Sweetapple, G. (1995) Emamectin Benzoate (L-656,748-088T 5 SG Formulation): Color, Physical State, Bulk Density, pH: Lab Project Number: 618-244-PC 63: 4232-95-0129-AS. Unpublished study prepared by Ricerca, Inc. 36 p.

52.63-8 Solubility

MRID	Citation Reference
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43850102	McCauley, J. (1995) Determination of Some Solubility Properties of MK-244: Lab Project Number: 618-244-EX2: 94457: 4457. Unpublished study prepared by Merck Research Labs. 69 p.
44883704	Phelps, L. (1999) Emamectin Benzoate Technical (Addendum to MRID #42794202) Product Chemistry Group B Data Requirements: Lab Project Number: 162-98: ASR-684: ASGSR-98-333. Unpublished study prepared by Novartis Crop Protection, Inc. 53 p. {OPPTS 830.7840}

53.63-9 Vapor Pressure

MRID	Citation Reference
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54.63-10 Dissociation Constant

MRID	Citation Reference
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55.63-11 Oct/Water partition Coef.

MRID	Citation Reference
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56.63-12 pH

MRID	Citation Reference
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57.63-13 Stability

MRID	Citation Reference
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58.63-17 Storage stability

MRID	Citation Reference
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42743650	Demchak, R. (1993) Aging and Storage Stability of MK-244; An Emamectin Benzoate 0.16 lb/gal Formulation, L-656,748-049C: Lab Project Number: 93265/91-002F: 618-244-PC63R5. Unpublished study prepared by Merck & Co., Inc. Merck Research Labs. 86 p.